To: PUC Judges
This is just another reason why Franklin Counteans do not want Transource running their lines through our county!

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Editorial Sun. 9-16-18 Public Opinion

The Transource tax bomb: Lower property values, less revenue

Clinton Barkdoll

The proposed Transource project has prompted extensive discussion about the adverse impact high voltage power lines may have on Franklin County tourism, economic development, land use, the environment, agriculture, health, and our overall landscape.

All of those are valid concerns and warrant serious scrutiny from government regulators. Courts must also carefully consider the legality of the project, especially in light of the fact that electricity rates will not decrease in the geographic areas where Transource is attempting to acquire real estate rights of way via the eminent domain process.

While government regulators and courts sort out those many issues, though, enough has not been said about the potential economic devastation this project may have on local school districts and municipalities.

Conventional wisdom is that real estate values will decrease in the immediate areas where high voltage transmission towers and lines are built. However, it has been hard to quantify exactly how much of a decrease in value will occur.

Recently, economists at the College of Charleston conducted the largest study of its kind in history to specifically address the question of how high voltage transmission lines affect real estate values. Researchers looked at 5,455 real estate parcels in South Carolina, all of which were adjacent to or within 1,000 feet of a recently constructed high voltage transmission line. The findings are astounding: for properties adjacent to the power lines, the value of the real estate decreased by 44.9%; for non-adjacent properties (up to 1,000 feet away from the power lines) the value of the real estate decreased by 17.9%.

One of the lead economists from the study further confirms the research model could be easily transferred to other geographic areas dealing with power line proposals. Perhaps local property values would decrease more or less than the South Carolina parcels, but the point is there would be substantial decreases in real estate values if Transource power lines and towers are built.

The real estate appraisal industry is considering the adoption of the South Carolina findings when appraising real estate after power line projects have been approved. The South Carolina study finally provides a methodology that appraisers throughout the U.S. can use when calculating values for real estate affected by high voltage transmission line construction.

If the Transource project moves forward, residents of all affected areas could flood their county governments with tax assessment appeals. Based on the South Carolina research, property owners will have strong arguments that real estate values have decreased, and therefore, tax assessments should be downwardly adjusted. Formal appraisals of the properties would further support these appeals, and tax assessment appeal boards (and the courts) will likely be constrained to lower the tax assessments.

There are hundreds of real estate parcels in Pennsylvania and Maryland adjacent to, or within 1,000 feet of, the proposed Transource high voltage transmission lines. If even a fraction of these property owners pursues tax appeals, the loss of tax revenue to local school districts, county governments, boroughs and townships could easily be millions of dollars, on a collective basis. If such a scenario unfolds, school districts and municipalities will need to increase property taxes and/or make cuts to programs. Either way, this is a lose-lose situation for all residents, even those not directly affected by the proposed power line route.

The decreased real estate values would also cause diluted revenue from transfer taxes, that pesky 2% tax collected every time a property is sold in Pennsylvania. Transfer taxes -- which are shared by the Pennsylvania government, along with the school district and municipality where the sold real estate is located – are a substantial source of revenue for all involved entities. Assuming Transource-affected properties are worth less and also become less marketable, it is safe to assume that transfer tax revenue will also decrease. In turn, Pennsylvania, school districts, local municipalities, and taxpayers, lose again.

The double whammy of the erosion of the real estate tax base and the dilution of transfer tax revenue will harm all citizens. Oversight bodies in Pennsylvania and Maryland should consider this when evaluating the Transource project. Residents in the affected areas, along with already financially strapped school districts and local governments, should prepare for serious economic fallout if this project is approved.

Continue to voice your opinions on Transource and consider attending one of the upcoming Pennsylvania Public Utility Commission hearings on Sept. 18 at New Franklin Fire Hall. All things considered, regulators should pull the plug on the Transource project.

Clinton Barkdoll is a Waynesboro resident.

Sincerely,
Dennis & Leilani Brechbill
3838 Fetterhoff Chapel Rd.

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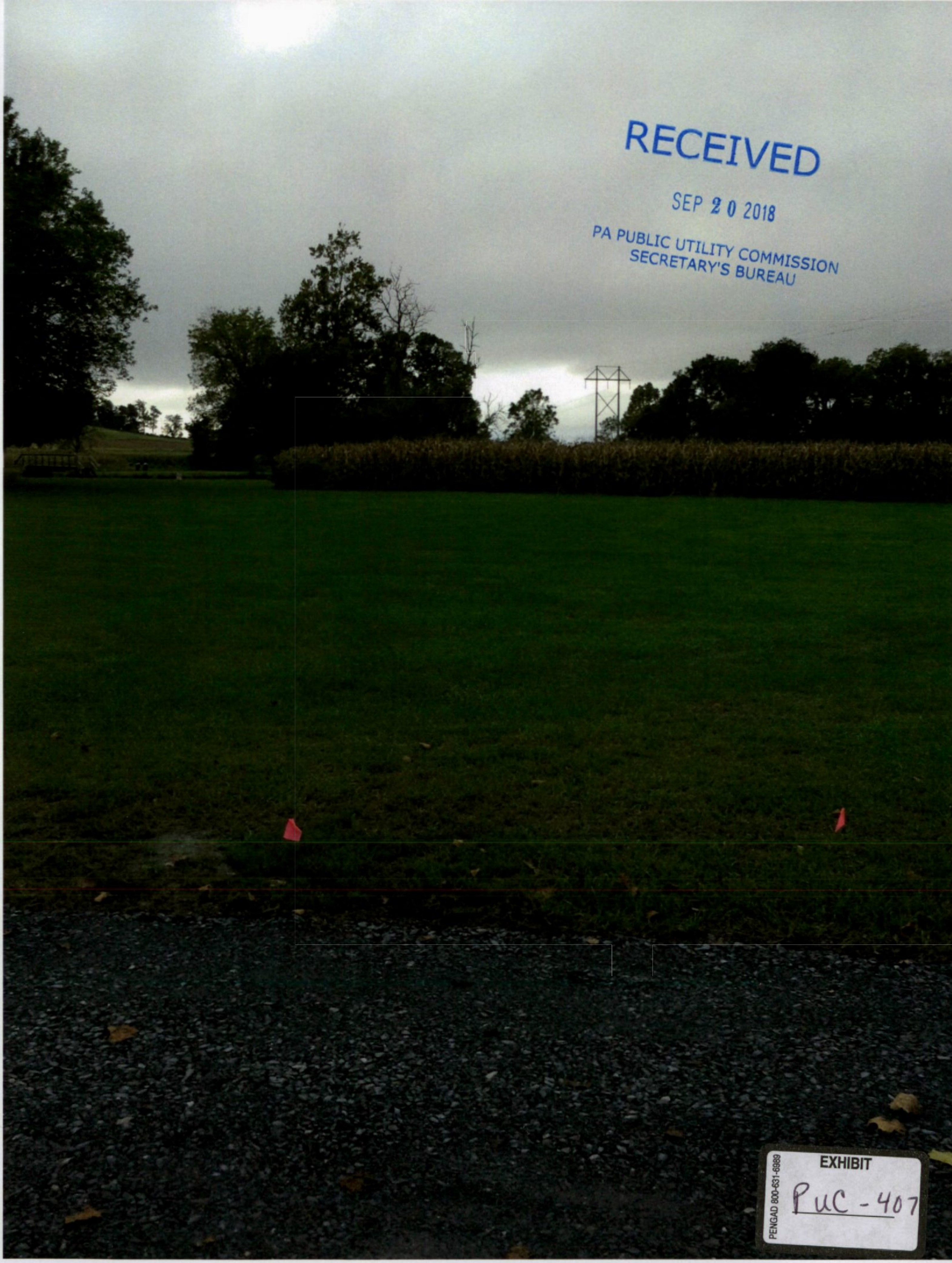
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The Pricing of Power Lines:
A Geospatial Approach to Measuring Residential Property Values

ABSTRACT

The valuation of power lines is a complex phenomenon. Using a sample of 5,455 vacant lots sold in Pickens County, South Carolina, we uncover substantive pricing discounts of 44.9% for properties adjacent to power lines, and a pricing discount of 17.9% for non-adjacent vacant properties up to 1,000 feet away from the power lines. Applying four different geospatial approaches – buffer zones, straight line distance, viewshed analysis and tower visibility – we find that HVTL pricing models should account for both proximity and visibility to reflect location specific variations in pricing.

Keywords: Power Lines, GIS, Valuation, Views, Hedonic Modeling

The Pricing of Power Lines: A Geospatial Approach to Measuring Residential Property Values

1. Introduction

The valuation of power lines is a complex phenomenon. Typically, survey respondents strongly oppose the construction of power lines in their neighborhood, yet empirical studies suggest that households suffer only modest pricing discounts, if any. Reese (1967, 560) observes: "If I were offered the choice between two houses, identical in detail and location, but one having no power line near and the other having such a line would this single difference have any monetary significance for me? My answer is yes."

Theory suggests that proximity to power lines will influence sale prices on nearby properties through four mechanisms: 1) visual disamenity; 2) perceived health impacts; 3) noise disturbances; and 4) access to green space. First, surveys suggest that power lines provide a visual disamenity. For example, Kung and Seagle (1992) found 53% of survey respondents perceive a view of High Voltage Transmission Lines (HVTLs) to be an eyesore. Second, there is fear that exposure to electromagnetic fields (EMF) may pose a carcinogenic risk (Gregory and von Winterfeldt 1996). However, a report by the National Institute of Environmental Health Sciences (Olden 1999) offers only weak scientific evidence that exposure to extremely low frequency electric and magnetic fields (ELF-EMF) poses any potential health risks. Nevertheless, perceptions of a health risk can act to depress prices. Third, power lines may generate a disturbing hum, which is louder for proximate properties (Reese 1967). A survey of appraisers by Delaney and Timmons (1992) reveals the relative importance of these variables; they found visual attractiveness cited by almost 94% of respondents as the reason for a diminution of value for properties proximate to power lines, with 59% citing potential health problems and 43% disturbing sounds. To offset the negative impact of power lines, an option for developers is to increase the lot size for impacted properties and/or provide landscaping to minimize the visual disamenity (Delaney and Timmons 1992). Thus, if developers offered larger lot sizes for properties adjacent to power lines, then this might explain the limited pricing discounts reported in empirical studies. Alternatively, homeowners may positively value living adjacent to the right of way since they will have fewer neighbors and may potentially use the right of way for recreational purposes.

We offer three contributions to the literature. First, we tackle the HVTL valuation conundrum by conducting a large-scale study of 5,455 vacant lots sold from 2000 to 2016 in Pickens County, South Carolina. The construction of the Oconee nuclear power station in the early 1970s on Lake Keowee led to a network of HVTLs traversing the rural landscape of Pickens County feeding power to approximately two million people. This study is the largest known academic sample of vacant lots specifically compiled to address the power line issue; the large scale reduces the impact of outliers on our study. Additionally, the use of vacant lots permits a rigorous examination of the pricing impact of HVTLs without the potential contamination of property data from varying configurations, age and quality of housing structures. The presence of housing structures can obscure the pricing impact of power lines on raw land due to the disproportionate influence of such structures on total property value.

Secondly, our findings indicate that adjacency to the power lines results in a statistically significant diminution of 44.9% for impacted lots; lots within 1000 feet, but not adjacent suffer a pricing diminution of 17.9%. As our findings are for vacant land, it is helpful to compare this percentage decline with the simulated impact on the built environment. For example, in a case where land value is 20% of total property value, if the impact of power line adjacency leads to a 44.9% decrease in land value, then total property value will proportionately decrease by 8.98%. In comparison, a review of 16 power line studies by Chalmers and Voorvaart (2009) found pricing discounts in only half of the studies, and where found the pricing discounts were typically less than 6%. Thus, the pricing discounts found for our study area are significantly higher than previously reported in many studies. Additionally, the vacant lots adjacent to the power lines averaged 3.03 acres compared to only 1.55 acres for the remaining lots in our study. In other words, vacant lots despite their size being almost double the acreage of comparison properties still suffered a 44.9% price decrease. Although one might expect the marginal utility of acreage to decrease with an increasing lot size, the results from our study area indicate a substantive negative pricing impact for vacant lot proximate to power lines. Overall, the assumption of negligible or no pricing discount is clearly refuted for our site area. However, congruent with earlier studies, we find that this negative pricing impact decays with distance and typically disappears after approximately 1,000 feet.

Third, we attempt to provide some clarification on the relative pricing impact of visibility of power lines. In particular, we argue that the quality of the view is an important factor determining the pricing discount associated with HVTL proximity. We focus on the visibility of HVTL suspension towers for three reasons. First, previous research indicates that visual attractiveness is key driver for pricing discounts associated with HVTL proximity (Kung and Seagle 1992; Delaney and Timmons 1992; Des Rosiers 2002). Second, the use of common techniques to identify the pricing impact of HVTL proximity, buffer zones and straight line distance, masks a great deal of "fuzziness" in the pricing of individual parcels. For example, one cannot accurately predict the pricing of two properties that are the same linear distance from HVTLs, but only one of which has a view of HVTLs. Moreover, it is difficult to evaluate the effective quality of views (Hindsley et al. 2013; Bourassa et al. 2004). Third, analytic tools exist that allow us to measure HVTL suspension tower visibility. A possible geospatial solution is to use viewshed analysis to indicate which properties have direct line of sight of HVTLs. Based on viewshed analysis, we find that lots with a direct view of the HVTL transmission towers suffer a statistically significant pricing discount of 22.1%. However, viewshed analysis would tend to underestimate the HVTL pricing impact as the estimated coefficient is diluted by nonexistent visibility relationships. As a result, we offer a new GIS-based spatial statistic that measures the line of sight visibility HVTL suspension towers from impacted lots. Our new measure, which we refer to as the "TOWER VISIBILITY INDEX" (TVI), accounts for line of sight obstructions of suspension towers as well as changes in the perceived size of the towers with distance. Our results indicate that tower visibility provides a negative pricing impact for properties with a 1% increase in tower visibility associated with a marginal pricing discount of 1.6%.

This study shows that visibility matters. Both viewshed and TVI variables produce a statistically significant pricing discount for HVTL impacted properties. Although none of the four measures used in this study provides a perfect tool to model pricing of properties impacted by HVTL towers, all four models show that HVTL impacted properties can suffer substantive pricing discounts. Given the multitude of factors that may influence the pricing of HVTL impacted properties, the viewshed and TVI variables provide a complementary analytic tool in the complex valuation process.

Our study starts with a review of the academic literature on the valuation of power lines. We examine a number of factors that may lead to the under-reporting of the economic discount of a view of HVTLs found in many previous studies. Next, we construct alternative spatial hedonic models to consider the impact of HVTLs and detail the results. Finally, we analyze the different geospatial approaches and provide suggestions to help future valuation studies.

2. Literature Review

The aesthetic value of a view has been the focal point of a wide range of power line studies dating from the 1960s (Kinnard 1967; Reese 1967). A general rule of thumb is that residential properties

200 feet from a power line suffer a pricing discount of 1% to 6% with the pricing effect disappearing after 300 feet (Kinnard et al 1997). A number of studies suggest that the price discount for proximity decays with distance. For example, Colwell (1990) found improved properties within 50 feet of power lines suffered a more severe pricing diminution of 6.6% that decreased to only 2.0% at 200 feet. Recent empirical studies tend to corroborate the story of limited pricing discounts for proximity to HVTLs (Roddewig and Brigden 2014; Chalmers and Voorvaart 2009; Pitts and Jackson 2007).

Reese (1967) posits that one reason for limited pricing discounts for power line proximate properties is that these properties are larger in acreage and better landscaped. Properties adjacent to power lines may incorporate generous rights of way (ROW) corridors; these easements provide access to greenbelts of landscaped open space and can play a role in minimizing pricing impact (Colwell 1990). Consequently, ROW adjacent properties may earn a positive price premium if the value of the green corridor is greater than negative value of a view of the HVTL (Sims and Dent 2005). Kinnard (1967) cites the role of vegetation cover in the pricing of a view. As vegetation cover grows over time, it obscures visibility of the power lines from a given residential property dissipating the pricing impact of HVTLs over time.

Pitts and Jackson (2007) observe that it is difficult to measure the impact of power lines on residential properties owing to the complexity of varied locations, market conditions and buyer preferences. For example, one would expect that any pricing discount accruing to visibility of 60 kV suspension towers to be lower than pricing discounts found for 500 kV suspension towers, ceteris paribus. Market conditions can be reflected not only in prices, but also lead to lower absorption rates and increased time on market for HVTL impacted properties (Kinnard and Dickey 1995; Reese 1967). Finally, Pitts and Jackson theorize that some individuals may simply be indifferent to the sight of power lines and suggest the limited impact of power lines on property pricing in empirical studies may be due to a lack of market consensus among consumers. For example, Seiler (2014) uses an experimental pricing format and finds that females are impacted by power line encumbrances more than males.

The importance of granularity is revealed in a micro-spatial study of over 500 homes in greater Montreal by Des Rosiers (2002); he finds wide pricing variances ranging from price discounts of above 20% for properties proximate to power lines to a small number of properties with an enlarged visual field receiving price premiums of up to 22%. Socio-economics was relevant as a direct view of a suspension tower was associated with a 10% price reduction for standard homes, but higher-priced properties suffered a disproportionately greater discount of between 15-20%. Similarly, Bottemiller and Wolverton (2013) reveal marked pricing variances for power line properties between the Portland and Seattle markets. They find a small pricing discount of less than 2% for power line proximate properties in Portland, but a significantly larger discount of 11.2% for power line proximate properties in Seattle and that higher-priced homes suffer a proportionately greater negative impact. Their results suggest that socio-demographics influence pricing variances.

In theory, the hedonic framework decomposes a property's value into its constituent characteristics providing an estimated market value on non-marketed characteristics such as quality of a view. The inherent problem in estimating the pricing impact of power lines is the difficulty of methodologically identifying which properties are impacted. For example, a common tool to identify if a property is encumbered by power lines is to apply a binary dummy variable using a buffer zone such as 200 feet. However, as detailed above, a dummy fails to capture the nuances of differing quality views or the benefit of ROWs. Weak statistical methodology means that the accuracy of early power line studies is suspect (Kroll and Priestley 1992; Colwell 1990; Furby et al. 1988). A second statistical issue in geospatial analysis is the modifiable areal unit problem (MAUP), which refers to the problem of using the appropriate geographical scale (or zone) in data analysis. The aggregation of point-based data (such as sales prices) into areal units can create statistical bias depending upon the scale of areal unit selected. The problem of MAUP can lead to overestimation or underestimation of a measurement. For example, Jackson's (2010) study of power lines in rural Wisconsin illustrates the sensitivity of pricing according to scale. Given the rural location, properties with a transmission line easement were large, averaging 62.8 acres, and had a modest diminution in value of less than 2.5%. However, Jackson also examined the case where the value diminution is assigned to only to smaller easement areas, averaging 3.8 acres, with no loss assumed in the remaining acreage. In this case, the severity of the pricing diminution assessed for the easement alone ranges from 16% to 35% illustrating the importance of granularity in valuation. A third statistical issue in valuation studies is the standard practice of discarding outliers as discarded outliers may include properties proximate to power lines that have suffered an abnormal negative pricing impact. For example, Sims and Dent (2005) discard 13 outliers in their study of the pricing impact of HVTLS, but acknowledge that these properties sold for approximately a 50% discount. Thus, standard statistical methodology can lead researchers to remove outlier variables that are the prime focus of the study.

An associated problem in valuation studies is the lack of comparable properties. Bolton (1993) observes that appraisers typically use the sales comparison approach of paired sales, but that it is difficult to find sufficient market comparisons for power line properties. This is especially valid if power line adjacent properties have unique features such as a larger lot size. This critique can also hold for larger statistical studies. For example, Chalmers and Voorvaart (2009) conducted a study of 1,286 qualifying sales covering nine study areas in Connecticut and Massachusetts. However, their study had only 33 properties (2.6%) within 246 feet of a power line easement (Kielisch 2013) resulting in only a small number of power line proximate properties per study area.

The studies cited above involve datasets of housing sales (with the exception of Jackson's study of rural land sales in Wisconsin). Impacts theory suggests that the HVTL pricing discount on vacant land would be a multiple of the pricing discount on house sales.[i] Thus, one would expect to find higher price discounts for vacant land sales compared to housing sales. Correspondingly, studies of vacant land sales (Jackson, 2010; Kielisch, 2013) have estimated higher price discounts of up to 35% for power line proximate properties compared to studies of housing sales.

A unique feature of power line studies is that utility companies have financed the vast majority of research. For example, utility companies financed 22 of 27 power line studies reviewed by Kroll and Priestley (1992). This creates the potential problem of bias as utility companies may have a stake in supporting the publication of studies that minimize the pricing discount (Wyman and Worzala 2012).

The above methodological issues associated with empirical studies of HVTLs motivate the current investigation. Our study explores a number of different geospatial techniques for capturing the pricing influence of HVTLs on residential properties.

3. Methodology

Our study site is Pickens County, SC, which is located in the northwest corner of South Carolina. The county is bounded on the south by Clemson, a small university town of less than 20,000 permanent residents and by the foothills of the Blue Ridge Mountains to the north. Lake Keowee forms a large portion of the western boundary of the county and is home to the Oconee Nuclear Power Station. Figure 1 displays the county and illustrates the network of HVTLs that originate from the Oconee Nuclear Power Station.

PUT FIGURE 1 HERE

The Pickens County Tax Assessor's office provided transaction data (sale price, sale date, deed type, etc.), parcel characteristics data (tax district, land use, etc.), and GIS data (parcel boundaries, lot size, etc.) for all real estate transactions between 2000 and 2016. Ideally, the sample would be limited to arms-length, fair market value transactions of vacant residential parcels; however, the transaction data provides limited details on the transaction type. Therefore, we only exclude non-arms-length and non-fair market value transactions that we are able to identify, which includes multi-parcel transactions and transactions involving the same parcel occurring within six months of each other.[ii] We also limit the sample by excluding parcels larger than 20 acres. Our final sample consists of 5,455 vacant lot sales spread among 3,877 parcels.

3.1: Empirical Specification

Following prior research on the valuation of a view (Benson et al. 1998), we use a semi-log hedonic model to estimate the pricing influence of HVTLs on vacant properties. A hedonic model reveals the willingness to pay for a bundle of independent variables and allows the estimation of their implicit marginal prices. Our model is estimated as follows:

$$\ln(P_{ijkt}) = \alpha + HVTL_{ijk}\boldsymbol{\beta} + X'_{ijk}\gamma + C_j + TD_k + Y_t + \varepsilon_{ijkt} \qquad (1).$$

In equation (1), $\ln(P_{ijkt})$ is the natural logarithm of the inflation adjusted sale price (in 2016 dollars) of a vacant lot sale observed for parcel i in census block group j and tax district k at time t, $HVTL_{ijk}$ is a matrix of the HVTL proximity measures, X'_{ijk} is a matrix of observed, exogenous parcel characteristics, C_j is a vector of census block group fixed effects, TD_k is a vector of tax district fixed effects, Y_t is a vector of year fixed effects and ε_{ijkt} is the unobserved random error term.[iii] In the model, the effect of an independent variable on the sale price is identified using within year, tax district and block group variation.

The coefficients of the HVTL matrix, $\boldsymbol{\beta}$, capture the pricing impact of HVTL proximity on vacant sale price. If a particular β is positive, then the positive benefit of HVTL proximity, which includes access to green space, outweighs the negative benefits, which includes visual and noise dis-utilities, and perceived health risks. Conversely, if a particular β is negative then the negative benefits outweigh any positive benefits.

Absent of structural housing characteristics, location-specific characteristics are the primary determinants of a vacant lot's sale price. Location characteristics can be subdivided into two groups: 1) neighborhood characteristics; and 2) parcel characteristics. Neighborhood factors include the millage rate, access to public goods (e.g. public schools, library, parks, etc.), and access to job centers (i.e. distance). To control for the variation in public good provision and millage rates across municipalities we include tax district fixed effects. Tax districts represent relatively large areas within the county and may contain significant variation in distance to job centers and other nearby local amenities; therefore, we also include census block group fixed effects to account for any remaining variation in distances to spatially located features.

Other control variables capture the pricing impact of a parcel's physical characteristics, view quality and lake access. Control variables for physical characteristics include the mean land slope, lot size and the square of lot size. We include the square of lot size to capture any non-linear impacts of the parcel size on sale prices. We also include dummy variables for the three private golf course communities in the county – The Cliffs at Keowee Springs, The Cliffs at Keowee Vineyards, and The Reserve at Lake Keowee. Variables capturing the view quality include: 1) the view area of nearby golf course; 2) the view area of nearby lakes; 3) a dummy variable if the parcel is within 100 feet of a golf course; and 4) a dummy variable is the parcel is within 100 feet of a lake. The empirical specification uses the natural log of lake and golf course view areas to allow for non-linear impacts. We also include a series of dummy variable indicating the average direction of land slope (e.g. north, northwest, etc.) within a parcel. Finally, we include the length of a parcel's shoreline on a lake.

Two concerns that arise in hedonic pricing models are the spatial dependence between the error terms and the spatial dependence between sale prices. Failure to control for the spatial dependence in the errors term may lead to incorrect inference (Cameron and Miller 2015); therefore, we cluster the standard errors using 2010 Census block groups. Cluster-robust standard errors allow for any unspecified correlation of the error terms, including serial and spatial correlation, within each cluster. We account for any potential spatial dependence in the sale prices by including a variable, NEARBY SALE PRICE, which captures the impact of nearby sale prices on the current sale price of a vacant lot. NEARBY SALE PRICE is measured as the natural log of the distance-weighted, inflation adjusted sale price of properties sold within the past six months. We include the NEARBY SALE PRICE variable since theory and empirical studies suggest that nearby sales may influence a vacant lots sale price through spatial competition (Turnbull and Dombrow 2006; Turnbull et. al. 2006; Zahirovic-Herbert and Turnbull 2008).

PUT TABLE 1 HERE

We present summary statistics for the dependent and control variables in Panel 1A of Table 1. The average vacant lot is 1.57 acres, sold for \$194,000 in 2016 dollars, has a mean land slope of 21.11%, views 48,000 feet (1.1 acres) of a golf course and 243,000 square feet (5.6 acres) of a lake. Approximately 23% or 1,276 sales are within 100 feet of a lake and 7% or 398 sales are within 100 feet of a golf course. Finally, the three private golf course communities of The Cliffs at Keowee Springs, The Cliffs at Keowee Vineyards, and Reserve at Lake Keowee contain 8% (430 sales), 8% (463 sales) and 19% (1,037 sales) of all sales within the sample. Table 2 shows the distribution of sales across year. Vacant lots sales occur across all years within the sample with the number of sales per year peaking at 706 in 2005. The number of sales in 2016 is low due to the timing of our data collection procedures.

PUT TABLE 2 HERE

3.2 Straight Line Distance and Buffer Zone Techniques

We begin our pricing impact analysis of power line proximity by employing two common HVTL valuation techniques seen in the literature – buffer zones and straight line distance. The buffer technique captures the price impact of the bundle of goods that nearby HVTLs provide by using one or a series of dummy variables to delineate if a parcel is within a certain distance range of an HVTL. Each dummy variable represents a different buffer zone, and the technique estimates the average price effect for properties within the zone using those parcels located outside of all buffer zones as a control group.

Implementation of the buffer zone technique requires the determination of the appropriate size distance ranges for the classification of parcels. Previous empirical works have found that pricing impact, if found, decays with distance from an HVTL and disappears after 300 feet (Kinnard et al 1997; Colwell 1990; Roddewig and Brigden 2014). We determine the size of the buffers zones by empirically testing different definitions of HVTL distance ranges by assigning each sale to one of a series of different distance-groups from the nearest HVTL. A distance group contains all lot sales that are within the same distance range from the nearest HVTL, and distance groups are defined to be 500-foot and 1,000-foot intervals starting at 0 feet and up to 10,000 feet. For each different distance interval, we then estimate equation (1) by including dummy variables for each distance group as the HVTL measures. After establishing the size of the buffer zone, we then determine if parcels that are directly adjacent to the HVTL right of way experience a more limited price discount relative to other parcels within the buffer zone. In particular, we investigate if parcels adjacent to the HVTL right of way experience a differential price impact relative to other parcels within 1,000 feet of an HVTL. To do so, we classify parcels in the first 1,000-foot buffer zone into those that are adjacent to the HVTL right of way and those that are not. We use the Pickens county parcel map and world imagery layers provided by ESRI's ArcGIS software to visually identify parcels directly adjacent to the HVTL right of way.

As noted by Des Rosiers (2002), the straight line distance technique captures the general behavior pattern of consumers in regards to HVTL proximity by using a transformed distance measure and assumes the price impact is a continuous function of the distance between the parcel and the nearest HVTL. We measure the distance to the nearest HVTL as the straight-line distance from the parcel centroid. In our empirical models, we use a log-transformed measure of distance to allow for non-linear impacts.[iv] Finally, we multiply the transformed distance measure by negative one for ease of comparison with results from the other models.

Panel 1B of Table 1 presents summary statistics for our distance-to-HTVL measures. The average parcel is 6,000 feet from the nearest HVTL; however, the most proximate parcel is within 10 feet while the least proximate parcel is 41,250 feet (approximately 8 miles) away. Approximately 2% of the sample (134 sales) is within 500 feet of an HVTL and 5% of the sample (194 sales) is between 500 and 1000 feet of an HVTL. Together, approximately 6% of the sample (328 sales) of the sample is within 1,000 feet. Within the first 1,000-foot buffer zones, 74 of the 328 sales are directly adjacent to the HVTL right of way.

3.3 : Straight Line Distance and Buffer Zone Techniques

Table 3 reports estimation results for our base and buffer zones models. Model 1A presents estimates from our base specification while Models 1B and 1C present estimates from specifications buffer zones defined by 1,000-foot and 500-foot distance intervals respectively. Model 1D present estimates when the first, 1,000-foot buffer zone is separated into two parts: 1) sales directly adjacent to the HVTL right of way; and 2) sales within 1,000 feet but not directly adjacent to the HVTL right of way. Models 1B – 1D include additional dummy variables for all buffer zones from 1,000 feet and up to 10,000 feet; however, we suppress these coefficients for brevity.[v] The results are available upon request. Finally, Model 1E measures the HVTL price impact by using log-transformed linear distance from the parcel to the nearest HVTL.

PUT TABLE 3 HERE

We find negative and statistically significant results across all four buffer zone models. Model 1B indicates that parcels within 1,000 feet experience a 24.9% decline in sale price, which is equivalent to $48,300 for the average sale.[vi] Model 1C disaggregates the 1,000-foot buffer zone into two 500-foot buffer zones and finds a 33.7% ($65,300) decline in sale price for parcels within 500 feet and an 18.3% ($35,500) decline in sale price for parcels between 500 and 1000 feet. Model 1D disaggregates the 1,000-foot buffer zone into parcels directly adjacent to the right of way and those that are not. The estimation results indicate that parcels adjacent to the right of way experience a 44.9% ($87,000) decline in sale price while parcels within 1,000 feet but not adjacent to the right of way experience at 17.9% ($34,700) decline in sale price. Finally, Model 1E reveals a highly significant negative coefficient of 0.088 when the HVLT proximity measure is the log-transformed linear distance. This coefficient indicates that a 1% increase in HVTL proximity leads to an 8.8% decline in the sale price. To compare the price discount between any two locations, one needs to multiply the estimated coefficient by the difference in the log transformed distances.[vii] For example, consider two lots – A and B – that are otherwise identical except that lot A is located 500 feet from an HVTL while lot B is located 1,000 feet from an HVTL. The estimated sale price difference between lots A and B is -6.1%; that is, lot A's sale price is estimated to be 6.1% lower than lot B's.

Estimates for our control variables are consistent in sign, significance and magnitude across all four models. We find a positive and statistically significant impact of LOT SIZE on sale price, and the results indicate that a one-acre increase in lot size leads to a 26% increase in sale price. However, the impact of lot size increases at a decreasing rate as indicated by the negative and statistically significant coefficient on the SQUARE OF LOT SIZE. We also find positive and statistically significant impacts for NEARBY SALE PRICE. The results indicate that a 1%

increase in NEARBY SALE PRICE leads to a 0.3% increase in the sale price. Both lake and golf amenities received positive price premiums with premiums ranging from 276% for LAKE PROXIMITY with a LAKE VIEW earning a 2.5% price premium. Similarly, the price premium is 51.3% for GOLF PROXIMITY with a GOLF VIEW earning a 1.2% price premium. Each of the three private golf course communities in Pickens County earned price premiums ranging from 74.5% at KEOWEE VINEYARDS to 101.4% at the RESERVE AT LAKE KEOWEE. Two other measures included in our Models are not reported in the final tables – SHORELINE and VIEW ASPECT – as they proved to be statistically insignificant.

Year fixed effects indicate that prices increased until 2006 with modest declines in the next two years. With the advent of the financial crisis, both price and sales volumes declined dramatically. For brevity, we suppress the estimates for buffer zone dummy variables outside of 1000 feet as well as estimates for the tax district, census block group and year fixed effects. We also tested for multicollinearity among the independent variables by examining the variance inflation factors (VIFs). For each estimated model, the VIFs between the independent variables were less than 10 and often less than 2.5; thus, we conclude that there is not collinearity between the independent variables. The adjusted R-squared values indicate that the models explain approximately 72 percent of the variation in sale prices.

4. HVTL View Measures

We now turn our attention to investigating the pricing impact of HVTL suspension tower visibility. We focus on the visibility of HVTL suspension towers for several reasons. First, visual attractiveness is the most cited reason for pricing discounts association with HVTL proximity (Delaney and Timmons 1992). Second, we are able to employ techniques that capture the visibility of HVTL suspension towers from different locations in space. We argue that differences in view quality caused by distance, elevation changes and vegetation induce signification variation in the pricing impact of HVTLs.

4.1 Viewshed Analysis

Our first measure of HVTL suspension tower visibility is a spatial statistic (VIEWSHED) representing if a lot views at least one HVTL suspension tower from any location in the parcel. The spatial statistic is created by using the ArcGIS Viewshed tool, which produces a binary variable indicating if a suspension tower is visible (value of 1) or is not visible (value of 0) from other locations within a specified distance (sight radius) taking into consideration elevation changes, the tower height and the observer's height. We hypothesize that the view of at least one suspension tower degrades view quality, which leads to lower sale prices. To date, we were unable to uncover any academic studies of HVTLs using viewshed analysis, although it has been used in other valuation studies (Hindsley et al. 2013; Shultz and Schmitz 2008).

To create the VIEWSHED variable, we mapped 1,236 HVTL suspension towers within or proximate to Pickens County using the Pipe/Transmission Line digital line file provided by the South Carolina Department of Natural Resources and ERSI's World Imagery Layers. We then applied the ArcGIS Viewshed tool to determine if any location of a parcel viewed at least one HVTL suspension tower. As shown in Panel 1C of Table 1, approximately 7% of the sample, or 363 sales, view at least one HVTL suspension tower within 1,000 feet.

There are three major drawbacks of viewshed analysis. First, viewshed analysis does not measure the degree of visibility of an individual suspension tower. In other words, a suspension tower is either visible or not regardless of the actual visibility of the tower to an observer. The inability of viewshed analysis to quantify the visibility of an individual suspension tower arises since it fails to account for three factors that potentially reduce the visibility of objects: 1) the depth issue – objects farther away are perceived to be smaller; 2) elevation obstructions; and 3) vegetation obstructions. Second, viewshed variables calculated using different sight radii may yield significantly different results; thus, leading to incorrect inference. If the sight radius is set too large, then viewshed analysis may overestimate the number of towers visible. Third, the VIEWSHED variable maybe diluted by obstructed views, and this over-estimation of the visibility of suspension towers leads to an under-estimation of the pricing impact of HVTLs. Finally, the variable ignores differences in visibility across parcels; thus, the estimated coefficient represents the average treatment effects for impacted parcels.

4.2 Tower Visibility Index

To account for the drawbacks of viewshed analysis we construct a new spatial statistic, the TOWER VISIBILITY INDEX (TVI), which represents the percent of a 6-foot observer's view that is obstructed by a nearby 100-foot HVTL suspension tower when the observer is looking directly at the tower.[viii] The TVI has a maximum value of 100, which indicates that the observer's view in the tower's direction is completely obstructed, and a minimum value of 0, which indicates that the tower is not visible to the observer. The TVI is an improvement over viewshed analysis since it quantifies a tower's visibility by taking into consideration elevation change, perceived size, and vegetation. Additionally, the calculation of the TVI does not require some distance interval or radius to be determined; thus, there is no concern of incorrect inference resulting from an incorrect radius being set.

The creation of the TVI requires the use of five spatial data sets: 1) a parcel map; 2) a digital elevation model; 3) the location of HVTL suspension towers; 4) the 2006 National Land Cover Dataset (NCLD); and 5) The Landfire dataset. We discussed the first three datasets in previous sections. We obtained the 2006 National Land Cover Dataset (NLCD) and the Landfire data from United States Geological Survey.[ix,x] We use the NLCD to identify points in space that have vegetation and we use the Landfire data to determine vegetation height those points.[xi,xii]

We overlay the study area with a grid of points 100 feet apart and join each grid point to the other spatial data sets through spatial processes. Each parcel is assigned $t = 1, \ldots, n_{i1}$ grid points and has $w = 1, \ldots, n_{i2}$ nearby HVTL suspension towers. We only calculate the TVI for towers with 6,660 feet of a parcel since beyond that threshold the value of the TVI is reduced below 0.01. If we let x_{itw} represent value of the TVI for observer point t of tower w in parcel i, then a parcel's aggregated TVI can be set to some function of x_{itw} for all observer point-tower combinations within the parcel. For simplicity, we set parcel i's aggregated TVI to be the maximum of all the x_{itw}'s within the parcel.

The following discussion focuses on the strategy to calculate a TVI for a single observer point-tower combination. First, identify points along the observer-tower line, which is a straight line starting at the observer's point and ending at the base of the suspension tower. We assume that any point that is within 50 feet of the observer-tower line potentially influences the observer's view of the tower. Second, calculate the tower's unobstructed visibility given the distance between the observer and the tower. Third, reduce the tower's visibility by the portion of the tower blocked by any elevation changes along the observer-tower line. Finally, reduce the tower's visibility by vegetated points.

The formula to calculate the TVI is shown in equation (2).

$$TVI = 100 * \left(\frac{\theta}{\theta^*}\right) * \left(\frac{x_2}{100}\right) * \sum_{l=1}^{h} \left(\frac{y_l}{x_2} * (1-\delta)^{z_l}\right) \qquad (2)$$

In equation (2), θ is the angle between the observer and the top of the suspension tower and θ^* is the angle between the base of the tower and a vertical line at the observer's point. We calculate θ using the inverse tangent function so that θ depends on the suspension tower's height and the length of the observer-tower line; thus, as the length of the observer-tower line increases, θ decreases. We assume that the suspension tower's height is 100 feet and can be divided into two components: 1) the portion that is blocked by the maximum elevation change (assumed to have length x_1); and 2) the unblocked portion (assumed to have length x_2). We also assume that the unblocked portion of the tower is divided into h segments indexed by l. Each segment has a length of y_l and is obscured by z_l vegetated points. Finally, the visibility reduction factor, which measures how much visibility is reduced by a vegetated point, is δ.

Equation (2) consists of four separate terms multiplied together. Initially, the TVI is set to a value of 100 before being (potentially) reduced by three factors. First, the value is reduced to reflect the perceived height given the distance between the observer and the tower. This reduction is carried out by multiplying the TVI by the percentage of the view obstructed by tower, θ/θ^*. Second, the TVI is reduced by a factor of $x_2/100$, which reduces the magnitude by the percent of the tower that is not visible due to the maximum elevation change along the observer-tower line. Finally, the TVI is reduced to take into consideration reduced visibility due to vegetation. The still visible portion of the tower is divided into smaller segments (y_i's), each of which is blocked by a different number of vegetated points. The visibility of each y_i is then reduced by the one minus the visibility reduction factor, δ, raised to the number of vegetated points (z_i) the observer views that tower segment through.

Panels 2A and 2B of Figure 2 illustrate the process to calculate the TVI. In Panel 2A, there are two points between the observer and the tower, Points 1 and 2, that potentially influence the observer's view since they are within 50 feet of the observer-tower line. Panel 2B illustrates the calculation of the TVI. Assume that the observer is located 100 feet from the tower and that the observer and the tower have the same elevation. The angle to the top of the tower, θ, is then 45 degrees and the angle between the tower base and a vertical line at the observer's point is 90 degrees. Point 1 contains a hill that blocks 30 feet of the suspension tower's height and Point 2 is vegetated so that the visibility of the remaining 70 feet is reduced by a factor of δ, which we assume to be 25%. In this case, the TVI is shown in equation (3).

$$TVI = 100 * \frac{45}{90} * \frac{70}{100} * \left(\frac{70}{70}\right) * (1 - 0.25) = 26.25 \qquad (3)$$

Thus, the tower blocks 26.25 percent of the observer's view.

PUT FIGURE 2 HERE

The TVI formula in equation (2) reveals factors that potentially eliminate an observer's view of a suspension tower. First, the observer may be sufficiently far away from the tower such that the tower takes up an insignificant portion of the view; in other words, $\theta/\theta^* \to 0$. Second, the entire tower may be blocked by the maximum elevation change; thus, $x_2/100 = 0$. This situation may arise if a parcel and tower are in close proximity but on opposite sides of a tall hill. Finally, the portion of the tower above the maximum elevation change is viewed through a sufficient number of vegetated points such that the tower is no longer visible; i.e., $\sum_{l=1}^{h}\left(\frac{y_l}{x_2} * (1-\delta)^{z_l}\right) \to 0$.

Figure 3 displays the TVI for The Highlands on Lake Keowee neighborhood using four nearby HVTL suspension towers. Panels 4A and 4B of Figure 4 display a suspension tower and the corresponding TOWER VISIBILITY INDEX value as measured from different observer points. Each panel in Figure 4 corresponds to the indicated point in Figure 3. Panel 1C of Table 1 displays summary statistics for TVI variable assuming the visibility reduction factor is 25%.[xiii] For the average parcel, 1.09 percent of the view is obstructed by the most visually intrusive HVTL suspension tower. The statistics indicate that there is a wide dispersion of visibility obstruction, ranging from 0 to 65 percent of the view in a particular direction.

PUT FIGURE 3 AND 4 HERE

4.3 Visibility Regression Results

Table 4 present regression results from our models employing the HVTL suspension tower visibility measures. Model 2A displays estimates when suspension tower visibility is measured using viewshed analysis restricted to 1,000 feet, while Model 2B presents estimates when using the tower visibility index with a visibility reduction factor of 25% to capture the visibility of nearby suspension towers. Model 2C includes a categorical variable, which splits the TVI into bins with value ranges of: 1) 0 to 1; 2) 1 to 10; 3) 10 to 20; and 4) greater than 20. We include Model 2C to test for monotonic ordering in the pricing effect. Finally, Model 2D displays estimates using the TVI as the visibility measure with the sample data restricted to only the subset of parcels that view at least one HVTL suspension tower. We include Model 2D to demonstrate that there is signification variation in the view quality for sales that view at least one tower (and by extension variation in the level of the pricing discount for sales within the 1,000-foot buffer zone).

The results in Table 4 provide evidence that HVTL suspension tower visibility have a negative and statistically significant pricing impact of vacant lot sale prices. The estimate for the viewshed variable in Model 2A indicates that a visible suspension tower reduces sale price by 22.1%, which is approximately $42,800 at the mean sale price. Model 2B present estimates using the TVI with visibility reduction factor of 25% as the suspension tower visibility measure. The magnitude of the coefficients indicates that a 1% increase in the TOWER VISBILITY INDEX leads to a 1.6% decline in sale price. In other words, a 1% reduction in view quality reduces sale price by $3,100. Translating Model 2B's regression results to the index value in Panels 4A and 4B of Figure 4 yield a pricing discount of 30% for Panel 4A and a pricing discount of 7.5% for Panel 4B.

Results from Model 2C indicate that there a monotonic ordering in the pricing discount associated with HVTL suspension tower visibility. In particular, the estimated magnitude of the pricing discount increases as the TVI increase. The results indicate that vacant lots with a TVI value between 1 and 10 experience a 9.9% price discount, lots with a TVI value between 10 and 20 experience 27.8% price discount, and lots with a TVI value greater than 20 experience of price discount of 51.6%. Results from Model 2D for the set of 363 lot sales that view at least one tower, the estimate for the TVI is negative and statistically significant indicating that there is significant variation in pricing discount arising from different view qualities. If this were not true, then the estimated TVI coefficient would not be statistically different from zero.

PUT TABLE 4 HERE

5. A Comparison on the Four Valuation Methods

The four methods of valuing the impact of HVTLs reveal the potential for wide pricing differences according to the technique utilized. To demonstrate this, we zoom in on the Highlands on Lake Keowee neighborhood, to present a granular representation of the four different pricing methodologies. We select the Highlands on Lake Keowee neighborhood due to the close proximity of properties within the neighborhood to four HVTL suspension towers. Figure 5 displays the estimated price reductions for the parcels within the neighborhood based on the four methodologies utilized in the paper. Panel 5A displays estimated price reductions using a 1,000–foot buffer zone, Panel 5B displays estimates from the straight line distance technique, and Panel 5C displays estimates from viewshed analysis. Finally, Panel 5D displays price discounts based on tower visibility.

PUT FIGURE 5 HERE

A comparison between the four panels of Figure 5 reveals the methodological concern(s) of the different techniques. Estimating the effect of HVTL proximity using a buffer zone (Panel 5A) or viewshed analysis (Panel 5C) produces the average price discount for all impacted parcels using those not impacted as the control group. Both of these techniques ignore variation in the pricing impact inside and outside of the impacted parcels. Our results indicate that lots within 1,000 feet experience a 24.9% decline in sale price and lots with a view of at least one HVTL tower experience at 22% price decline. Under both techniques above, the price impact for non-impacted lots is not statistically significant than zero. The straight line distance methodology (Panel 5B) reveals a pricing impact that varies within the 1,000-foot buffer zone and a pricing impact that extends far beyond the 1,000-foot buffer zone. This result demonstrates one of the pitfalls of the straight line distance technique as it is assigning a price effect when one may not be present. A second problem of the straight line distance technique is that the estimated coefficient may diluted by obstructed views resulting in an underestimation of the pricing impact of HVTLs.

Panel 5D displays the sale price impact derived from the TOWER VISIBILITY INDEX result, Similar to the straight line distance technique, the TVI allows for pricing variation within and outside of the 1,000-foot buffer zone. Panel 5D shows that a smaller number of parcels have an estimated price impact of greater than 20% and that the majority of the parcels experience a price discount between 1 and 10 percent. The panel also reveals significant variation in the estimated price discount inside and outside the 1,000-foot buffer zone. The estimated impact falls off considerably as distance to the HVTL towers grows confirming the importance of measuring both proximity and visibility of HVTL towers. The TOWER VISIBLITY INDEX methodology is not without its own pitfalls since it is computationally intensive and requires access to advanced GIS software.

6. Conclusion

Survey respondents suggest there are three reasons that HVTLs have a negative impact on property prices: visual disamenity, noise disturbances and health concerns. We employ four different techniques on a countywide sample of over 5,000 vacant lots – binary proximity variables, straight line distance, viewshed analysis and tower visibility. In each case, this study confirms our hypothesis that pricing discounts for proximity and/or a view of HVTL suspension towers can be substantive. However, each technique alone has its drawbacks. Neither buffer zone variables nor straight line distance techniques can identify properties with the view disamenity. Thus, we use two different tools to model the visual disamenity – viewshed analysis and tower visibility. We contend that viewshed analysis is a weaker diagnostic tool as it indicates which properties have line of sight of power lines, but does not account for the decay of view with distance or the possibility that visual obstructions such as trees or building structures may impede the view disamenity. Consequently, we offer a new GIS-based spatial statistic – TOWER VISIBILITY INDEX – that measures the line of sight visibility of HVTL suspension towers from impacted lots. The TVI variable accounts for the visual obstruction provided by trees and the decay in the quality of view with distance. Our findings indicate that HVTL suspension towers provide a measurable view disamenity that should be accounted for in the valuation of impacted properties. The TVI variable estimates a price discount of 51.6% for lots with a TVI value greater than 20 experience; further, a 1% reduction in view quality reduces the marginal sale price by 1.6% ($3,100).

Our research finds evidence that both proximity and view corridors matter. We find for our study area a substantive pricing discount (of 44.9%) is imposed for residential vacant lots adjacent to HVTLs, and likewise that unobstructed visibility of proximate HVTL towers is associated with substantive marginal pricing discounts. If our findings are replicated in future studies, then this contrasts with earlier studies of power lines (Chalmers and Voorwart 2009; Cowger et al 1996; Kinnard et al 1997; Kinnard et al 1989; etc.), that found minimal or no pricing discounts for proximate properties. We hypothesize three reasons. First, developers provide countervailing positive amenities such as ROWs, landscaped gardens, accessible amenities or larger lots that may reduce the level of pricing discount. For example, our study found that the average lot size of properties directly adjacent to power lines was over 3 acres compared to 1.55 acres for non-adjacent properties. We suspect that neighborhood developers have an intuitive understanding of the substantive pricing discounts associated with the HVTL disamenity when they engage in the costly practice of interring power lines. Second, early studies frequently relied on techniques using binary proximity variables and/or distance due to computational ease. However, as described above each suffers from the possibility of measurement error as neither explicitly models the view disamenity. For example, distance variables cannot accurately model two lots 300 feet away from power lines, where only one suffers from a power line view. Another tool – viewshed analysis – suffers from a similar inability to differentiate quality of view as viewshed does not decay with distance. The technique we develop and employ in this paper, the TOWER VISIBILITY INDEX, provides an alternative methodology that captures the decay of pricing associated with distance from the view disamenity. Thus, when measuring spatial amenities it is important to create measures that accurately capture the value of the amenity at different points in space and take into consideration obstructions between the point and the source of the disamenity. A third potential problem is the use of small neighborhood sample sets in earlier studies (Mitchell and Kinnard 1996; Colwell and Foley 1979; Colwell 1990). The use of countywide data in our sample that specifically includes outliers (eliminated in studies such as Sims and Dent, 2005) potentially provides a more statistically accurate generalization of the influence of power lines and suspension towers.

Our findings of substantive pricing discounts due to proximity of HVTLs and TOWER VISIBILITY are site specific to this study, and we caution that pricing discounts for vacant properties in our rural setting may not be generalizable to complex suburban settings. We focus on vacant lot sales; the addition of residential housing structures may proportionally diminish the pricing impact of HVTLs on overall property value. Nevertheless, the scale of HVTL pricing discounts found in our study suggests that future studies of residential property may consider applying geospatial techniques to help investigate the complex pricing phenomenon associated with power line disamenities.

End Notes

[i] For example, if land composed 20% of housing costs, then the multiple would be five times – in this case, a 6% pricing discount for housing sales may be equivalent to a 30% pricing discount for vacant land sales. Adding further complexity to this issue is the influence of land leverage (land as a proportion of total property value) across different communities. As the degree of land leverage increases, the greater the pricing impact on total property value, all else equal.

[ii] We did not screen our sales by sale price or sale price per acre. To test if the results are robust to the presence of outliers, we restricted the sample by excluding sales where the sale price per acre is below the 5% percentile ($5800) or above the 95% percentile ($702,000). We also ran the main specifications on a restricted sample that excludes sales if the sale price per acre was below $1,000 or above $1,000,000. We determine the second set of cutoff criteria by interviewing a licensed appraiser in Pickens County. The robustness tests show that our results are robust to excluding sales based on the cutoff criteria above and therefore we conclude that outliers are not biasing the results.

[iii] We adjusted sales prices using the CPI calculator provided by the Bureau of Labor Statistics.

[iv] We tested various transformations of linear distance including no transformation, inverse distance, and inverse-distance squared. We also tested a specification that included a binary variable for HVTL adjacency and untransformed distance. We chose to use a log-transformed since it yielded the best fit statistics. These results are available upon request.

[v] We created alternative buffer interval models including: (1) 100-foot buffer intervals; and (2) 250-foot buffer intervals. The 100-foot and 250-foot intervals also indicated a decay of impact with distance and the loss of significance beyond 1,000 feet. The results are available upon request.

[vi] For a semilog functional form, we can calculate the percent impact for dummy variables using the formula $100*(e^{\beta} - 1)$ where β is the coefficient for that variable (Halvorsen and Palmquist 1980).

[vii] The formula to calculate the estimated price difference between two lots – A and B – that are located at distances of D_A and D_B away from the HVTL is as follows: $(Est.Coefficient) * (\ln(D_A) - \ln(D_B))$

[viii] Defining the TVI in this manner allows an obstructed view in one direction, but an unobstructed view in another direction.

[ix] The 2006 National Land Cover Data set was retrieved from http://www.mrlc.gov/nlcd2006.php .

[x] We use the 2008 data to extract average canopy height. Landfire data retrieved from http://landfire.cr.uss.gov/viewer .

[xi] A point contains vegetation if its NCLD classification is 41, 42, 43 or 90

[xii] We use five canopy heights: 0 feet, 8.2 feet, 24.6 feet, 57.4 feet and 123 feet.

[xiii] We also run models using visibility reduction factors of 50%, 75% and 90%. In each situation, the models yield results that are consistent in sign, significance and magnitude. These results are available upon request.

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Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max	Note
Panel 1A: Summary Statistics for Base Variables					
Inflation Adjusted Sale Price	193,863	281,941	100	2,497,387	2016 Dollars
Nearby Sale Price	209,461	222,333	963	2,074,230	2016 Dollars
Lot Size	1.57	1.61	0.25	19.30	Acres
Slope	21.11	12.14	2.20	67.47	Mean percent change in elevation
Shore Line	0.06	0.14	0	4.42	Thousands of Feet
Golf View	48	102	0	748	Thousands of Square Feet
Lake View	243	498	0	4161	Thousands of Square Feet
Aspect	182	67	21	334	Mean direction of slope, in degrees
Lake Proximity	0.23		0	1	Indicates if within 100 feet of a lake
Golf Proximity	0.07		0	1	Within 100 feet of a golf course
Cliffs at Keowee Springs	0.08		0	1	Within Cliffs at Keowee Springs neighborhood
Keowee Vineyards	0.08		0	1	Within Keowee Vineyards neighborhood
Reserve at Lake Keowee	0.19		0	1	Within the Reserve at Lake Keowee neighborhood
Panel 1B: Summary Statistics for HVTL Distance Measures					
Distance to HVTL	5.90	3.82	0.01	41.25	Thousands of Feet
Within 500 Feet of an HVTL	0.02		0	1	134 Sales
Between 500 and 1000 Feet on an HVTL	0.05		0	1	194 Sales
Within 1000 Feet of an HVTL	0.06		0	1	328 Sales
Adjacent to HVTL ROW	0.01		0	1	74 Sales
Within 1000 Feet but not adjacent to an HVTL	0.05		0	1	254 Sales
Panel 1C: Summary Statistics for HVTL Visibility Measures					
Viewshed, 1000 Feet	0.07		0	1	363 Sales
Tower Visibility Index (TVI)	1.09	4.13	0	64.95	Percent of View Blocked
Tower Visibility Index for Parcels that view at least one HTVL suspension tower	10.54	12.40	0	65.95	Percent of View Blocked

Table 2: Vacant Sales by Year

Year	Number of Sales	Percent of Sample
2000	462	8.5
2001	392	7.2
2002	429	7.9
2003	405	7.4
2004	564	10.3
2005	706	12.9
2006	455	8.3
2007	370	6.8
2008	238	4.4
2009	201	3.7
2010	203	3.7
2011	168	3.1
2012	180	3.3
2013	213	3.9
2014	224	4.1
2015	218	4
2016	27	0.5
	5,455	100

Table 3 Regression Results – Straight Line Distance and Buffer Zone Techniques

Dependent Variable: ln(Inflation Adjusted Sale Price, 2016 Dollars)					
	Model 1A	Model 1B	Model 1C	Model 1D	Model 1E
Variables	Base Model	1000 Feet	500 Feet	Adjacent and 1000 Feet	Straight Line Distance
Within 1000 Feet		**-0.286****			
		(0.114)			
With 500 Feet			**-0.410*****		
			(0.151)		
Between 500 and 1000 Feet			**-0.202***		
			(0.102)		
Adjacent to HVTL				**-0.595*****	
				(0.127)	
Within 1000 Feet, Not Adjacent				**-0.197***	
				(0.113)	
Distance					**-0.0882****
					(0.0407)
Nearby Sale Price	0.288***	0.282***	0.283***	0.284***	0.286***
	(0.0477)	(0.0479)	(0.0472)	(0.0478)	(0.0468)
Lot Size	0.254***	0.265***	0.264***	0.268***	0.263***
	(0.0431)	(0.0457)	(0.0458)	(0.0446)	(0.0454)
Square of Lot Size	-0.0116***	-0.0123***	-0.0122***	-0.0124***	-0.0121***
	(0.00199)	(0.00204)	(0.00201)	(0.00203)	(0.00198)
Slope	-0.00638***	-0.00650***	-0.00654***	-0.00647***	-0.00649***
	(0.00201)	(0.00209)	(0.00205)	(0.00206)	(0.00198)
Golf View	0.0115***	0.0108***	0.0108***	0.0105***	0.0107***
	(0.00385)	(0.00355)	(0.00353)	(0.00357)	(0.00355)
Lake View	0.0245*	0.0215*	0.0219*	0.0222*	0.0218*
	(0.0130)	(0.0128)	(0.0121)	(0.0130)	(0.0126)
Golf Proximity	0.414***	0.403***	0.410***	0.405***	0.390***
	(0.0329)	(0.0275)	(0.0289)	(0.0271)	(0.0314)
Lake Proximity	1.325***	1.312***	1.312***	1.302***	1.322***
	(0.128)	(0.120)	(0.122)	(0.119)	(0.116)
Cliffs at Keowee Springs	0.583***	0.652***	0.645***	0.663***	0.615***
	(0.0767)	(0.0951)	(0.0979)	(0.0919)	(0.0905)
Keowee Vineyards	0.557***	0.507**	0.496**	0.467**	0.538**
	(0.208)	(0.228)	(0.221)	(0.217)	(0.213)
Reserve at Lake Keowee	0.700***	0.662***	0.665***	0.664***	0.651***
	(0.0646)	(0.0413)	(0.0396)	(0.0426)	(0.0443)
2000	0.603*	0.636*	0.644*	0.637*	0.612*
	(0.321)	(0.322)	(0.331)	(0.323)	(0.312)
2001	0.603	0.638*	0.648*	0.642*	0.614*
	(0.372)	(0.375)	(0.383)	(0.376)	(0.364)
2002	0.572	0.609*	0.619*	0.612*	0.583*

	(0.355)	(0.352)	(0.360)	(0.354)	(0.347)
2003	0.665*	0.699*	0.709*	0.701*	0.676*
	(0.385)	(0.386)	(0.392)	(0.386)	(0.378)
2004	0.679*	0.721**	0.733**	0.725**	0.689**
	(0.343)	(0.346)	(0.354)	(0.348)	(0.338)
2005	0.757*	0.801**	0.811**	0.802**	0.777**
	(0.384)	(0.382)	(0.389)	(0.383)	(0.375)
2006	0.781**	0.819**	0.828**	0.820**	0.796**
	(0.383)	(0.382)	(0.389)	(0.384)	(0.375)
2007	0.739**	0.777**	0.786**	0.781**	0.748**
	(0.362)	(0.363)	(0.371)	(0.364)	(0.356)
2008	0.725*	0.761**	0.770**	0.759**	0.733*
	(0.376)	(0.372)	(0.383)	(0.374)	(0.370)
2009	0.502	0.542	0.548	0.540	0.512
	(0.358)	(0.356)	(0.364)	(0.357)	(0.352)
2010	0.133	0.176	0.189	0.183	0.152
	(0.421)	(0.414)	(0.422)	(0.414)	(0.408)
2011	0.0545	0.0832	0.0941	0.0856	0.0609
	(0.338)	(0.336)	(0.345)	(0.338)	(0.334)
2012	-0.0638	-0.0171	-0.00712	-0.0189	-0.0483
	(0.275)	(0.271)	(0.282)	(0.273)	(0.267)
2013	-0.163	-0.124	-0.112	-0.122	-0.152
	(0.366)	(0.364)	(0.369)	(0.367)	(0.355)
2014	-0.114	-0.0736	-0.0638	-0.0700	-0.0983
	(0.311)	(0.305)	(0.312)	(0.308)	(0.300)
2015	0.0199	0.0575	0.0654	0.0581	0.0337
	(0.250)	(0.246)	(0.253)	(0.246)	(0.243)
Constant	8.201***	8.219***	8.204***	8.200***	7.379***
	(0.681)	(0.670)	(0.671)	(0.672)	(0.569)
Observations	5,455	5,455	5,455	5,455	5,455
R-squared	0.722	0.724	0.724	0.724	0.723
Adjusted R-squared	0.715	0.717	0.717	0.717	0.717

Cluster robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; All specifications include controls for lake frontage and fixed effects for direction of view, tax district, and block group. Models (2) and (4) contain additional dummy variables starting at 1,000 feet and ending at 10,000 feet defined by 1,000 foot intervals. Model (3) contains additional dummy variables starting at 1,000 feet and ending at 10,000 feet defined by 500 foot intervals.

Table 4: HVTL Suspension Tower Visibility Measures

Dependent Variable: ln(Inflation Adjusted Sale Price, 2016 Dollars)				
	Model 2A	Model 2B	Model 2C	Model 2D
Variables	All Parcels	All Parcels	All Parcels	Parcels with a view of at least 1 tower
Viewshed	**-0.249****			
	(0.111)			
TVI		**-0.0160*****		**-0.0133*****
		(0.00526)		**(0.00471)**
TVI between 0 and 1			**-0.0626**	
			(0.0392)	
TVI between 1 and 10			**-0.104****	
			(0.0496)	
TVI between 10 and 20			**-0.326*****	
			(0.105)	
TVI greater than 20			**-0.725*****	
			(0.186)	
Nearby Sale Price	0.284***	0.287***	0.288***	0.135*
	(0.0470)	(0.0466)	(0.0467)	(0.0781)
Lot Size	0.262***	0.261***	0.265***	0.264***
	(0.0450)	(0.0429)	(0.0438)	(0.0793)
Square of Lot Size	-0.0120***	-0.0118***	-0.0120***	-0.0117
	(0.00199)	(0.00198)	(0.00195)	(0.00802)
Slope	-0.00661***	-0.00652***	-0.00649***	-0.000715
	(0.00199)	(0.00197)	(0.00202)	(0.00820)
Golf View	0.0114***	0.0111***	0.0105***	0.0142
	(0.00364)	(0.00370)	(0.00376)	(0.0147)
Lake View	0.0218	0.0242*	0.0243**	0.0266**
	(0.0132)	(0.0126)	(0.0122)	(0.0129)
Golf Proximity	0.414***	0.413***	0.403***	0.728***
	(0.0275)	(0.0300)	(0.0309)	(0.215)
Lake Proximity	1.325***	1.307***	1.308***	1.590***
	(0.118)	(0.111)	(0.116)	(0.204)
Cliffs at Keowee Springs	0.597***	0.611***	0.649***	1.476***
	(0.0828)	(0.0798)	(0.0930)	(0.334)
Keowee Vineyards	0.523**	0.426**	0.463**	0.709***
	(0.201)	(0.189)	(0.201)	(0.253)
Reserve at Lake Keowee	0.666***	0.682***	0.676***	
	(0.0509)	(0.0613)	(0.0554)	
Constant	8.224***	8.192***	8.177***	6.594***
	(0.661)	(0.664)	(0.661)	(0.941)
Observations	5,455	5,455	5,455	363
R-squared	0.723	0.723	0.724	0.496

Adjusted R-squared	0.717	0.717	0.717	0.444

Cluster robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$; All specifications include controls for lake frontage and fixed effects for direction of view, tax district, block group and sale year.

Figure 1: Pickens County, South Carolina and Selected Features

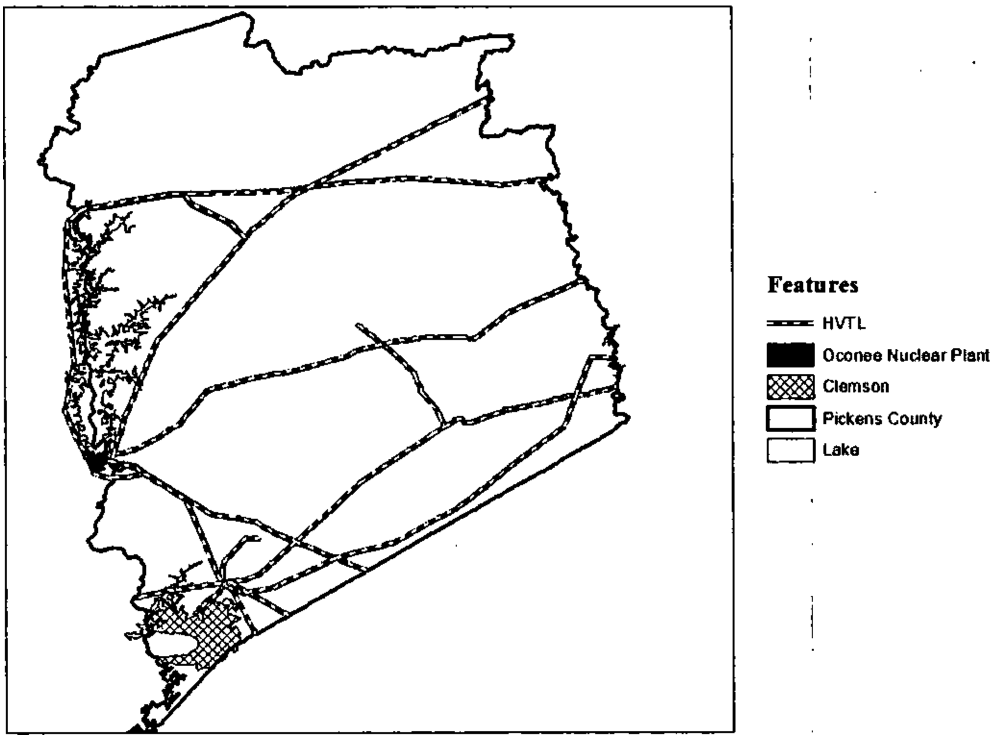
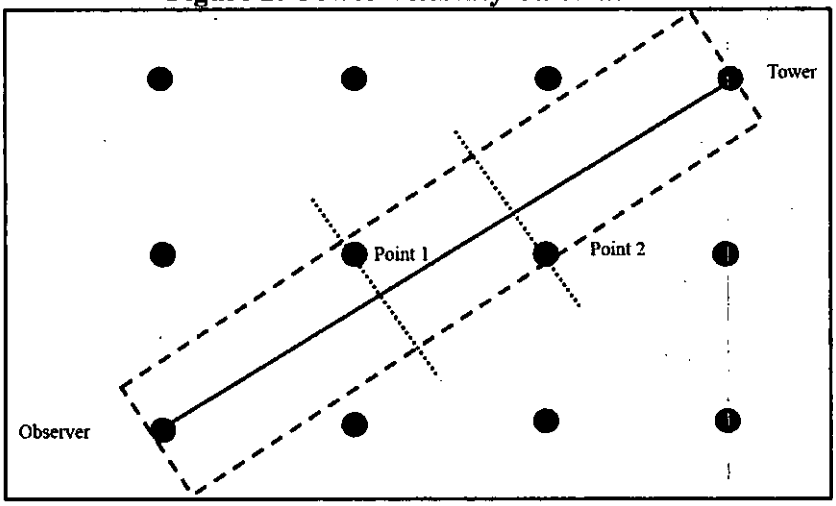
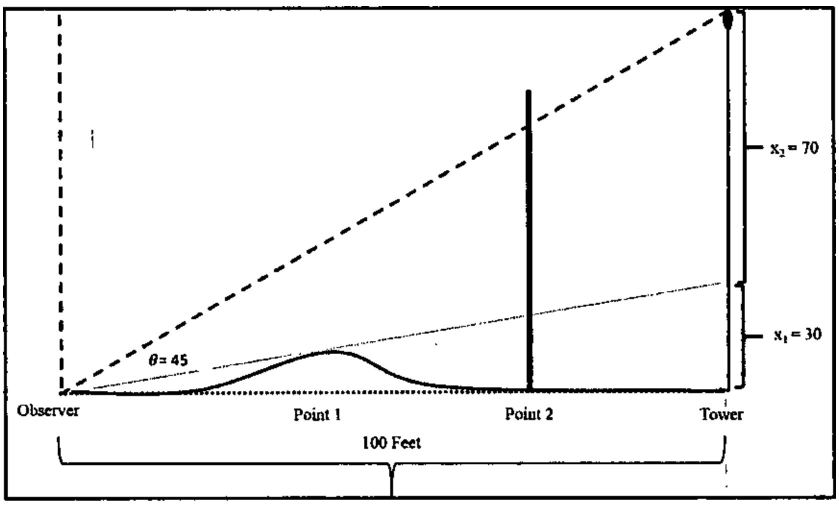


Figure 2: Tower Visibility Calculation



Panel 2A: Sight Path



Panel 2B: TVI Calculation

Panel 2A illustrates points that may influence an observer's view of a suspension tower. The solid line represents the straight line between the observer and the tower, dots represents grid points, the dotted lines through Points 1 and 2 represent view obstructions at those points, and the dashed box indicates grid points that may influence the observer's view of the tower. Panel 2B illustrates the calculation of the TVI using Points 1 and 2. We assume that the tower is 100 feet in height and that the observer is 100 feet from the tower; thus, the angle between the observer and the top of the tower, θ, is 45 degrees. We also assume that the observer and the tower have the same elevation; thus, the angle between the tower base and a vertical line at the observer point, θ^*, is 90 degrees. Point 1 contains the highest elevation along the observer-tower line, which blocks 30 feet of the tower's height (x_1), and Point 2 contains vegetation, which obscures the remaining 70 feet of the tower's height (x_2). Assuming the visibility reduction factor is 25%, the TVI is 26.25.

Figure 3: Tower Visibility Index

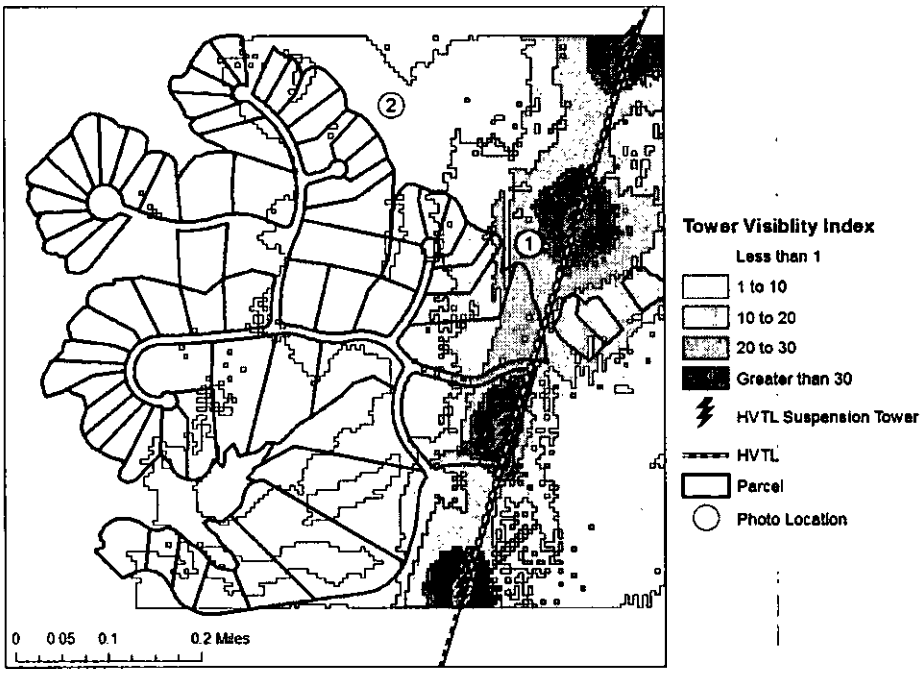
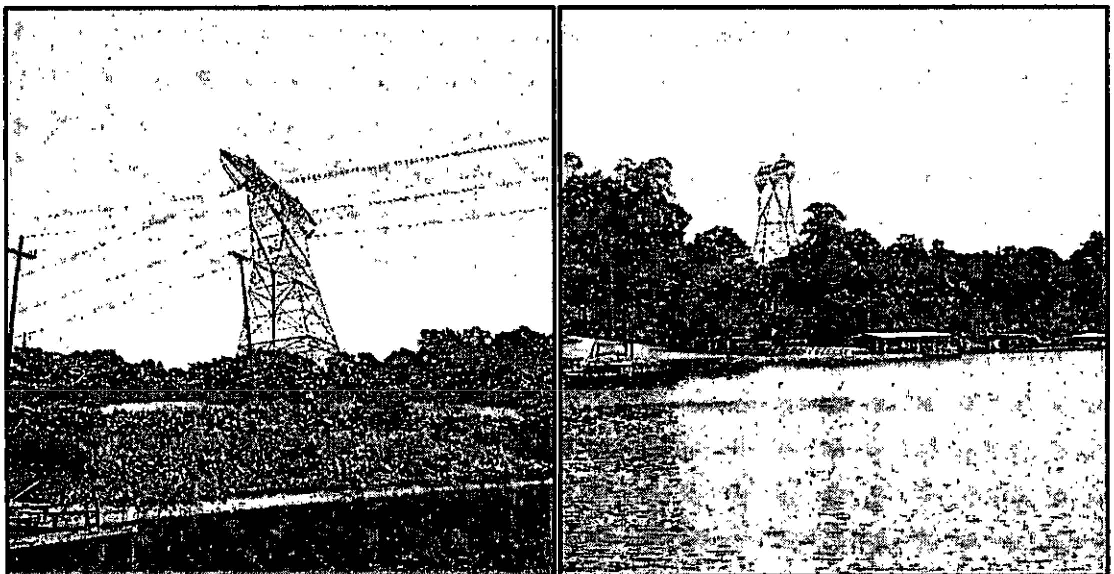
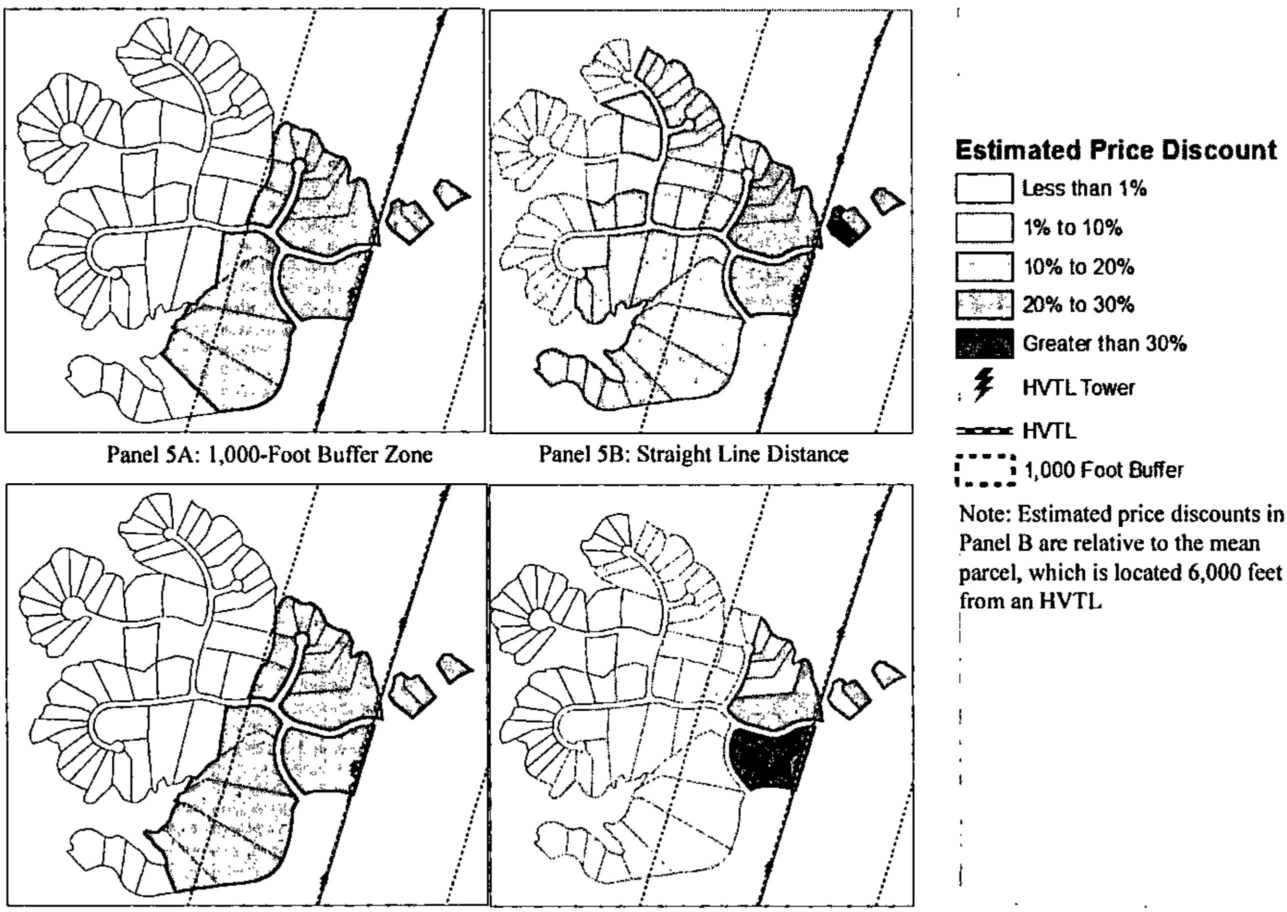


Figure 4: Tower Visibility Examples



Panel A: Photo 1	Panel B: Photo 2
Tower Visibility Index : 18.3	Tower Visibility Index : 4.7
Distance to Tower: 280 Feet	Distance to Tower: 1,250 Feet

Figure 5: A Comparison on Valuation Techniques



Note: Estimated price discounts in Panel B are relative to the mean parcel, which is located 6,000 feet from an HVTL

BOG TURTLE CONSERVATION ZONES[1]

(revised April 18, 2001)

Projects in and adjacent to bog turtle habitat can cause habitat destruction, degradation and fragmentation. Of critical importance is evaluating the potential direct and indirect effects of activities that occur in or are proposed for upland areas adjacent to bog turtle habitat. Even if the wetland impacts from an activity are avoided (i.e., the activity does not result in encroachment into the wetland), activities in adjacent upland areas can seriously compromise wetland habitat quality, fragment travel corridors, and alter wetland hydrology, thereby adversely affecting bog turtles.

The following bog turtle conservation zones have been designated with the intent of protecting and recovering known bog turtle populations within the northern range of this species. The conservation suggestions for each zone are meant to guide the evaluation of activities that may affect high-potential bog turtle habitat, potential travel corridors, and adjacent upland habitat that may serve to buffer bog turtles from indirect effects. *Nevertheless, it is important to recognize that consultations and project reviews will continue to be conducted on a case-by-case basis, taking into account site- and project-specific characteristics.*

<u>*Zone 1*</u>

This zone includes the wetland and visible spring seeps occupied by bog turtles. Bog turtles rely upon different portions of the wetland at different times of year to fulfill various needs; therefore, this zone includes the entire wetland (the delineation of which will be scientifically based), not just those portions that have been identified as, or appear to be, optimal for nesting, basking or hibernating. In this zone, bog turtles and their habitat are most vulnerable to disturbance, therefore, the greatest degree of protection is necessary.

Within this zone, the following activities are likely to result in habitat destruction or degradation and should be avoided. These activities (not in priority order) include:

< development (e.g., roads, sewer lines, utility lines, storm water or sedimentation basins, residences, driveways, parking lots, and other structures)
< wetland draining, ditching, tiling, filling, excavation, stream diversion and construction of impoundments
< heavy grazing
< herbicide, pesticide or fertilizer application[2]
< mowing or cutting of vegetation[2]
< mining
< delineation of lot lines (e.g., for development, even if the proposed building or structure will not be in the wetland)

Some activities within this zone may be compatible with bog turtle conservation but warrant careful evaluation on a case-by-case basis:

< light to moderate grazing
< non-motorized recreational use (e.g., hiking, hunting, fishing)

Zone 2

The boundary of this zone extends *at least 300 feet* from the edge of Zone 1 and includes upland areas adjacent to Zone 1. Activities in this zone could indirectly destroy or degrade wetland habitat over the short or long-term, thereby adversely affecting bog turtles. In addition, activities in this zone have the potential to cut off travel corridors between wetlands occupied or likely to be occupied by bog turtles, thereby isolating or dividing populations and increasing the risk of turtles being killed while attempting to disperse. Some of the indirect effects to wetlands resulting from activities in the adjacent uplands include: changes in hydrology (e.g., from roads, detention basins, irrigation, increases in impervious surfaces, sand and gravel mining); degradation of water quality (e.g., due to herbicides, pesticides, oil and salt from various sources including roads, agricultural fields, parking lots and residential developments); acceleration of succession (e.g., from fertilizer runoff); and introduction of exotic plants (e.g., due to soil disturbance and roads). This zone acts as a filter and buffer, preventing or minimizing the effects of land-use activities on bog turtles and their habitat. This zone is also likely to include at least a portion of the groundwater recharge/supply area for the wetland.

Activities that should be avoided in this zone due to their potential for adverse effects to bog turtles and their habitat include:

< development (e.g., roads, sewer lines, utility lines, storm water or sedimentation basins, residences, driveways, parking lots, and other structures)
< mining
< herbicide application[2]
< pesticide or fertilizer application
< farming (with the exception of light to moderate grazing - see below)
< certain types of stream-bank stabilization techniques (e.g., rip-rapping)
< delineation of lot lines (e.g., for development, even if the proposed building or structure will not be in the wetland)

Careful evaluation of proposed activities on a case-by-case basis will reveal the manner in which, and degree to which activities in this zone would affect bog turtles and their habitat. Assuming impacts within Zone 1 have been avoided, evaluation of proposed activities within Zone 2 will often require an assessment of anticipated impacts on wetland hydrology, water quality, and habitat continuity.

Activities that are likely to be compatible with bog turtle conservation, but that should be evaluated on a case-by-case basis within this zone include:

< light to moderate grazing
< non-motorized recreational use (e.g., hiking, hunting, fishing)
< mowing or cutting of vegetation

Zone 3

This zone includes upland, wetland, and riparian areas extending either to the geomorphic edge of the drainage basin or at least one-half mile beyond the boundary of Zone 2. Despite the distance from Zone 1, activities in these areas have the potential to adversely affect bog turtles and their habitat. This particularly applies to activities affecting wetlands or streams connected to or contiguous with Zone 1, because these areas may support undocumented occurrences of bog turtles and/or provide travel corridors. In addition, some activities (e.g., roads, groundwater withdrawal, water/stream diversions, mining, impoundments, dams, "pump-and-treat" activities) far beyond Zone 1 have the potential to alter the hydrology of bog turtle habitat, therefore, another purpose of Zone 3 is to protect the ground and surface water recharge zones for bog turtle wetlands. Where the integrity of Zone 2 has been compromised (e.g., through increases in impervious surfaces, heavy grazing, channelization of stormwater runoff), there is also a higher risk of activities in Zone 3 altering the water chemistry of bog turtle wetlands (e.g., via nutrient loading, sedimentation, and contaminants).

Activities occurring in this zone should be carefully assessed in consultation with the Fish and Wildlife Service and/or appropriate State wildlife agency to determine their potential for adverse effects to bog turtles and their habitat. Prior to conducting activities that may directly or indirectly affect wetlands, bog turtles and/or bog turtle habitat surveys should be conducted in accordance with accepted survey guidelines.

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[1] These guidelines are taken directly from the final "Bog Turtle (*Clemmys muhlenbergii*), Northern Population, Recovery Plan" (dated May 15, 2001).

[2] Except when conducted as part of a bog turtle habitat management plan approved by the Fish and Wildlife Service or State wildlife agency

Application of Transource Pennsylvania LLC
Independence Energy Connection-East & West Projects
Docket Nos. A-2017-2640195 and A-2017-2640200

Interrogatories of the Office of Consumer Advocate
Set XXIV
(Responses dated 8/22/2018)

Data Request 01:
Please discuss whether any bog turtle surveys have been completed in conjunction with the Transource transmission facilities proposed to be located in Pennsylvania. If yes, please provide a copy of any reports/results for the survey. If no, please advise when such surveys are expected to be completed.

Response:

The Company has completed bog turtle surveys for the Furnace Run – Conastone transmission line (IEC-East). These surveys included a Phase I: Habitat Screening for the entire survey corridor and a Phase II: Presence/Absence survey for areas of suitable habitat within or immediately adjacent to the preliminary project alignment, as determined during the Phase I assessment. The reports are not complete at this time. However, the Company did not find any bog turtles during the surveys. The Company will provide the survey reports for IEC –East once they are complete.

No surveys were warranted for the Rice-Ringgold transmission line (IEC-West) as no suitable habitat was located within 300 feet of the transmission line within their habitat range for Franklin County.

The Company will provide the survey reports for IEC–East once they are complete.

Witness: Barry A. Baker

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SEP 20 2018

PA PUBLIC UTILITY COMMISSION
~~SECRETARY'S BUREAU~~

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT
WATER OBSTRUCTION AND ENCROACHMENT

Bog Turtle Habitat Screening

U.S. Army Corps of Engineers/Department of Environmental Protection State Programmatic General Permit/Water Obstruction and Encroachment General Permit

Federal/State Screening Process for Bog Turtles (*Glyptemys muhlenbergii*) and/or their habitat in Adams, Berks, Bucks, Chester, Cumberland, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Schuylkill (Swatara Creek Watershed), and York Counties.

In 1974 the Pennsylvania Fish and Boat Commission, under Section 2305 of the Fish and Boat Code, listed the bog turtle as an endangered species, and in 1997 the U.S. Fish and Wildlife Service, under the Endangered Species Act of 1973, listed the bog turtle as a threatened species. Poaching and loss of habitat are two primary reasons for the decline in turtle populations throughout the Mid-Atlantic Region.

The 4-inch bog turtle's preferred wetland habitat is spring seeps and open marshy meadows in the valleys of southcentral and eastern Pennsylvania. Here the water is slow moving and the earth is mucky. Mucky soils provide cover for the turtles in spring and summer. October through April, the turtles use the same mucky soils as a place to hibernate. Plants common to these wetland areas include cattails, rushes, jewelweed, skunk cabbage, sedges, and sphagnum moss.

In order to provide continued protection for the turtle and to minimize conflicts during project development and permitting, the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service and PA Department of Environmental Protection have developed a screening process to identify potential bog turtle habitat. Representatives of these agencies will provide on-site technical assistance to determine if proposed projects may impact wetlands which serve as bog turtle habitat.

This special screening process is only required for those activities which will impact wetlands in the counties or watersheds listed above. If your proposed activity does not impact wetlands in these counties, you may proceed with the registration of the general permit without this screening process.

INSTRUCTIONS

If your proposed project includes a **wetland impact** in one of the fifteen counties listed above, follow the steps below prior to submitting the General Permit Registration form.

1. Using the primary contact list on the next page, identify the primary contact for your county where the wetland impact will take place.
2. Complete the attached form to provide driving directions, a project description, and a sketch or a plan detailing the proposed project. In addition, include a copy of a USGS quadrangle showing your project location, the agencies will be able to conduct a threatened and endangered species review for your project prior to the site visit which may also expedite your permit registration process. Submit this information by fax or mail to the primary contact to request a field view to screen for potential bog turtle habitat.
3. The agency representative will contact you to schedule an on-site assessment of the wetlands for bog turtle habitat. They will complete the bog turtle habitat screening form, sign it, and explain the results to you. You do not have to be present during the field view.
4. If it is determined that the project area (which includes the direct and indirect impact area) does not contain potential bog turtle habitat, submit the completed bog turtle habitat screening form provided to you along with the remainder of the information required by the general permit registration package, including the General Permit Registration form, to the appropriate Regional Office or Delegated County Conservation District for processing.

EXHIBIT
PUC-411
PENGAD 800-631-6989

5. If it is determined that the project area (which includes the direct and indirect impact area) is potential bog turtle habitat, the agency representative will discuss your options with you. These may include moving the project to an alternate location, contacting a professional bog turtle surveyor, or consulting with the U.S. Fish and Wildlife Service. Neither a state general permit nor a federal State Programmatic General Permit can be registered without the U.S. Fish and Wildlife Service clearing the potential bog turtle conflict.

6. If you cannot avoid the impacts to bog turtle habitat, an Individual Chapter 105 and Section 404 Permit Application will be required for processing, public notice, and review. An application does not guarantee permit approval.

7. If you have any questions specific to this process, please contact the appropriate agency representative for your county.

PRIMARY CONTACT LIST BY COUNTY

Adams, Cumberland Counties

Debby Nizer
U. S. Army Corps of Engineers
Baltimore Dist., Regulatory Branch, PA Section
P. O. Box 1715
Baltimore, MD 21203-1715
Phone: 410-962-6085
Fax: 410-962-6024

Berks (Baltimore District), York Counties

Mike Danko
U. S. Army Corps of Engineers
Carlisle Regulatory Field Office
401 East Louther Street, Suite 205
Carlisle, PA 17013
Phone: 717-249-8730
Fax: 717-240-0523

Berks (Philadelphia District), Bucks, Chester (Philadelphia District), Delaware, Montgomery Counties

Chief, Applications Section
U. S. Army Corps of Engineers
Philadelphia Dist., Regulatory Branch
Wanamaker Building
100 Pen Square East
Philadelphia, PA 19107-3390
Phone: 215-656-6728
Fax: 215-656-6724

Chester (Baltimore District), Lancaster, Lebanon Counties

Pat Strong
U. S. Army Corps of Engineers
Baltimore Dist., Regulatory Branch, PA Section
P. O. Box 1715
Baltimore, MD 21203-1715
Phone: 410-962-1847
Fax: 410-962-6024

Franklin, Lehigh, Northampton, Schuylkill (Swatara Creek Watershed) Counties

U.S. Fish and Wildlife Service
315 South Allen St., Suite 322
State College, PA 16801
Phone: 814-234-4090
Fax: 814-234-0748

Monroe County

Victor Motts
Monroe County Conservation District
8050 Running Valley Road
Stroudsburg, PA 18360-8841
Phone: 570-629-3060
Fax: 570-629-3063

If you have more general questions or need information on permitting, please contact the appropriate DEP Regional Office listed below.

DEP
Northeast Regional Office
2 Public Square
Wilkes-Barre, PA 18711-0790
570-826-2511

Lehigh, Monroe, and Northampton, and Schuylkill (Swatara Creek Watershed) Counties

DEP
Southcentral Regional Office
909 Elmerton Avenue
Harrisburg, PA 17110
717-705-4707

Adams, Berks, Cumberland, Franklin, Lancaster, Lebanon, and York Counties

DEP
Southeast Regional Office
2 East Main Street
Norristown, PA 19401
484-250-5940

Bucks, Chester, Delaware, and Montgomery Counties

SPECIAL BOG TURTLE HABITAT SCREENING

**U. S. ARMY CORPS OF ENGINEERS/DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE PROGRAMMATIC GENERAL PERMIT/WATER OBSTRUCTION AND
ENCROACHMENT GENERAL PERMIT**

APPLICANT INFORMATION

Applicant Name ______________________________

Mailing Address ______________________________ Telephone (___) ______________

City ______________________ State ____________ ZIP+4 ______________

Email Address ______________________________

PROJECT DESCRIPTION

Project Name ______________________________

County ______________________ Municipality ______________________

Latitude ______________________ Longitude ______________________

Which general permit(s) are you planning to register? GP-5 ☐ GP-6 ☐ GP-7 ☐ GP-8 ☐ GP-9 ☐ GP-11 ☐

Detailed Written Directions to Project ______________________________

____

____

____

Briefly Describe Your Project ______________________________

____

____

____

SIGNATURE

I hereby grant permission for representatives of the U. S. Army Corps of Engineers or other authorized screening representative to inspect the project site as necessary in order to perform the requested habitat determination.

______________________________ ______________

Signature Date

On the reverse side of this page, prepare a sketch showing your project, the wetlands, and all proposed impacts.

____
Applicant Name

BOG TURTLE HABITAT - SKETCH PLAN

To ensure the sketch plan is complete, include the following on the site plan in the immediate vicinity of the project. (√ all that apply)

YES	N/A		YES	N/A	
☐	☐	Stream Impacts with Dimensions Total Length ________ Total sq. ft. ________	☐	☐	Stream Name ____________________
			☐	☐	Chapter 93 Stream Designation ____________
☐	☐	Wetland Impacts Total _______ sq. ft.	☐	☐	Location of Property Lines Relative to the Project
			☐	☐	Existing Utilities
☐	☐	Wetland Acreage Onsite _______	☐	☐	Proposed Utilities
☐	☐	Stream Limits and Flow Direction	☐	☐	Existing Buildings, Roadways, Other Structures
☐	☐	Floodway Limits (if known)	☐	☐	Proposed Buildings, Roadways, Other Structures
☐	☐	Limits of Earth Disturbance Associated with this Activity	☐	☐	Other Waters (i.e. pond, lakes)

Scale 1" = ______ ft.

My name is Chris Monheim and I'm the head girls cross country coach at the Chambersburg Area High School. Thank you for the opportunity to speak. I was involved with and part of a meeting that took place with the Transource Power representatives last year. At the time of the meeting I was under the impression that this project, while clearly a potential inconvenience for our cross country course and program, would not have a large overall effect on our course or what we do. Since that meeting, it has been made clear that the proposed power line will definitely alter our course, if not destroy it completely. For selfish reasons this is a huge concern, but it also affects hundreds of athletes, parents, and community members as well.

Our memorial course has been around for more than 25 years and is now officially named the Tim Cook Memorial Cross Country Course to honor the memory of the coaching legend Tim Cook, who tragically passed away in 2002. The course is widely regarded as one of the most challenging and beautiful courses in the area and is host to many running related events throughout the year. Hundreds, if not thousands of participants each year from middle school runners, to high school runners, to adult runners enjoy the challenge and the beauty that the property at Falling Springs Elementary school provides.

It is my great hope that the interests of the countless athletes, parents, and fans of our sport will be considered when considering the proposed power line. The Tim Cook Memorial Cross Country Course is just one of the many special places that will be affected by the proposed plans and it's my sincere hope that this can be avoided.

Thanks for your time,

Chris Monheim – Chambersburg Area High School Girls Cross Country Coach

258 Ramsey Avenue

Chambersburg, PA 17201

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SECRETARY'S BUREAU

Submitted 9-18-2018

Laura Mueller's Testimony - 09/18/18, New Franklin VFD Hall - p. 1 of 2

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SECRETARY'S BUREAU

Laura Mueller
5308 Fairway Drive West
Fayetteville PA 17222.

My biggest concern is how completely **out of scale** these towers would be with our beautiful landscape and current land use, preserved over generations.

Without a public purpose, Transource has no basis to even fantasize about exercising "eminent domain" to put them in our state. Transource PA plans to provide electricity—NOT to the public, and NOT in our area—but only to their private subscribers in the Baltimore-Washington market.

We just moved from that "market" in April this year. During our nine years there, we received dozens of solicitations from electric companies all over the country. Transource may hope to gain a competitive edge, but the rate difference they described is insignificant in that market. How much more would the area's consumers lose if their food production from here is disrupted by this project?

According to ***Money*** magazine, Howard County MD is the #1 place to live in America. Between Baltimore and Washington DC, it has half the land area of Franklin County and twice the population. With NASA and JHU-APL scientists there, thousands of electricity customers opt for wind and solar power to lower carbon and methane emissions from energy use, as we did.

Recurrent flooding in Ellicott City showed us our community's resilience depended on ***us*** to reduce climate disruption's impacts. The flood on July 30 2016 was not supposed to recur for 1000 years, yet less than two years later came an even more destructive flood. Residents who took loans in 2016 to rebuild or reopen their businesses were wiped out again this year, on June 21.

Howard County MD government helps save farms by contributing to solar fields, giving farmers additional income, so their land continues to be farmed by their family. Geothermal, solar hot water, and photovoltaic panels energize street signs, businesses and homes. Columbia Association rigs its bikes in "spinning" classes to provide more than 1/3 of each facility's electricity. Projects like Groundswell efficiently produce and distribute community-owned solar, providing income in economically-stressed neighborhoods. Now **THAT is a "public purpose."** Let's produce electricity right where it is used, with fossil-free solar and wind, for highest efficiency of energy production in direct support of local communities.

EXHIBIT
PENGAD 800-631-6989
PUC-413

These imposing towers pose increasing threats, due to "global weirding's" intensifying lightning, tornadoes, and acidified rainfall of 2-to-4 inches per hour. Entire mountains have fallen, breaking in half into mudslides. When our area's karst geology shifts under monopole towers, they would lean and even fall, their sagging wires grounding and breaking to spark fierce fires.

This year we may have difficulty imagining fires after our highest rainfall here in one of the four hottest years on record. But remember back to 2006? In Frederick County MD we had six weeks with no rain at all. Every plant dried up and died in the fields. Whole corn crops were lost. This and worse can happen in any season.

"Around a dozen of the *fires* that devastated northern California's wine country last year were sparked by *power lines*, according to state officials. ... In 2015, fires started by electrical lines and equipment burned more acres in California than any other cause. ... In recent years, they have consistently been among the three major causes of California wildfires. ... In the United States, fossil fuels burned to make electricity and heat put more greenhouse-gas emissions into the atmosphere than any industry."*

On Friday 9/14/18 at Rep. Rob Kauffman's Senior Fair at the Fayetteville Volunteer Fire Department, I asked two firefighters and three EMT's what training they have for dealing with emergencies from 230-kilovolt lines. They all said, "None." The EMT's added that across the United States, no training exists. "We would just cordon off the affected area and wait until the power company came to address the problem." How well did waiting for the utility company work out for thousands of residents evacuated in Massachusetts' Merrimac Valley?

Every constituency in Franklin County opposes Transource's proposed 29 miles of power lines. We have faith in our judiciary to hold a forester's 50-year perspective, rather than just a gardener's seasonal one, by seeing the risk to our county and NOT extending "eminent domain" for this unnecessary project. We trust PUC's Commissioners to acknowledge how focused, faithful, collaborative care has deepened and widened this land's value, far beyond traditional economic measurements, for our community and for those who depend on us, now and into the future. These Commissioners best uphold our Commonwealth Constitution in maintaining protections for us and our land that sustains us all.

*https://www.theatlantic.com/technology/archive/2018/05/power-lines-are-burning-the-west/561212/

DANNER'S INSURANCE SINCE 1928
P.O. BOX 705
BIGLERVILLE, PA 17307-0705

PHONE (717) 677-8733
FAX (717) 677-7170

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PA PUBLIC UTILITY COMMISSION
SECRETARY'S BUREAU

September 18, 2018

Pennsylvania Utilities Commission

Dear Commissioners:

As a long-time resident of Franklin County serving the insurance industry the project of Transource is deeply troubling and dangerous to the common good of the farm, business, and residential community at large. Installation of utility power towers and transmission lines creates a financial, physical, environmental, and moral hazard far greater than its value to offer power to metropolitan areas. My only question to you is this part of the solution or part of the problem? Why should taxpayers bear the burden of losing property value, risk the safety of their homes and families, accept the view of towers as the new landscape, and struggle with the loss of the beauty that makes Franklin County a special place to live. This truly is not a solution but is a problem that generations will bear because of WHY??
Kindly consider these factors among many others as you decide what is best and the right thing to do. Thank you for your time.

Sincerely,

Bob Faubel
Agent

EXHIBIT
PENGAD 800-631-6989
PUC-414

FCADC
FRANKLIN COUNTY AREA DEVELOPMENT CORPORATION

1900 Wayne Road
Chambersburg, PA 17202
(717) 263-8282
FAX (717) 263-0662
www.fcadc.com

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SEP 20 2018

PA PUBLIC UTILITY COMMISSION
SECRETARY'S BUREAU

TO: Pennsylvania Public Utility Commission (PA PUC)

FROM: L. Michael Ross, President M.R.
FCADC

DATE: September 18, 2018

SUBJECT: PJM/Transource Powerline - A-2018-3001881, et al

As President of the Franklin County Area Development Corporation (FCADC), I herewith offer testimony in opposition to the proposed powerline by PJM/Transource (reference A-2018-3001881, et al). The FCADC position is reflected on the attached:

- Memorandum to the Chambersburg Area School District dated June 4, 2018
- Stop Transource Editorial dated February 21, 2018
- Letter to Abby Foster dated September 27, 2017

Also attached is an article published on August 17th by the Wall Street Journal "How Power Lines Can Fry Property Values." Finally, it should be noted that I previously testified in opposition to this project at the public forum of the PUC on May 22, 2018.

For informational purposes, my contact information is:

L. Michael Ross
President
Franklin County Area Development Corporation
1900 Wayne Road
Chambersburg, PA 17202
P: 717-263-8282
F: 717-263-0662
E: mike@fcadc.com

EXHIBIT
PENGAD 800-631-6989
PUC-415

FCADC
FRANKLIN COUNTY AREA DEVELOPMENT CORPORATION

1900 Wayne Road
Chambersburg, PA 17202
(717) 263-8282
FAX (717) 263-0662
www.fcadc.com

TO: Members of the Board
Chambersburg Area School District

FROM: L. Michael Ross, President
Franklin County Area Development Corporation (FCADC)

DATE: June 4, 2018

SUBJECT: Transource Independence Energy Project

I am writing in my capacity as president of the Franklin County Area Development Corporation (FCADC) in regard to the proposed Transource Independence Energy Project. Specifically, I am requesting the CASD Board of Directors to formally oppose the project.

The FCADC was one of the first opponents of the project and we evidenced our opposition to Transource in a letter dated September 29, 2017. As we stated in our initial opposition and which remains at the heart of the matter, neither PJM or its surrogate, Transource, has been able to establish a quantified need for the project, and as a consequence neither has been able to articulate the benefits to Franklin County.

I was contacted in March by Jim Hook of the Public Opinion requesting a response to a press release that was put out by Transource in support of the proposed project. My response is below:

> *"My initial response to the Transource press release is that the estimated project cost has been reduced without explanation from $320 Million (which was the estimate provided during the public information sessions during the summer/fall of 2017) to* ***$230 Million****. Presumably the $90 million reduction would have a corresponding reduction in the projected "benefits to Franklin County", however such benefits are loosely defined in the press release and are formulaically based on ill-defined assumptions in the Battle Group study. Moreover, the press release that was provided to me states that "the IEC project will continue to generate property taxes for the local governments in MARYLAND, with a projected $700,000 during its first year in service." Franklin County is in PENNSYLVANIA. Regardless, there is no supporting evidence as to how such assumptions were developed and it would be impossible to verify their accuracy unless the project is brought to fruition. To that point however, what would be the penalty to Transource or PJM should their*

assumptions not prove accurate? Meanwhile, the negative structural, economic, and quality of life impacts to Franklin County would be permanent. Once a tower is placed in the Lowes parking lot, at the Mall, or next to the Falling Springs trout stream, it will be permanent.

While I recognize the impact of the construction jobs, the vast majority of those will be short term until the project is built. The statement in the press release that talks to ***$40 Million in economic activities*** *reverts back to the formulaically based study prepared by the Battle Group. I can only assume the Battle Group has been contracted by PJM or Transource to provide the economic analysis, which by its very nature makes it a biased report.*

So to conclude, my reaction to the press release and the Battle Group study remains the same: neither PJM or Transource has been able to articulate the need for the project; nor have they been able to quantify the benefits for Franklin Countians...or for that matter, anyone. Furthermore, neither Transource nor PJM has been able to adequately address what would be very real visual, safety, and private property depreciation impacts."

As you are aware, there are numerous constituent groups in addition to the FCADC who are opposed to this project to include the Franklin County Visitors Bureau; the PA Office of Consumer Advocate; the Office of the Small Business Advocate; Senator Rich Alloway; Representative Rob Kauffman; the Supervisors of Guilford, Greene, Quincy, and Washington Townships; the South Mountain Partnership; Trout Unlimited; Stop Transource Franklin County; and West Penn Power, PECO, First Energy Service Company, and PP&L Electric Service Corporation.

With that said, arguably the most important constituent group that still needs to weigh in is you. There stands to be a significant impact on the CASD cross-country course at Falling Spring Elementary School. The construction of the tower and lines will change the landscape forever and not only impact the course at Falling Spring but also the Tim Cook Memorial, which is a hallmark event locally.

This is one of the few projects in which it is difficult to find advocates. I, along with Janet Pollard of the Franklin County Visitors Bureau, have spoken to the ill effects of the county's annual $413 Million Ag sector and $326 Million Tourism sector; moreover, our office has not received any correspondence of any type from any active business in support of the project. In fact, one of the first calls I received was from the senior management at Martin's Famous Pastry Shoppe expressing their opposition to the project and its potential effects on future expansion. In conclusion, the FCADC respectfully requests **that the CASD Board of Directors vote to oppose the project.**

C: Senator Rich Alloway
Representative Rob Kauffman
Janet Pollard, President, Franklin County Visitors Bureau, Inc.
FCADC Board of Directors
Dr. Joseph Padasak, Superintendent, CASD

BC: Lantz Sourbier, Stop Transource Franklin County

Stop Transource

As president of the Franklin County Area Development Corporation (FCADC) for the past 32 years, I have had the opportunity to be involved in hundreds of community and economic development projects across the County, and in virtually every instance there have been opponents and proponents of the specific project. Often times, a project can divide a community, however, there are exceptions. Take for example the Transource proposal to build a power line across Franklin County. PJM/Transource has managed to unite virtually every constituent group in Franklin County in **opposition** to the project.

The FCADC was one of the first opponents of the project and we evidenced our opposition to Transource in a letter dated September 29, 2017. As we stated in our initial opposition and which remains at the heart of the matter, neither PJM or its surrogate, Transource, has been able to establish a quantified need for the project; more importantly, they have never been able to articulate the benefits to Franklin County. To that point, if the recent editorial that appeared in the *Public Opinion* (2/9/18) was an attempt to establish a need for the project, it was a pathetic effort. It attempted to speak to the project's benefits in broad generalities and noted that "the Independence project will result in millions of dollars of cost savings..." Really! How many millions and how much of that will be realized by Franklin County rate payers?

There was no mention in the editorial of the negative impacts to our County in terms of the destruction of the visual view shed and its corresponding relationship to our $326 Million annual tourism industry; or the placement of towers in farm fields and the corresponding impact to our $413 Million agricultural sector; or the fact that under the current proposal, a tower is to be placed on the Lowe's property on Lincoln Way East in Chambersburg. Finally, it is worth noting that the FCADC has not received a single call, email, or letter from a Franklin County business voicing support for the project. (As an aside, one should be aware that Transource simply assumed that because the FCADC is involved in economic development that we would automatically support the project. We all know the definition of *assume.)*

As this project goes through the public hearing process under the jurisdiction of the Pennsylvania Public Utilities Commission, the FCADC will be in support of the local ***Stop Transource*** coalition.

Dated and Emailed to Newspapers on February 21, 2018

Ran in papers on:

- The Record Herald; Saturday, February 24, 2018
- Public Opinion; Tuesday, February 27, 2018
- The Herald-Mail; Sunday, March 4, 2018

FCADC
FRANKLIN COUNTY AREA DEVELOPMENT CORPORATION

1900 Wayne Road
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September 29, 2017

Abby Foster
Community Affairs Representative
Transource Energy
PO Box 573
Harrisburg, PA 17108-0573

PO Box 192
White Hall, MD 21161-0192

RE: Pennsylvania Portion Transource Independence Energy Connection Project

Dear Ms. Foster:

As a matter of background, the mission of the Franklin County Area Development Corporation (FCADC) is to formulate, implement and promote a comprehensive countywide economic development strategy that results in economic diversification, planned growth and family sustainable job creation. Diversification is essential to a strong economy and two of our strongest industry sectors are tourism and agriculture. To that point, Franklin County tourism generates $326.7 million in traveler spending annually, while our agricultural sector, which ranks second among the Commonwealth's 67 counties in the production of milk, cattle, peaches, apples and corn for silage, is a $413 Million industry.

The proposed Transource Independence Energy Connection Project is raising considerable concerns given that it would negatively impact view shed and agriculture. The proposed chain of metal, high-voltage power line towers is distinctly uninviting and counter to what attracts visitors to the beauty of the county. In addition, and arguably more important, there is documented evidence that proximity to power lines is harmful to milk production. Regardless of what route is taken, it will impact production agriculture.

While agriculture and tourism are two industry sectors that will be negatively impacted by the proposed line, our office has received calls from other businesses ranging from manufacturing and transportation & logistics objecting to the project, several of the businesses are concerned that the placement of the towers will impact future expansions.

The specific cost in a present-day action for Transource to develop the electric transmission line project is identified as a $320 million investment, per the June 2017 Fact Sheet of the

Transource Independence Energy Connection Project. Unfortunately, the investment does not have any immediate direct benefits to Franklin County residents or businesses. The benefits are intended to primarily benefit the Washington, DC metro area. In doing so, the long-term and far-reaching impacts on the project in Franklin County will curtail future expansion of existing businesses, negatively impact dairy production, and forever change the scenic landscape and view sheds of Franklin County. For those reasons, the FCADC is not supportive of this project.

Sincerely,

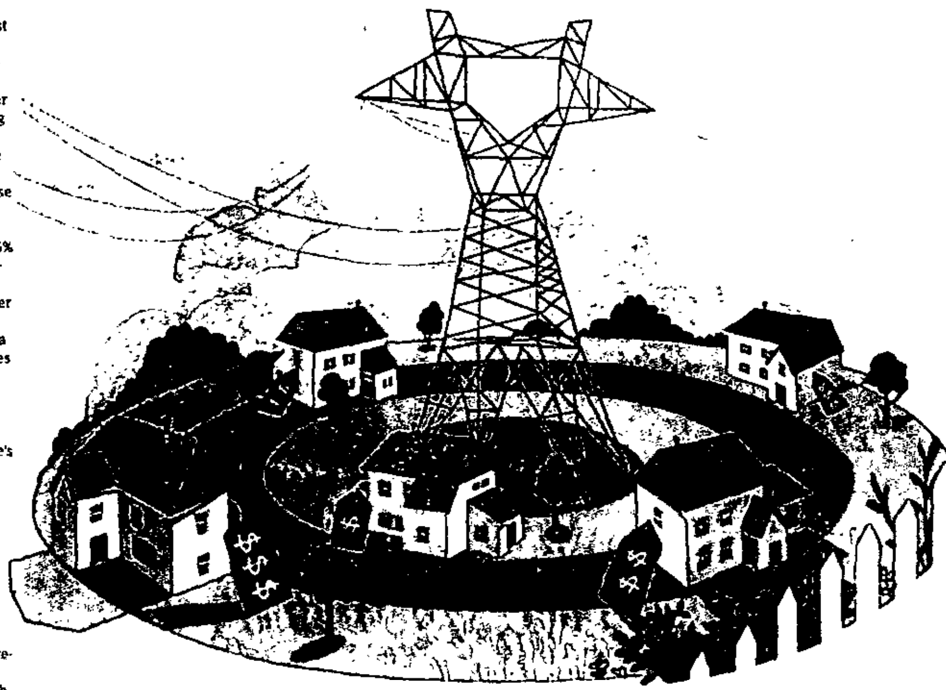
L. Michael Ross
President

C: FCADC Board of Directors
Franklin County Visitors Bureau, Inc.
Congressman Bill Shuster, 9th District
Senator Rich Alloway, 33rd District
Senator John Eichelberger, 30th District
Representative Rob Kauffman, 89th District
Representative Paul Schemel, 90th District
Representative Jesse Topper, 78th District

SPREAD SHEET | ADAM BONISLAWSKI

How Power Lines Can Fry Property Values

Researchers show the impact of high-voltage towers on the price of adjacent lots and even land with views of transmission lines



Research has shown that property next to power lines comes at a discount. Just how much of a discount, though, is a little shocking.

A recent study in the Journal of Real Estate Research by College of Charleston assistant professors Chris Mothorpe and David Wyman, finds that vacant lots adjacent to high-voltage transmission lines sell for 45% less than equivalent lots not located near transmission lines. Non-adjacent lots located within 1,000 feet of transmission lines sell at a discount of 18%.

Previous studies have similarly found that proximity to power lines lowers real-estate values, but Prof. Mothorpe says most of these analyses have looked at lots with homes already built, which, he notes, complicates the question.

"You could have similar lots with similar views but different houses, and the pricing impact would be different because the housing structures would be different," he says. "So by just focusing on vacant land, we were able to not have to deal with those kind of issues."

Assuming a market where land represents 20% of a home's overall value, the 45% decrease translates to a drop in total property value of around 9%, the authors note.

The researchers also developed a "Tower Visibility Index" that Prof. Mothorpe says accounts for not only a lot's proximity to a transmission line but also whether features like trees or hills hide the line from view.

"Even if the tower is within 1,000 feet, if it's behind a big hill, I might not even know it's there," he says, which would lessen the tower's impact on a property's value. "There's that idea of out of sight, out of mind."

For their analysis, the professors used sales data from 5,455 vacant lots sold between 2000 and 2016 in Pickens County, S.C., where a network of high-voltage lines transmits electricity from the Oconee Nuclear Station.

Prof. Mothorpe suggests three main factors driving the discount: health concerns associated with proximity to high-voltage lines (though, as the authors note, researchers have not established solid links between proximity to power lines and health issues); the unattractive views; and, for properties very close to the lines, the humming sound they produce.

"It's hard [based on the study data] to distinguish between the three," he says. "But my intuition tells me the visual [component] is the largest of the three."

At almost 50% off, maybe it's worth just looking the other way.

45%
decrease in sale price for a vacant lot adjacent to a power line

18%
decrease in sale price for vacant lots 1,000 feet from a power line

9%
decrease in overall property value of a house adjacent a power line

Franklin County PA
Web Parcel Mapper

09-0C18H-102.-000000

PROPERTY INFORMATION

UPI: 09-0C18H-102.-000000
ADDRESS: 1719 BARNEGAT LIGHT DR
PA

TYPE: Tax Parcel
DEED AREA: 0.66 ACRES

CURRENT OWNER INFORMATION

OWNER: MARK A REIFF
ADDRESS: 361 RUNNING PUMP ROAD
SHIPPENSBURG PA 17257

DEED REF: 14-012592 SOLD: 07/15/2014
PRICE: $ 175000

ASSESSMENT VALUES

BLDGS	$	33650
LAND	$	3420
TOTAL	$	37070

TAXABLE STATUS

EXEMPT: NO

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EXHIBIT
PUC-416
PENGAD 800-631-6989

Franklin County PA
Web Parcel Mapper

09-0C18H-094.-000000

PROPERTY INFORMATION

UPI:	09-0C18H-094.-000000
ADDRESS:	1690 ROCK RD
	PA
TYPE:	Tax Parcel
DEED AREA:	1.41 ACRES

CURRENT OWNER INFORMATION

OWNER:	LARRY & LYNDA THOMPSON		
ADDRESS:	PO BOX 1189		
	SHEPERDSTOWN WV 25443		
DEED REF:	11-008373	SOLD:	03/18/2011
		PRICE:	$ 176400

ASSESSMENT VALUES

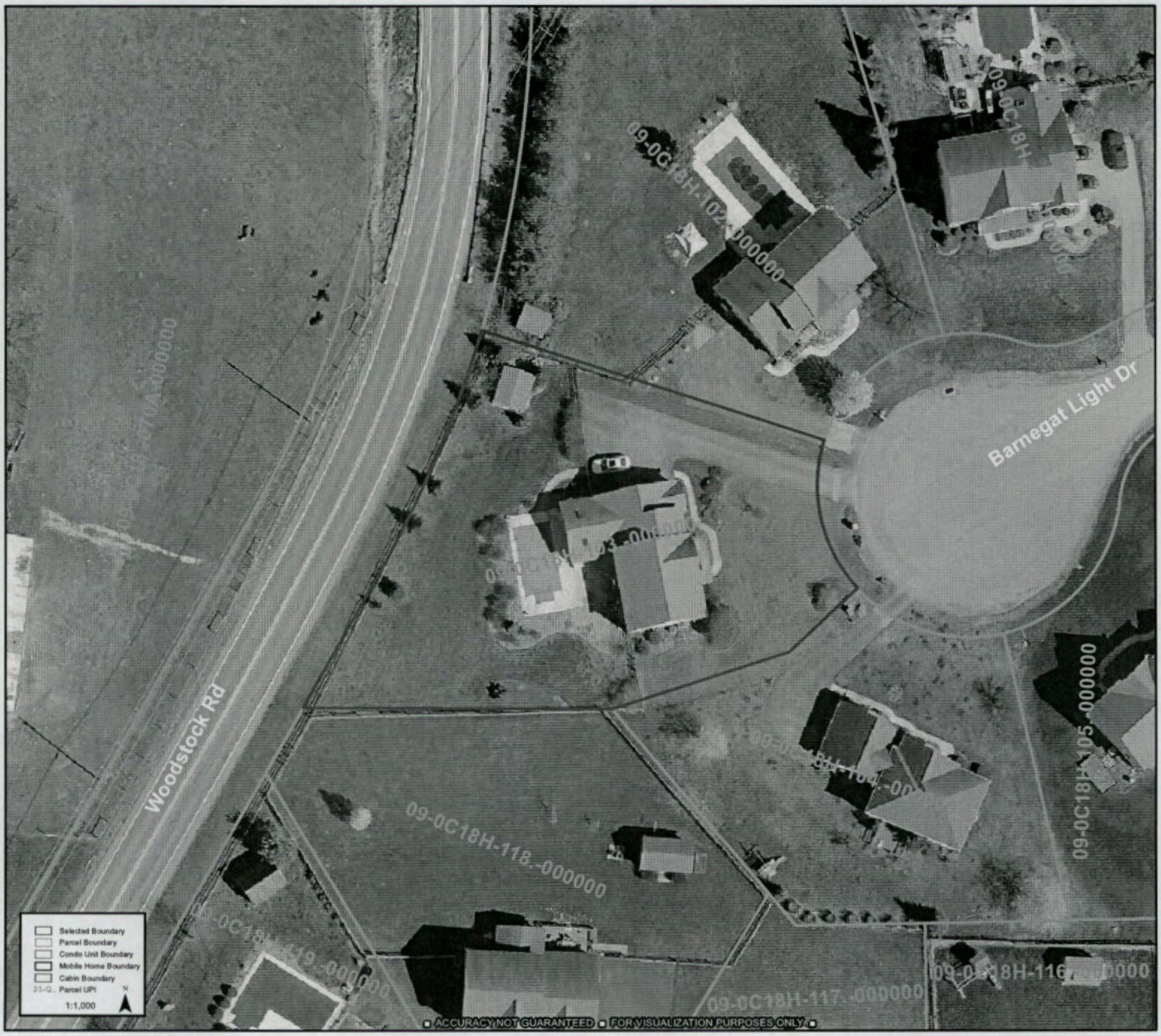
BLDGS	$	36920
LAND	$	8490
TOTAL	$	45410

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

09-0C18H-103.-000000



PROPERTY INFORMATION

UPI: 09-0C18H-103.-000000
ADDRESS: 1711 BARNEGAT LIGHT DR
PA

TYPE: Tax Parcel
DEED AREA: 0.56 ACRES

CURRENT OWNER INFORMATION

OWNER: RANDY L & MICHAELANN K MOSER
ADDRESS: 1711 BARNEGAT LIGHT DRIVE
CHAMBERSBURG PA 17202

DEED REF: 2562-0535 SOLD: 09/10/2004
PRICE: $ 262650

ASSESSMENT VALUES

BLDGS	$	36210
LAND	$	4190
TOTAL	$	40400

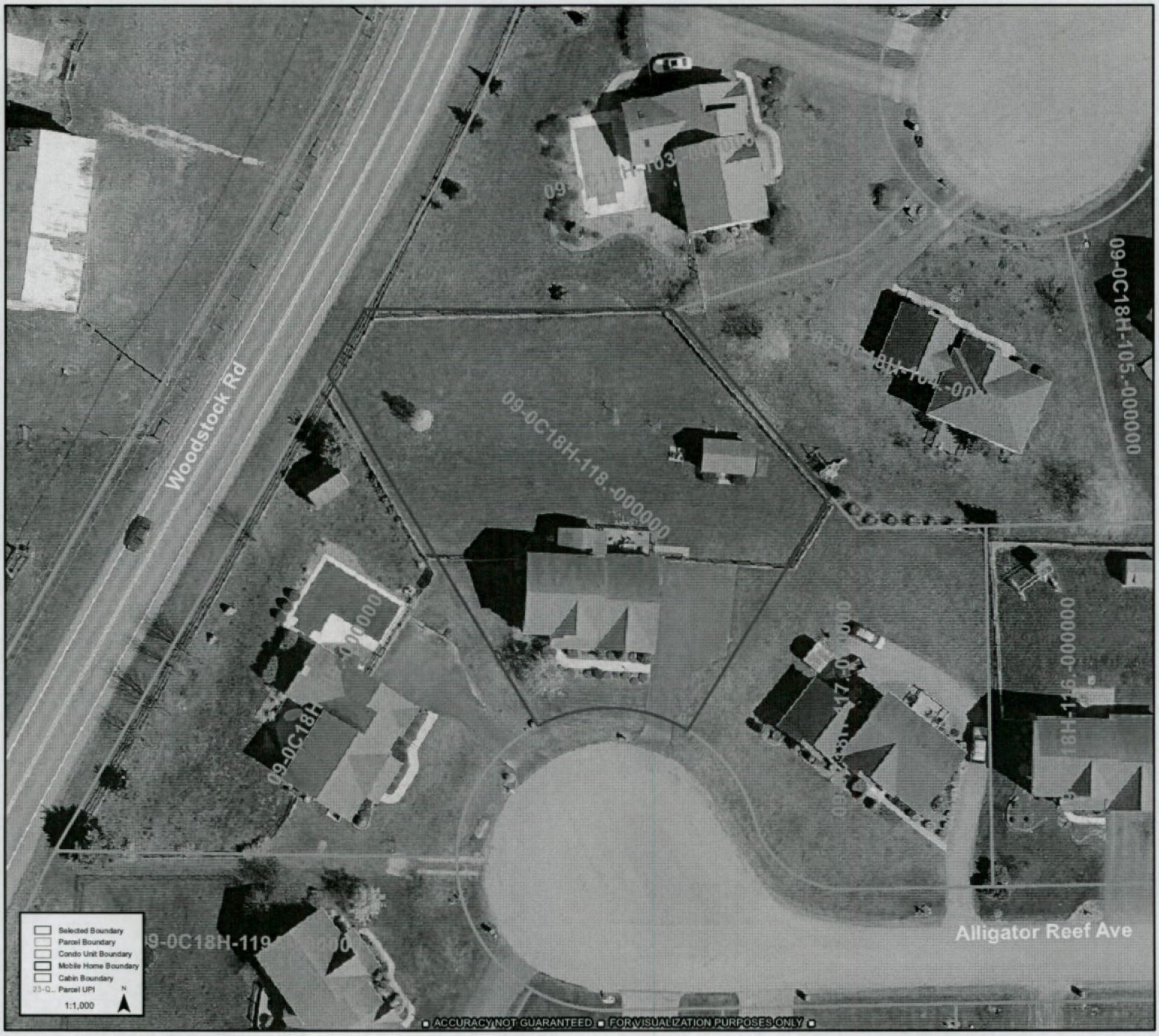
TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY PENNSYLVANIA 1784

Franklin County PA
Web Parcel Mapper

09-0C18H-118.-000000



PROPERTY INFORMATION

UPI:	09-0C18H-118.-000000
ADDRESS:	1683 ALLIGATOR REEF AVE PA
TYPE:	Tax Parcel
DEED AREA:	0.42 ACRES

CURRENT OWNER INFORMATION

OWNER:	NOAH R & KELLY L WEILAND
ADDRESS:	1683 ALLIGATOR REEF AVENUE CHAMBERSBURG PA 17202

DEED REF:	16-009346	SOLD:	05/25/2016
		PRICE:	$ 255900

ASSESSMENT VALUES

BLDGS	$	28180
LAND	$	3370
TOTAL	$	31550

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

09-0C18H-119.-000000

PROPERTY INFORMATION

UPI: 09-0C18H-119.-000000
ADDRESS: 1675 ALLIGATOR REEF AVE
PA

TYPE: Tax Parcel
DEED AREA: 0.6 ACRES

CURRENT OWNER INFORMATION

OWNER: JAMES & DANYAL SIMMONS
ADDRESS: 1675 ALLIGATOR REEF AVENUE
CHAMBERSBURG PA 17202

DEED REF: 2907-0426 SOLD: 09/16/2005
PRICE: $ 236000

ASSESSMENT VALUES

BLDGS	$	35760
LAND	$	4930
TOTAL	$	40690

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

09-0C18.-101A-000000

PROPERTY INFORMATION

UPI: 09-0C18.-101A-000000
ADDRESS: 1703 ROCK RD
PA

TYPE: Tax Parcel
DEED AREA: 1.34 ACRES

CURRENT OWNER INFORMATION

OWNER: ALBERT B & CHERRY T WAGNER
ADDRESS: 1703 ROCK ROAD
CHAMBERSBURG PA 17202

DEED REF: 0825-0530 SOLD: 12/03/1980
PRICE: $ 250

ASSESSMENT VALUES

BLDGS	$	0
LAND	$	1350
TOTAL	$	1350

TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY
1784
PENNSYLVANIA

Franklin County PA
Web Parcel Mapper

10-0D05.-218.-000000

PROPERTY INFORMATION

UPI:	10-0D05.-218.-000000
ADDRESS:	664 GREENFIELD DR PA
TYPE:	Tax Parcel
DEED AREA:	0.3 ACRES

CURRENT OWNER INFORMATION

OWNER:	JAMES A EGER
ADDRESS:	664 GREENFIELD DRIVE CHAMBERSBURG PA 17202

DEED REF:	1329-0223	SOLD:	02/28/1997
		PRICE:	$ 114500

ASSESSMENT VALUES

BLDGS	$	23430
LAND	$	1320
TOTAL	$	24750

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D05.-184.-000000

PROPERTY INFORMATION

UPI:	10-0D05.-184.-000000
ADDRESS:	660 GREENFIELD DR PA
TYPE:	Tax Parcel
DEED AREA:	0.34 ACRES

CURRENT OWNER INFORMATION

OWNER:	DONNA K HARLACHER		
ADDRESS:	660 GREENFIELD DRIVE CHAMBERSBURG PA 17202		
DEED REF:	2556-0032	SOLD:	09/01/2004
		PRICE:	$ 130000

ASSESSMENT VALUES

BLDGS	$	15900
LAND	$	1680
TOTAL	$	17580

TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY 1784 PENNSYLVANIA

Franklin County PA
Web Parcel Mapper

10-0D05.-228.-000000

PROPERTY INFORMATION

UPI:	10-0D05.-228.-000000
ADDRESS:	652 GREENFIELD DR PA
TYPE:	Tax Parcel
DEED AREA:	0.28 ACRES

CURRENT OWNER INFORMATION

OWNER:	BILL C KALATHAS
ADDRESS:	652 GREENFIELD DRIVE CHAMBERSBURG PA 17202
DEED REF:	2663-0296
SOLD:	01/05/2005
PRICE:	$ 120000

ASSESSMENT VALUES

BLDGS	$	16080
LAND	$	1600
TOTAL	$	17680

TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY
1784
PENNSYLVANIA

Franklin County PA
Web Parcel Mapper

10-0D05.-199.-000000

PROPERTY INFORMATION

UPI: 10-0D05.-199.-000000
ADDRESS: 644 GREENFIELD DR
PA

TYPE: Tax Parcel
DEED AREA: 0.28 ACRES

CURRENT OWNER INFORMATION

OWNER: WILLIAM R FEASLEY
ADDRESS: 637 GREENFIELD DRIVE
CHAMBERSBURG PA 17202-7408

DEED REF: 1258-0577 SOLD: 05/25/1995
PRICE: $ 90000

ASSESSMENT VALUES

BLDGS	$	14960
LAND	$	1600
TOTAL	$	16560

TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY 1784 PENNSYLVANIA

Franklin County PA
Web Parcel Mapper

10-0D05J-043.-000000

PROPERTY INFORMATION

UPI: 10-0D05J-043.-000000
ADDRESS: 0 CHERRY AVE
PA

TYPE: Tax Parcel
DEED AREA: 0.82 ACRES

CURRENT OWNER INFORMATION

OWNER: OWEN R CLARK
ADDRESS: 267 WARM SPRING ROAD
CHAMBERSBURG PA 17202

DEED REF: 3615-0038 SOLD: 10/04/2007
PRICE: $ 0

ASSESSMENT VALUES

BLDGS	$	0
LAND	$	2630
TOTAL	$	2630

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D05.-046A-000000

PROPERTY INFORMATION

UPI: 10-0D05.-046A-000000
ADDRESS: 0 EDWARDS AVE
PA

TYPE: Tax Parcel
DEED AREA: 1.72 ACRES

CURRENT OWNER INFORMATION

OWNER: SPRING RIDGE ASSOCIATES
ADDRESS: 1115 SHELLER AVENUE
CHAMBERSBURG PA 17201

DEED REF: 1083-0017 SOLD: 05/16/1990
PRICE: $ 297310

ASSESSMENT VALUES

BLDGS	$	0
LAND	$	2580
TOTAL	$	2580

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D05.-045A-000000

PROPERTY INFORMATION

UPI: 10-0D05.-045A-000000
ADDRESS: 0 LINMAR DR
PA

TYPE: Tax Parcel
DEED AREA: 1.44 ACRES

CURRENT OWNER INFORMATION

OWNER: WILLIAM A FRIEDSBERG
ADDRESS: 1607 LINMAR DRIVE
CHAMBERSBURG PA 17202

DEED REF: 2704-0307 SOLD: 02/24/2005
PRICE: $ 179900

ASSESSMENT VALUES

BLDGS	$	0
LAND	$	2180
TOTAL	$	2180

TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY PENNSYLVANIA 1784

Franklin County PA
Web Parcel Mapper

10-0D05.-316.-000000

PROPERTY INFORMATION

UPI: 10-0D05.-316.-000000
ADDRESS: 1576 SPRING SIDE DR PA

TYPE: Tax Parcel
DEED AREA: 0.37 ACRES

CURRENT OWNER INFORMATION

OWNER: FRANCIS H & KATHLEEN B MAILLIE
ADDRESS: 1576 SPRINGSIDE DRIVE EAST
CHAMBERSBURG PA 17202

DEED REF: 2840-0190 SOLD: 07/19/2005
PRICE: $ 171900

ASSESSMENT VALUES

BLDGS	$	22210
LAND	$	4460
TOTAL	$	26670

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D05.-315.-000000

PROPERTY INFORMATION

UPI:	10-0D05.-315.-000000
ADDRESS:	1574 SPRING SIDE DR PA
TYPE:	Tax Parcel
DEED AREA:	0.34 ACRES

CURRENT OWNER INFORMATION

OWNER:	STEPHEN M & BRENDA D OTT		
ADDRESS:	1574 SPRINGSIDE DRIVE EAST CHAMBERSBURG PA 17202		
DEED REF:	2826-0097	SOLD:	07/05/2005
		PRICE:	$ 167900

ASSESSMENT VALUES

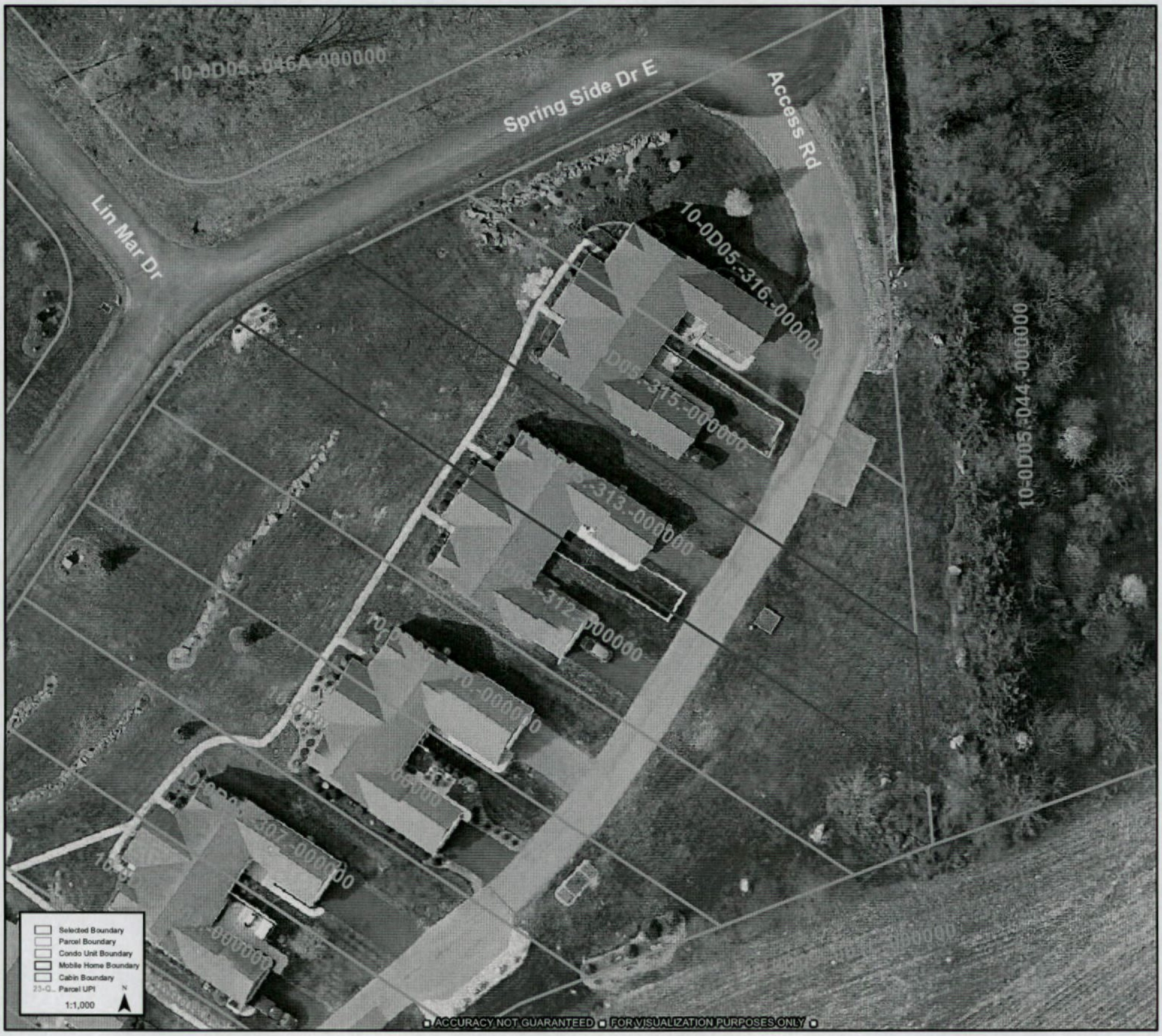
BLDGS	$	20660
LAND	$	2660
TOTAL	$	23320

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D05.-313.-000000



PROPERTY INFORMATION

UPI: 10-0D05.-313.-000000
ADDRESS: 1562 SPRING SIDE DR
PA

TYPE: Tax Parcel
DEED AREA: 0.41 ACRES

CURRENT OWNER INFORMATION

OWNER: TYNIA M WEIGLE
ADDRESS: 1562 SPRING SIDE DRIVE EAST
CHAMBERSBURG PA 17202

DEED REF: 2704-0177 SOLD: 02/18/2005
PRICE: $ 165900

ASSESSMENT VALUES

BLDGS	$	20660
LAND	$	2620
TOTAL	$	23280

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D09.-002.-000000

PROPERTY INFORMATION

UPI:	10-0D09.-002.-000000
ADDRESS:	1341 FALLING SPRING RD
	PA
TYPE:	Tax Parcel
DEED AREA:	1.61 ACRES

CURRENT OWNER INFORMATION

OWNER:	BETTY S MEYERS
ADDRESS:	1341 FALLING SPRING ROAD
	CHAMBERSBURG PA 17202

DEED REF:	0585-0929	SOLD:	09/26/1964
		PRICE:	$ 12000

ASSESSMENT VALUES

BLDGS	$	8250
LAND	$	830
TOTAL	$	9080

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D09.-002A-000000

PROPERTY INFORMATION

UPI:	10-0D09.-002A-000000
ADDRESS:	1353 FALLING SPRING RD PA
TYPE:	Tax Parcel
DEED AREA:	1.17 ACRES

CURRENT OWNER INFORMATION

OWNER:	DOUGLAS N & PAULA R ANDREE
ADDRESS:	1353 FALLING SPRING ROAD CHAMBERSBURG PA 17202
DEED REF:	13-003436
SOLD:	02/12/2013
PRICE:	$ 150000

ASSESSMENT VALUES

BLDGS	$ 12720
LAND	$ 500
TOTAL	$ 13220

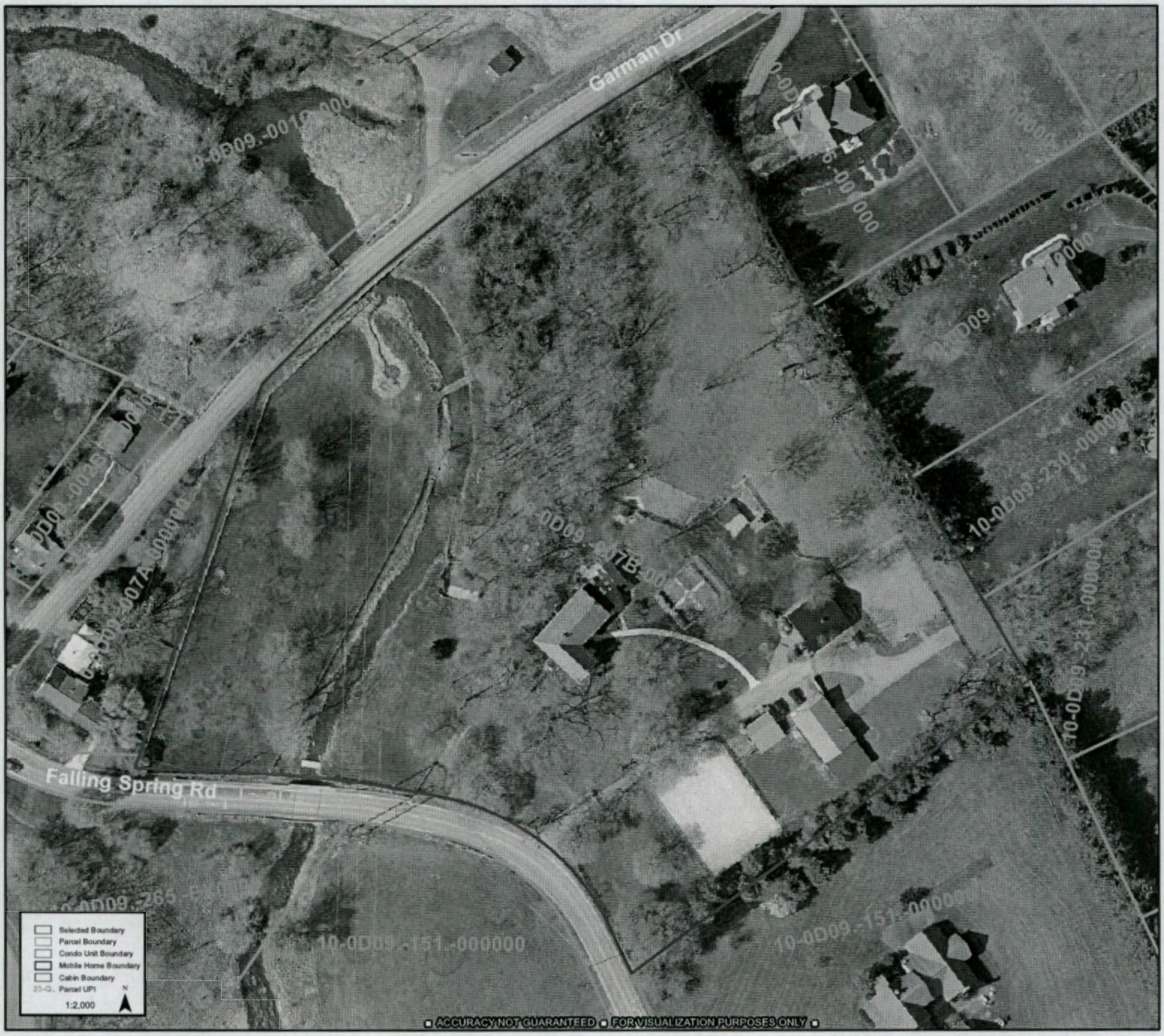
TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY 1784 PENNSYLVANIA

Franklin County PA
Web Parcel Mapper

10-0D09.-007B-000000



PROPERTY INFORMATION

UPI: 10-0D09.-007B-000000
ADDRESS: 1447 FALLING SPRING RD
PA

TYPE: Tax Parcel
DEED AREA: 7.68 ACRES

CURRENT OWNER INFORMATION

OWNER: DAVID D & ANGELA D SHETTER
ADDRESS: 1447 FALLING SPRING ROAD
CHAMBERSBURG PA 17202

DEED REF: 14-011489 SOLD: 07/01/2014
PRICE: $ 840000

ASSESSMENT VALUES

BLDGS	$	44820
LAND	$	2050
TOTAL	$	46870

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D08.-194.-000000

PROPERTY INFORMATION

UPI: 10-0D08.-194.-000000
ADDRESS: 0 FALLING SPRING ROAD

TYPE: Tax Parcel
DEED AREA: 10.59 ACRES

CURRENT OWNER INFORMATION

OWNER: MATTHEW W DILLER
ADDRESS: 3333 MUIRFIELD DR
CHAMBERSBURG PA 17202

DEED REF: 12-026894 SOLD: 12/21/2012
PRICE: $ 0

ASSESSMENT VALUES

BLDGS	$	0
LAND	$	3340
TOTAL	$	3340

TAXABLE STATUS

EXEMPT: NO

Franklin County PA
Web Parcel Mapper

10-0D09.-003.-000000

PROPERTY INFORMATION

UPI: 10-0D09.-003.-000000
ADDRESS: 1284 FALLING SPRING RD
PA

TYPE: Tax Parcel
DEED AREA: 43.96 ACRES

CURRENT OWNER INFORMATION

OWNER: BARRY A & KAREN N DILLER
ADDRESS: 1284 FALLING SPRING ROAD
CHAMBERSBURG PA 17202

DEED REF: 1689-0081 SOLD: 06/30/2001
PRICE: $ 0

ASSESSMENT VALUES

BLDGS	$	102770
LAND	$	8710
TOTAL	$	111480

TAXABLE STATUS

EXEMPT: NO

FRANKLIN COUNTY
1784
PENNSYLVANIA

RECEIVED
SEP 20 2018
PA PUBLIC UTILITY COMMISSION
SECRETARY'S BUREAU

EXHIBIT
PUC-417

EXHIBIT
PUC-418
PENGAD 800-631-6989


RECEIVED
SEP 20 2018
PA PUBLIC UTILITY COMMISSION
SECRETARY'S BUREAU
EXHIBIT
PUC-419
PENGAD 800-631-6989

EXHIBIT
PUC-420
PENGAD 800-631-6989

RECEIVED
SEP 20 2018
PA PUBLIC UTILITY COMMISSION
SECRETARY'S BUREAU

2017

ANNUAL REPORT + 2018 Forecast

Heath Talhelm, Town Council President and Walter Bietsch, Mayor at the Utility Departments' addition under construction.

The Only Town In Pennsylvania with All Services & Utilities:

Electric Distribution • Electric Generation • Water • Sewer
Trash • Stormwater • Natural Gas • Police • Emergency Services
Land Use • Recreation • Public Works • Community Development

Electric

A Unique Chambersburg Tradition
Award Winning Municipal Electric System

By Ron Pezon, PE, CEM, CSDP, CDSM

The Borough's municipal electric utility has been diligently serving the expanding energy needs of our community for approximately 124 years; operating around the clock, logging some of the best reliability available and at prices competing with the lowest cost electric utilities in the Country.

Sometimes it appears that today's Chambersburg Electric Department operates much like the small town commercial electric utilities of yesteryear, but in other ways, Chambersburg is able to enjoy the vast benefits of today's competitive wholesale power purchasing marketplace to find inexpensive power supply for our homes and businesses. The Borough's operating model uses a legacy or traditional utility infrastructure consisting of generation, transmission, substation, distribution systems, meters and services. This is unique as deregulation has forced commercial, for-profit utilities, to no longer maintain this "vertically integrated" organization model. As a municipal non-profit community utility, we can still maintain this classic organization, which if managed well, is able to deliver the best of power reliability and prices to our end-users.

Our Mission: "The Chambersburg Electric Department with character, competence, and collaboration will provide to our customers valuable energy products and services that are safe, reliable, and competitively priced. The Electric Department will produce economic and other benefits to the Borough, its citizens, its customers, and employees, while operating in a professional and courteous manner within a structure of local accountability and local control."

The continuous improvement philosophy implemented in the Borough over the past several decades has begun to pay "dividends" in upgraded equipment, well trained experienced personnel, and knowledge of customer needs. Not only do the Borough residents notice the high quality of its electric services, but so did our national professional association.

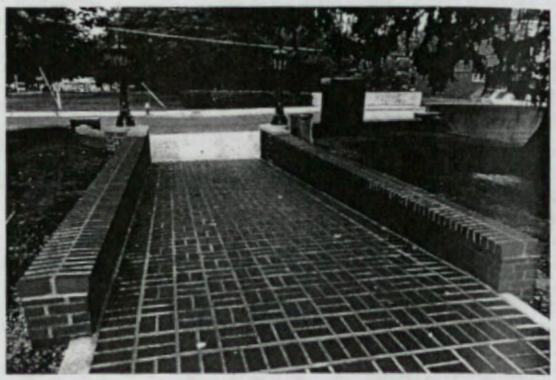
Reliable Public Power Provider (RP3)

The American Public Power Association, an organization serving over 2,000 public electric utilities like Chambersburg recognized Chambersburg Electric for the fourth time in 2017.

RP3 stands for Reliable Public Power Provider. The American Public Power Association instituted the RP3 Program to recognize public power entities that have achieved high levels of operational safety, personnel development, system development, and electric system reliability. The Chambersburg Electric Department has achieved this high-level of performance with APPA's RP3 recognition since 2009.

RELIABLE PUBLIC POWER PROVIDER RP3
American Public Power Association

Accomplishments 2017



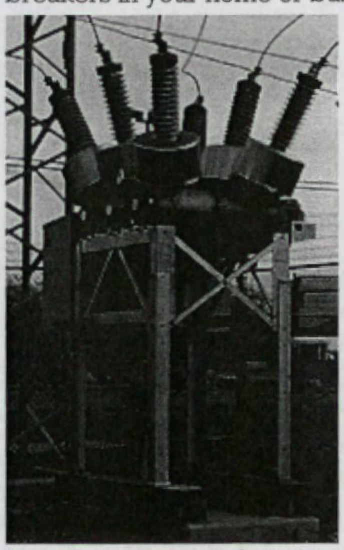
New Ramp from 2nd Street to the "Park of the Valiant" honoring Electric Department.

Consistent with our mission and that recognition, the Department made some fairly significant improvements to the "Park of the Valiant" and various other electric supply systems during the past year.

That Park with the fountain on North 2nd Street near the original power plant site commemorates the day in 1904 the public and media rose up to defend ownership of the municipally owned electric system including its first generator. The old entrance to the park was a set of deteriorating steps. The entrance was upgraded to a nice gentle ramp, suitable now for opening up the park facility to all Borough residents.

Further, as an example of continual infrastructure upgrades, Chambersburg replaced three old transmission circuit breakers that were nearing the end of their useful lives. We attempt to replace critical components before they are overloaded, malfunction, or fail. If not replaced, system electrical devices can sometimes fail in service catastrophically causing possibly numerous extended customer power outages.

In function, these large circuit breakers work just like the circuit breakers in your home or business; these are just way-larger! See the new Grant Street Substation circuit breaker below.

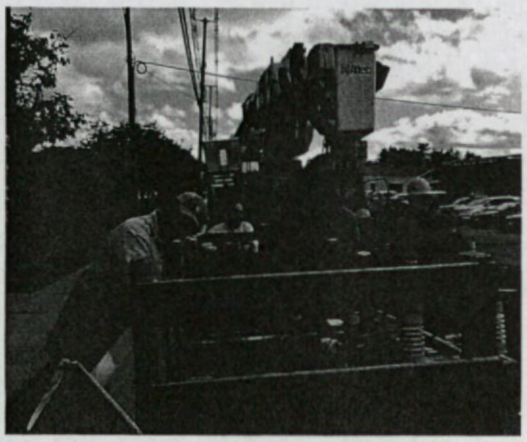


New Grant Street Substation Breaker

The department finished extending a new 12 kV distribution feeder to connect the Commerce Street Substation to a feeder that comes from the Cree Substation (Walker Road area). In 2018, the Commerce Street feeder cable will pick up the residential and business services presently connected to the old 4 kV circuit in that area. There will be weeks of many small short-duration local outages planned around the Broad Street area while the transformers and electric service drops are transferred over. After all of the services are transferred, there will be a subsequent somewhat longer outage to finally swap all the customers from the old line to the new upgraded line. The strategy of replacing old and obsolete equipment before it fails significantly reduces outage frequencies and durations. The old over head wires will be removed, making a more reliable and nicer looking streetscape in that neighborhood.

The Department is ultimately working to connect each of the Boroughs seven electric substation outputs for added system load transferability and reliability. This distribution system design and operating practice allows the line crews to isolate a problem and restore power to the largest number of customers possible in most cases in the shortest amount of time. In some of the more severe outage cases then, we can switch many customers to the "good sections" of line from another substation while we figure out how to repair the damaged facilities, and then subsequently repair them. This planning and operating practice limits the number of customers affected and reduces outage time experiences to a minimum. Our practice is called "restore and repair" using these pre-purposed multiple substations, feeders, and field installed switch-points.

An example of that safe and successful practice is shown below, where line crew members (L-R) Chuck, Keith, Rob, and line worker leader Rich have finished up an emergency repair on a switch damaged from a vehicle hit on Lincoln Way East.



Line Crews Recap Repairs Made to a Damaged Overhead Switch

Overall reliability can be significantly improved using the restore and repair concept switch points, and transfer capabilities. In larger electric utility systems these switching facilities and operating practices are often too expensive to implement. Chambersburg, with its compact system design is well-suited for this "best of class" system development and operating practice.

With all the spending on the system over the years you would think rates would have to climb accordingly. Well, not so in Chambersburg, at least due to the system improvement costs alone.

Rates

In recent history, we did see power purchase costs, and therefore rates, similarly climb into the lower double digits per kWh. Residential rates rose to about 12.6 cents per kWh at its worst time in recent history. From that high point in 2010 as a reminder, rates were forecasted to rise even further, but over the subsequent five years, staff consistently lowered costs while Borough Council consistently lowered overall electric rates in the following way, with a long term plan in mind:

The long term plan devised, and through favorable state legislation on power bidding around that time was changed from

Year	Month	Rate Reduction
2010	June	7.5%
	October	7.5%
2013	May	5%
	November	5%
2014	November	3.7%

the usual one-supplier concept to purchasing multiple power supplies from various power suppliers and over different term lengths. This new practice was the beginning of lowering and smoothing out for Borough residents the volatility of electric rates as seen in the markets from time to time.

The change in overall rates, from where the rates were proposed to go in 2010 as compared to where they actually went was a net reduction from that plan of about 30% over the subsequent 5-year period. The rate schedules were all lowered further in 2013 and finally in 2014 as a direct result of the new portfolio power purchasing strategy adopted by council on May 14, 2012. The new multiple source and block portfolio approach approved by Council was responsible for significantly lowering then, and stabilizing power supply costs over the past three years.

Expanding the Power Supply Portfolio:

Unlike the now widespread investor-owned electric utilities of today, Chambersburg, using its locally owned and operated system keeps most of the benefits of municipal management within the Borough and for the exclusive benefit of its residents.

Instead of each business and citizen having to wisely select their own power supply arrangement (or worse yet, let the big utility decide what they think is best for you), your local power supply team shops the wholesale electric marketplace to get you the best least cost electricity on your behalf. We pool all the needs of the citizens and businesses in Chambersburg and ***WeShop4U*** as a power "pool"; up to twice per year for the Borough's 11,400 or so retail customers, the power supply team goes shopping for bulk power deals. Also, the Borough, through its power generation is able to bring back home some of the outside or "market" derived financial benefits to its customers in the form of stable rates and power quality.

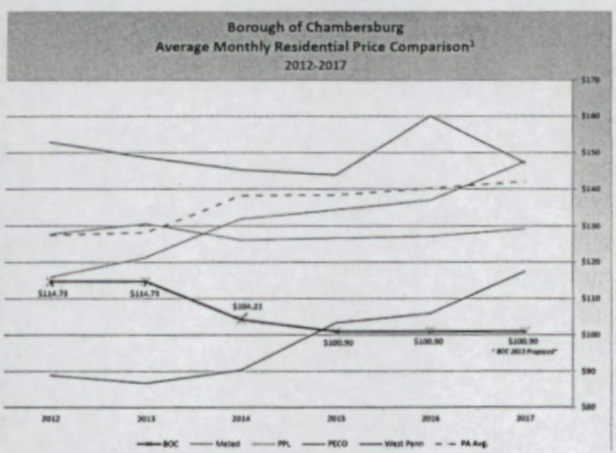
In 2017 and through 2023, the Borough will enjoy more than 18 different power supply agreements. The Borough also owns about 30 MW of dual-fueled (Natural Gas/Fuel Oil) reciprocating engine generation capability at two power plant locations that is sold to the regional transmission operator called "PJM" (Pennsylvania, Jersey, Maryland Interconnection). These generation assets, along with the power purchases from the Landfill Gas to power generators help offset the sometimes very st electricity in summer and winter. The power pur- team regularly considers options to fill in the un-pro- acancies in the portfolio plan to stabilize power prices ↄ the future.

ıing the Borough's renewable, sustainable energy ob- . (that make sense) in 2017 the power purchase team evaluating some small scale "community" solar electric tion projects. The power purchasing team will evalu- ıe and other technologies as they come along however ill be implemented without first performing rigorous fi- evaluations with positive results and second, bringing posals to Council for community discussion and possi- proval based on merits and long term viability.

oes Chambersburg's Overall Rate Compare?

ıka is the only state in the union that generates electric- ts consumers entirely from public power entities simi- bigger than Chambersburg. According to the official ıka government website ("Annual Average Electricity Comparison by State"), as of 2015, Washington State was . first as lowest customer cost per kWh (a standard unit tricity cost and measurement) at 7.41 cents per kWh. ıka, the whole state itself, being fully public power, was 15th in the U.S. at 9.04 cents per kWh. Chambersburg re to be compared in this study would just inch ahead is to be ranked 16th at an overall 9.12 cents per kWh in llinois was listed as 16th at 9.28 cents per kWh). Overall Pennsylvania ranked 31st in the U.S. coming in at 10.41 per kWh according to the study or about 14% higher on e than Chambersburg in that year. The national aver- ost per kWh in 2015 was right around Pennsylvania at cents per kWh. The states ranked in the study with the t cost per kWh were Alaska and Hawaii at 17.94 and cents per kWh respectively.

oersburg has not changed electric rates since Novem- 2014. This was accomplished even while replacing ograding aging infrastructure during that time and to this Whereas, simply reading the news, we know that many nding Pennsylvania utilities have already or will raise ates since this study was conducted in 2015 and with ructure upgrades often as the most common reason.



verage Residential Customer Monthly Bill omparison Using 1,000 kWh/Month

Electric rates in the Borough did rise for a time as we saw too in the outside world. Due to Town Council's strategic actions since 2010 however, Chambersburg's rates have come down to what is now below that of ***all*** surrounding investor-owned utilities. As a result of the new portfolio approach, the Borough's electric rates have settled in well below that of the state average for both overall electric rates and the typical (1,000 kWh/month) residential bill.

Renewable Energy and Sustainability

In 2017, due to its broad variety of accomplishments, the Borough was recognized as a Sustainable Pennsylvania Community by the Pennsylvania Municipal League in partnership with Sustainable Pittsburgh.

The Federal EPA award-winning Landfill Methane Outreach Program "Project of the Year 2013" Landfill gas to energy plant is nearing its halfway point in the initial ten year agreement. The Borough is looking at time-extension possibilities and various other viable expansion pricing structures in the coming years, including an Energy Power Partner's (EPP) owned small community solar power generating station with its power to also come back into Chambersburg on the Express Generator Feeder (EGF) or "extension cord" as the term was coined back in the day. The New York Power Authority hydro-electric power, landfill gas plant purchases, roof top solar, and new renewable power contracts are helping the Borough achieve a sustained estimated 16% renewable energy contribution toward is overall annual energy use.

Borough-Owned Generation Assets:

Chambersburg buys all of its power "wholesale" through the energy "portfolio" and re-sells it through the internal transmission and distribution systems to its retail customers. The department sells all of the power "generated" to the PJM bringing home its financial benefits to directly help lower the overall annual power supply costs. To maintain such high electricity delivery reliability and favorable long term financials, the Electric Department must routinely conduct maintenance on facilities and sometimes perform significant repair and/or upgrade projects.

Replacing CO Panel at Orchard Park Generating Station

Both of the Borough-owned Falling Spring and the Orchard Park Generating Stations were professionally tested for emissions compliance and subsequently passed the state's approved interim permitting standard stack tests in 2017. Maintenance of emission systems for compliance sometimes means that the very large carbon monoxide (CO) emission reducing panels need to be cleaned or replaced as shown hanging from the crane.

The Borough operates its generation assets according to strict Federal and State environmental regulations. In 2017, the power supply team performed routine and preventative maintenance on many of the generators and auxiliary equipment to ensure quick start ups and dependable and safe plant operations.

Jerry Howe, Power Supply Supv. Inspects CO Catalyst Change-Out

The department finished the relay and protection portion of the upgrade project at the Falling Spring Generating Station, Grant Street Substation critical to decommissioning an outdoor set of metal clad switchgear built in the early 1970's, and which is considered by many evaluators to be at the end of its useful life. The decommissioning project required replacing generator protection relays and will yet require moving the generator #5 and #6 power outputs over to another newer set of indoor switchgear at the Grant Street Substation allowing continued reliable generation sales to the PJM.

<u>Substation Improvements and Feeder Ties</u>

We continue to upgrade area substations, feeders, and transformers to serve the growing electricity needs of the community. The electric load is growing as a result of the good economic climate in this area that we have been experiencing over the past at least 5 years. Chambersburg's distribution systems are typically being built out in a way modeled after the best reliable systems.

In a sense, with the reliability achievements of late, the whole of Chambersburg on average would be considered a "Premium Power Park" by any state or national standard. Our infrastructure is just that good.

The Borough has a long term plan to upgrade substation transformers to meet the growing load and building out substation ties through existing and new feeder ties such that load can be transferred from one substation to another. The load transfer capability allows the line crews to "restore and repair". This means that they can transfer most customers to another distribution feeder restoring their power after isolating the problem, then repairing the problem section of line.

Pulling in New Conductor along Broad Street

The department also focuses on the worst performing circuits to reduce momentary outages as well as the extended outages from aged distribution facilities.

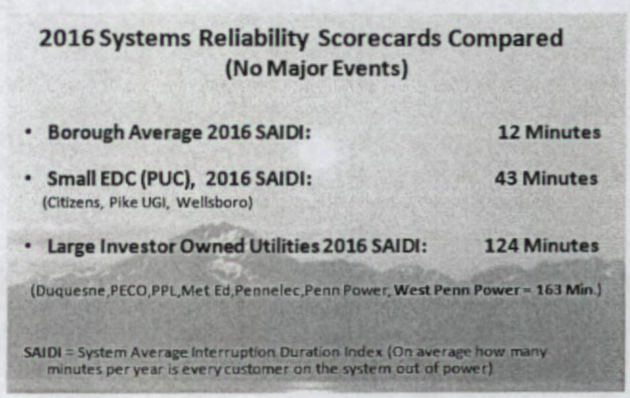
<u>2018 Reliability:</u>

Chambersburg has long strived to be one of the best electric system's for deliverability and reliability. The department systematically maintains and replaces obsolete equipment, attempting to replace or repair devices prior to them failing in service. It takes less time to replace equipment in a planned and organized way than it does to make repairs under emergency conditions. Usually, the "predictive" approach is more effective in keeping reliability up and costs down as compared to waiting for things to fail, sometimes catastrophically, and while in service.

The Electric Department and its customers continue to enjoy among the highest reliability statistics in the nation due to maintaining and upgrading/replacing aged infrastructure whenever possible prior to equipment failures.

There are several measurements for "reliability" in the electric utility industry. The main two measurements that we use are the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI). Outages over 5 minutes are counted in the statistics for the duration index and momentary interruptions (those 5 minutes or less) are counted in the frequency index. We all know what extended outages are. Momentary interruptions are those annoying outages required to clear a major fault/short circuit on the system, when power is restored right away, but unfortunately it makes some older clocks without battery back-up "blink", needing to be reset.

You can see in the chart below that Chambersburg stacks up well against all Pennsylvania utilities, big and small. Neighboring West Penn Power logged, according to the PA PUC 2016 Reliability Report, that on average every customer on their system was out of power for 163 minutes each during that year. Every customer served by the Borough in 2016 was out of power for an overall average of 12 minutes each.



eia U.S. Energy Information Administration

Analysis & Projections

Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants

Release Date: November 22, 2016

Addendum - Capital Cost Estimates for Additional Utility Scale Generating Plants Release Date: April 7, 2017

Introduction

The current and future projected cost and performance characteristics of new electric generating capacity are critical inputs into the development of energy projections and analyses. The construction and operating costs, along with the performance characteristics of new generating plants, play an important role in determining the mix of capacity additions that will serve future demand for electricity. These parameters also help to determine how new capacity competes against existing capacity, and the response of the electric generators to the imposition of environmental controls on conventional pollutants or any limitations on greenhouse gas emissions.

EIA commissioned an external consultant to develop up–to–date cost and performance estimates for utility–scale electric generating plants for AEO2013.[1] This information allowed EIA to compare the costs of different power plant technologies on a standardized basis and was a key input enhancement to the National Energy Model System (NEMS). For the AEO2016 development, EIA commissioned the same consultant group to update the cost and performance estimates for a select set of the technologies evaluated in the original 2012 study. This paper summarizes the results of the findings and discusses how EIA used the updated information to analyze the development of new capacity in the electric power sector.

Developing updated estimates: key design considerations

The focus of the 2016 update was to gather current information on the "overnight" construction costs, operating costs, and performance characteristics for a wide range of generating technologies.[2] The estimates were developed through costing exercises, using a common methodology across technologies. Comparing cost estimates developed on a similar basis using the same methodology is of particular importance to ensure modeling consistency.

Each technology is represented by a generic facility of a specific size and configuration, in a location that does not have unusual constraints or infrastructure requirements. Where possible, costs estimates were based on information on system design, configuration, and construction derived from actual or planned projects known to the consultant, using generic assumptions for labor and materials rates. When this information was not available, the project costs were estimated using a more generic technology representation and costing models that account for the current labor and materials rates necessary to complete the construction of a generic facility as well as consistent assumptions for the contractual relationship between the project owner and the construction contractor.

The specific overnight costs for each type of facility were broken down to include:

- **Civil and structural costs:** allowance for site preparation, drainage, the installation of underground utilities, structural steel supply, and construction of buildings on the site

- **Mechanical equipment supply and installation:** major equipment, including but not limited to, boilers, flue gas desulfurization scrubbers, cooling towers, steam turbine generators, condensers, photovoltaic modules, combustion turbines, wind turbines, and other auxiliary equipment
- **Electrical and instrumentation and control:** electrical transformers, switchgear, motor control centers, switchyards, distributed control systems, and other electrical commodities
- **Project indirect costs**: engineering, distributable labor and materials, craft labor overtime and incentives, scaffolding costs, construction management start up and commissioning, and fees for contingency[3]
- **Owners costs:** development costs, preliminary feasibility and engineering studies, environmental studies and permitting, legal fees, insurance costs, property taxes during construction, and the electrical interconnection costs, including a tie-in to a nearby electrical transmission system

Non–fuel operations and maintenance (O&M) costs associated with each of the power plant technologies were evaluated as well. The O&M costs that do not vary significantly with a plant's electricity generation are classified as fixed, including salaries for facility staff and maintenance that is scheduled on a calendar basis. The costs incurred to generate electricity are classified as variable such as the cost of consumable materials and maintenance that may be scheduled based on the number of operating hours or start–stop cycles of the plant. The heat rates4 were also evaluated for the appropriate technologies. It should be noted that all estimates provided in this report are broad in scope. A more in– depth cost assessment would require a more detailed level of engineering and design work, tailored to a specific site.

Findings

Table 1 summarizes updated cost estimates for generic utility–scale generating technologies, including four powered by coal, six by natural gas, three by solar energy, and one each by wind, biomass, uranium, and battery storage. EIA does not model all of these generating plant types, but included them in the study in order to present consistent cost and performance information for a broad range of generating technologies and to aid in the evaluation for potential inclusion of new or different technologies or technology configurations in future analyses.

The specific technologies represented in the NEMS model for AEO2016 that use the cost data from this report are identified in the last column of Table 1.

Table 2 compares the updated overnight cost estimates to those developed for the 2013 report. To facilitate comparisons, the costs are expressed in 2016 dollars.[5]Notable changes include:

- **Ultra Supercritical Coal (USC) with and without carbon capture and storage (USC/CCS).** USC with carbon capture and storage was added for this study to help meet EPA's 111b new source performance standard for carbon emissions. While USC without carbon capture cannot be built under current regulations, inclusion of this technology maintains the capability to analyze policy alternatives that may exclude 111b requirements.
- **Conventional Natural Gas Combined Cycle (NGCC) and Advanced Natural Gas Combined Cycle (ANGCC):** The updated overnight capital cost for conventional and advanced NGCC plants remained level relative to the cost in the 2013 study. The capacity of the NGCC unit increased from 400 MW in the 2013 study to 429 MW, while the capacity of the ANGCC unit increased from 620 MW to 702 MW for ANGCC to reflect trends toward larger installations for this technology.
- **Onshore Wind**: Overnight costs for onshore wind decreased by approximately 25 percent relative to the 2013 study, primarily due to lower wind turbine prices. EIA adjusted regional cost factors for wind plants from those reported in this report for inclusion in AEO 2016 [Table 8.2]. The regional factors in this report primarily account for regional variation in labor and materials costs, but subsequent evaluation of the regional variation in wind plant costs found that other factors, such as typical plant size, may account for a larger share of the observed regional differences in cost for the wind plants.
- **Solar Photovoltaic:** The overnight capital costs for solar photovoltaic technologies decreased by 67 percent for the 20 MW fixed tilt photovoltaic systems from the costs presented in the 2013 study. Solar photovoltaic single–axis

tracking systems were introduced in this report (including both a 20 MW and 150 MW system configurations). There is not a significant difference in Capital costs between fixed–tilt and single–axis–tracking systems. The overall decreases in costs can be attributed to a decline in the component costs and the construction cost savings for the balance of plant systems.

As previously noted, costs are developed using a consistent methodology that includes a broad project scope and includes indirect and owners costs. The cost figures will not necessarily match those derived in other studies that employ different approaches to cost estimation.

EIA's analysis of technology choice in the electric power sector

EIA's modeling employs a net present value (NPV) capital budgeting methodology to evaluate different investment options for new power plants. Estimates of the overnight capital cost, fixed and variable operations and maintenance costs, and plant heat rates for generic generating technologies serve as a starting point for developing the total cost of new generating capacity. However, other parameters also play a key role in determining the total capital costs. Because several of these factors are dynamic, the realized overall capital cost for given technologies can vary based on a variety of circumstances. Five of the most notable parameters are:

- **Financing:** EIA determines the cost of capital required to build new power plants by calculating a weighted average cost of capital using a mix of macro–economic parameters determined through EIA's modeling and an assumed capital structure for the electric power industry.
- **Lead Time:** The amount of time needed to build a given type of power plant varies by technology. Projects with longer lead times increase financing costs. Each year of construction represents a year of additional interest charges before the plant is placed in service and starts generating revenue. Furthermore, plants with front–weighted construction and development profiles will incur higher interest charges during construction than plants where most of the construction expenditures occur at the end of the development cycle.
- **Inflation of material and construction costs:** The projected relationship between the rate of inflation for the overall economy and key drivers of plant costs, such as materials and construction, are important elements impacting overall plant costs. A projected economy–wide inflation rate that exceeds the projected inflation rate for materials and construction costs results in a projected decline in real (inflation–adjusted) capital costs and vice versa.
- **Resource Supply:** Technologies such as wind, geothermal, or hydroelectric must be sited in suitable locations to take advantage of the particular resource. In order to capture the site specific costs associated with these technologies, EIA develops upward sloping supply curves for each of these technologies. These curves assume that the lowest –cost, most–favorable resources will be developed first, and when only higher–cost, less–favorable sites remain, development costs will increase and/or project performance will decrease.
- **Learning by doing:** The overnight capital costs developed for the report serve as an input to EIA's long term modeling and represent the cost of construction for a project that could begin as early as 2015. However, these costs are assumed to decrease over time in real terms as equipment manufacturers, power plant owners, and construction firms gain more experience with certain technologies. The rate at which these costs decline is often referred to as the learning rate.

EIA determines learning rates at the power plant component level, not for the power plant technology itself because some technologies share the same component types. It is assumed that the knowledge and experienced gained through the manufacture and installation of a given component in one type of power plant can be carried over to the same component in another type of plant. As an example, the experience gained through the construction of natural gas combustion turbine plants can be leveraged to influence the overall cost of building a Natural Gas Combined Cycle unit, which in part, includes the components of a combustion turbine natural gas plant. Other technologies, such as nuclear power and pulverized coal (PC) plants without CCS, do not share component systems, and their learning rates are determined solely as a function of the amount of capacity built over time.

Technologies and their components are represented in the NEMS model at various stages of maturity. EIA classifies technologies into three such stages: mature, evolutionary, and revolutionary. The initial learning rate is evaluated for each technology. The technology classification determines how the rate of cost reduction changes as each technology progresses through the learning function. Generally, overnight costs for technologies and associated components decline at a specified rate based on a doubling of new capacity. The cost decline is fastest for revolutionary technologies and slower for evolutionary and mature technologies.[6]

The capacity additions used to influence learning are primarily developed from NEMS results. However, external capacity additions from international projects are also included for some technologies, to account for additional learning from such projects. For power plant technologies with multiple components, the capacity additions are weighted by the contribution of each component to the overall plant construction cost.[7]

Table 3 classifies the status of each technology and component as modeled in AEO2016.

The NEMS model also assumes that efficiency for all fossil–fueled plants improves as a result of learning by doing. The power plant heat rates provided by the consultant are intended to represent the characteristics of a plant that starts construction in 2015 referred to as "first–of–a–kind." NEMS assumes that the heat rate for all fossil fueled technologies declines over time to a level referred to as an "nth–of– a–kind" heat rate.[8] The magnitude of heat rate improvement depends on the current state of the technology, with revolutionary technologies seeing a more significant decline in heat rate than mature technologies. Heat rate improvements are independent of capacity expansion. Fixed and variable O&M are not assumed to achieve learning–related savings. The performance of wind plants, as measured by capacity factor, is also assumed to improve as a result of learning by doing.[9]

Impact of location on power plant capital costs

The estimates provided in this report are representative of a generic facility located in a region without any special issues that would alter its cost. However, the cost of building power plants in different regions of the United States can vary significantly. The report includes location–based cost adjustment tables for each technology in 64 metropolitan areas. These adjustments were made to reflect the impact of remote location costs, costs associated with seismic design that may vary by region, and labor wage and productivity differences by region. In order to reflect these costs in Ela's modeling, these adjustments were aggregated to represent the 22 Electricity Market Module regions. EIA also assumes that the development of certain technologies is not feasible in given regions for geographic, logistical, or regulatory reasons. The regional cost adjustments and development restrictions are summarized in Table 4.

Subsequent peer review of these results indicated that the regional factors used for wind plants do not adequately reflect observed regional variation of wind plant costs, which appear to be substantially determined by factors other than those considered above. In particular, EIA found a significant regional variation in typical plant size that generally correlated with regional variation in installation costs. Therefore, EIA does not use the regional factors included in this report for its analysis of wind technologies. Regional factors used for AEO2016 and related analyses can be found in Table 8.2 of the AEO2016 Assumptions document, and are also shown in Table 4.

Summary

The estimates provided by the consultant for this report are key inputs for EIA electric market projections, but they are not the sole driver of electric generation capacity expansion decisions. The evolution of the electricity mix in each of the 22 regions modeled in AEO2016 is sensitive to many factors, including the projected evolution of capital costs over the modeling horizon, projected fuel costs, whether wholesale power markets are regulated or competitive, the existing generation mix, additional costs associated with environmental control requirements, and future electricity demand.

Users interested in additional details regarding these updated cost estimates should review the consultant study prepared by Leidos Engineering, LLC in Appendix B.

see full report report

see addendum

Footnotes

[1] U.S. Energy Information Administration, Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants 2013.

[2] The term "overnight" refers to the cost of the project as if no interest were incurred during its construction.

[3] Fees for contingency include contractor overhead costs, fees, profit, and construction.

[4] Heat Rate is a measure of generating station thermal efficiency commonly stated as Btu per kilowatthour.

[5] U.S. Energy Information Administration, Annual Energy Outlook 2016, Table 20, GDP chain-type price index.

[6] U.S. Energy Information Administration, Electricity Market Module Assumptions Document, Table 8.3.

[7] U.S. Energy Information Administration, Electricity Market Module Assumptions Document Table 8.4.

[8] U.S. Energy Information Administration, AEO2016 Cost and Performance Characteristics of New Central Station Electricity Generating Technologies, Table 8.2.

[9] U.S. Energy Information Administration, Renewable Fuels Module

Independent Statistics & Analysis
U.S. Energy Information Administration

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Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2018

The tables presented below will be incorporated in the Electricity Market Module chapter of the AEO2018 Assumptions document. Table 8.2 represents EIA's assessment of the cost to develop and install various generating technologies used in the electric power sector. Generating technologies typically found in end-use applications, such as combined heat and power or "roof-top" photovoltaics (PV), will be described elsewhere in the Assumptions document. The costs shown in Table 8.2, except as noted below, represent costs for a typical facility for each generating technology before adjusting for regional cost factors. Overnight costs exclude interest accrued during plant construction and development. Technologies with limited commercial experience may include a "Technological Optimism" factor to account for the tendency during technology research and development to underestimate the full engineering and development costs for new technologies.

All technologies demonstrate some degree of variability in cost based on project size, location, and access to key infrastructure (such as grid interconnections, fuel supply, and transportation). For wind and solar PV in particular, the cost favorability of the lowest-cost regions compound the underlying variability in regional cost and create a significant differential between the unadjusted costs and the capacity-weighted average national costs as observed from recent market experience. To correct for this, Table 8.2 shows a weighted average cost for both wind and solar PV based on the regional cost factors assumed for these technologies in the AEO2018 and the actual regional distribution of the builds that occurred in 2016. For AEO2018, the electricity model includes two solar PV technologies, one using single-axis tracking technology and the other using fixed tilt arrays.

Table 8.3 presents a full listing of the overnight costs for each technology and electricity region (http://www.eia.gov/outlooks/aeo/pdf/nerc_map.pdf), if the resource or technology is available to be built in the given region. The regional costs reflect the impact of locational adjustments, including one to address ambient air conditions for technologies that include a combustion turbine and one to adjust for additional costs associated with accessing remote wind resources. Temperature, humidity and air pressure can impact the available capacity of a combustion turbine, and EIA's modeling addresses this through an additional cost multiplier by region. Unlike most other generation technologies where fuel can be transported to the plant, wind generators must be located in areas with the best wind resources. As sites near existing transmission, with access to a road network, or otherwise located on lower-development-cost lands are utilized, additional costs may be incurred to access sites with less favorable characteristics. EIA represents this through a multiplier applied to the wind plant capital costs that increases as the best sites in a given region are developed.

Table 8.2. Cost and performance characteristics of new central station electricity generating technologies

Technology	First available year[1]	Size (MW)	Lead time (years)	Base overnight cost (2017 $/kW)	Project Contingency Factor[2]	Technological Optimism Factor[3]	Total overnight cost[4,10] (2017 $/kW)	Variable O&M[5] (2017 $/MWh)	Fixed O&M (2017$/kW/yr)	Heat rate[6] (Btu/kWh)	nth-of-a-kind heat rate (Btu/kWh)
Coal with 30% carbon sequestration (CCS)	2021	650	4	4,641	1.07	1.03	5,089	7.17	70.70	9,750	9,221
Coal with 90% CCS	2021	650	4	5,132	1.07	1.03	5,628	9.70	82.10	11,650	9,257
Conv Gas/Oil Combined Cycle (CC)	2020	702	3	935	1.05	1.00	982	3.54	11.11	6,600	6,350
Adv Gas/Oil CC	2020	429	3	1,026	1.08	1.00	1,108	2.02	10.10	6,300	6,200
Adv CC with CCS	2020	340	3	1,936	1.08	1.04	2,175	7.20	33.75	7,525	7,49
Conv Combustion Turbine[7]	2019	100	2	1,054	1.05	1.00	1,107	3.54	17.67	9,880	9,600
Adv Combustion Turbine	2019	237	2	648	1.05	1.00	680	10.81	6.87	9,800	8,550
Fuel Cells	2020	10	3	6,192	1.05	1.10	7,132	45.64	0.00	9,500	6,960
Adv Nuclear	2022	2,234	6	5,148	1.10	1.05	5,946	2.32	101.28	10,460	10,460
Distributed Generation - Base	2020	2	3	1,479	1.05	1.00	1,553	8.23	18.52	8,969	8,900
Distributed Generation - Peak	2019	1	2	1,777	1.05	1.00	1,866	8.23	18.52	9,961	9,880
Battery Storage	2018	30	1	2,067	1.05	1.00	2,170	7.12	35.60	N/A	N/A
Biomass	2021	50	4	3,584	1.07	1.00	3,837	5.58	112.15	13,500	13,500
Geothermal[8,9]	2021	50	4	2,615	1.05	1.00	2,746	0.00	119.87	9,271	9,271
MSW - Landfill Gas	2020	50	3	8,170	1.07	1.00	8,742	9.29	417.02	18,000	18,000
Conventional Hydropower[9]	2021	500	4	2,634	1.10	1.00	2,898	1.33	40.05	9,271	9,271
Wind[10]	2020	100	3	1,548	1.07	1.00	1,657	0.00	47.47	9,271	9,271
Wind Offshore[8]	2021	400	4	4,694	1.10	1.25	6,454	0.00	78.56	9,271	9,271
Solar Thermal[8]	2020	100	3	3,952	1.07	1.00	4,228	0.00	71.41	9,271	9,271
Solar PV - tracking[8, 11]	2019	150	2	2,004	1.05	1.00	2,105	0.00	22.02	9,271	9,271
Solar PV – fixed tilt[8,11]	2019	150	2	1,763	1.05	1.00	1,851	0.00	22.02	9,271	9,271

[1] - Represents the first year that a new unit could become operational.

[2] –AACE International, the Association for the Advancement of Cost Engineering, has defined contingency as "An amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs."

[3] - The technological optimism factor is applied to the first four units of a new, unproven design and reflects the demonstrated tendency to underestimate actual costs for a first-of-a-kind unit.

[4] - Overnight capital cost including contingency factors, excluding regional multipliers (except as noted for wind and solar PV) and learning effects. Interest charges are also excluded. These represent current costs for plants that would come online in 2018.

[5] - O&M = Operations and maintenance.

[6] - For hydropower, wind, solar and geothermal technologies, the heat rate shown represents the average heat rate for conventional thermal generation as of 2016. This heat rate is used for purposes of calculating primary energy consumption displaced for these resources, and does not imply an estimate of their actual energy conversion efficiency. The nuclear average heat rate is the weighted average tested heat rate for nuclear units as reported on the Form EIA-860, "Annual Electric Generator Report." No heat rate is reported for battery storage because it is not a primary conversion technology; conversion losses are accounted for when the electricity is first generated; electricity-to-storage losses are accounted for through the additional demand for electricity required to meet load.

[7] – Conventional combustion turbine units can be built by the model prior to 2018 if necessary to meet a given region's reserve margin.

[8] - Capital costs are shown before investment tax credits are applied.

[9] - Because geothermal and hydropower cost and performance characteristics are specific for each site, the table entries represent the cost of the least expensive plant that could be built in the Northwest Power Pool region, where most of the proposed sites are located.

[10] - Wind and both solar PV technologies' total overnight cost shown in the table represents the average input value across all 22 electricity market regions, as weighted by the respective capacity of that type installed during 2016 in each region to account for the substantial regional variation in wind and solar costs (as shown in Table 8.3). The input value used for wind in AEO2018 was $1,887 per kilowatt (kW), for solar PV with tracking was $2,207/kW, and for solar PV fixed tilt was $2,068, representing the cost of building a plant excluding regional factors. Region-specific factors contributing to the substantial regional variation in cost include differences in typical project size across regions, accessibility of resources, and variation in labor and other construction costs through the country.

[11] - Costs and capacities are expressed in terms of net AC power available to the grid for the installed capacity.

Source: Input costs are consistent with those used in AEO2017, and are primarily based on a report provided by external consultants, which can be found here: http://www.eia.gov/analysis/studies/powerplants/capitalcost/. The base costs above reflect calculated learning cost reductions based on recent builds occuring since the cost report was provided. The cost differential between the two PV technologies was based on Lawrence Berkeley National Lab's Utility-Scale Solar Report. Hydropower site costs for non-powered dams were updated for AEO2018 using data from Oak Ridge National Lab.

Table 8.3. Total overnight capital costs of new electricity generating technologies by region

2017 $/kW

Technology	1 (ERCT)	2 (FRCC)	3 (MROE)	4 (MROW)	5 (NEWE)	6 (NYCW)	7 (NYLI)	8 (NYUP)	9 (RFCE)	10 (RFCM)	11 (RFCW)
Coal with 30% CCS	4,560	4,764	5,034	4,893	5,334	N/A	N/A	4,967	5,563	5,059	5,140
Coal with 90% CCS	5,043	5,268	5,549	5,409	5,867	N/A	N/A	5,493	6,112	5,594	5,668
Conv Gas/Oil Combined Cycle (CC)	899	928	937	959	1,091	1,583	1,583	1,109	1,162	981	1,006
Adv Gas/Oil CC	1,062	1,084	1,052	1,095	1,230	1,687	1,687	1,250	1,300	1,099	1,145
Adv CC with CCS	2,030	2,106	2,115	2,092	2,227	3,173	3,173	2,239	2,379	2,131	2,190
Conv Combustion Turbine	1,063	1,104	1,052	1,095	1,149	1,558	1,558	1,134	1,217	1,096	1,122
Adv Combustion Turbine	661	683	655	683	737	1,054	1,054	732	794	682	703
Fuel Cells	6,683	6,847	7,168	6,953	7,196	8,644	8,644	7,096	7,325	7,125	7,111
Adv Nuclear	5,702	5,785	5,987	5,860	6,195	N/A	N/A	6,291	6,356	5,940	6,059
Distributed Generation - Base	1,382	1,423	1,524	1,519	1,775	2,537	2,537	1,797	1,859	1,577	1,594
Distributed Generation - Peak	1,792	1,862	1,773	1,846	1,938	2,628	2,628	1,912	2,052	1,849	1,892
Battery Storage	2,126	2,143	2,168	2,163	2,201	2,543	2,543	2,163	2,221	2,168	2,173
Biomass	3,538	3,638	3,910	3,714	3,952	4,708	4,708	3,968	4,086	3,818	3,875
Geothermal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MSW - Landfill Gas	8,043	8,296	8,812	8,465	8,821	11,015	11,015	8,733	9,030	8,716	8,689
Conventional Hydropower	N/A	5,165	N/A	1,694	1,904	N/A	N/A	3,896	4,047	N/A	3,527
Wind	1,573	N/A	2,371	1,604	2,510	N/A	2,725	2,246	2,132	2,475	1,817
Wind Offshore	5,893	6,454	6,493	6,524	6,622	8,268	8,268	6,396	6,622	6,422	6,493
Solar Thermal	3,603	3,831	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Solar PV - tracking	2,220	1,798	2,114	1,917	2,471	3,282	2,103	1,988	2,333	3,050	2,020
Solar PV – fixed tilt	2,081	1,685	1,982	1,797	2,316	3,076	1,970	1,863	2,186	2,859	1,893
	4,560	4,764	5,034	4,893	5,334	N/A	N/A	4,967	5,563	5,059	5,140

Technology	12 (SRDA)	13 (SRGW)	14 (SRSE)	15 (SRCE)	16 (SRVC)	17 (SPNO)	18 (SPSO)	19 (AZNM)	20 (CAMX)	21 (NWPP)	22 (RMPA)
Coal with 30% CCS	4,642	5,171	4,601	4,652	4,489	4,896	4,759	4,942	5,665	5,008	4,876
Coal with 90% CCS	5,139	5,713	5,088	5,144	4,958	5,409	5,262	5,459	6,230	5,527	5,375
Conv Gas/Oil Combined Cycle (CC)	896	1,018	923	901	874	973	938	1,072	1,237	1,021	1,149
Adv Gas/Oil CC	1,059	1,158	1,087	1,080	1,039	1,123	1,099	1,312	1,414	1,205	1,354
Adv CC with CCS	2,047	2,251	2,061	2,017	1,974	2,164	2,100	2,461	2,539	2,250	2,443
Conv Combustion Turbine	1,077	1,143	1,107	1,058	1,047	1,118	1,096	1,278	1,271	1,159	1,330
Adv Combustion Turbine	670	713	700	658	656	697	685	807	818	727	977
Fuel Cells	6,747	7,253	6,718	6,761	6,647	6,982	6,861	7,032	7,453	7,054	6,832
Adv Nuclear	5,738	6,035	5,720	5,749	5,684	5,874	5,803	5,904	N/A	5,963	5,946
Distributed Generation - Base	1,389	1,605	1,417	1,407	1,356	1,513	1,459	1,553	1,931	1,567	1,636
Distributed Generation - Peak	1,816	1,928	1,866	1,784	1,765	1,886	1,848	2,154	2,143	1,954	2,243
Battery Storage	2,139	2,191	2,134	2,137	2,126	2,159	2,146	2,160	2,254	2,177	2,149
Biomass	3,568	3,902	3,549	3,584	3,503	3,733	3,668	3,837	4,129	3,845	3,591
Geothermal	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,070	2,802	2,746	N/A
MSW - Landfill Gas	8,156	8,908	8,086	8,156	7,964	8,523	8,322	8,585	9,223	8,585	8,279
Conventional Hydropower	N/A	N/A	4,323	1,366	1,993	1,802	N/A	3,435	3,500	2,898	3,460
Wind	2,217	1,625	2,217	2,217	2,046	1,527	1,567	2,869	2,205	1,824	1,663
Wind Offshore	6,454	N/A	5,931	N/A	5,828	N/A	N/A	N/A	6,732	6,557	N/A
Solar Thermal	N/A	N/A	N/A	N/A	N/A	N/A	3,878	4,152	4,727	4,178	3,894
Solar PV - tracking	1,917	1,673	1,684	1,423	1,762	1,473	1,904	2,266	2,383	1,493	1,957
Solar PV – fixed tilt	1,797	1,568	1,578	1,333	1,651	1,381	1,785	2,124	2,233	1,399	1,834

Costs include contingency factors and regional cost and ambient conditions multipliers. Interest charges are excluded. The costs are shown before investment tax credits are applied.

N/A: Not available; plant type cannot be built in the region due to lack of resources, sites or specific state legislation.

Electricity Market Module region map: http://www.eia.gov/outlooks/aeo/pdf/nerc_map.pdf.

Converters

Convert Megawatt to Kilovolt Ampere

Please provide values below to convert megawatt [MW] to kilovolt ampere [kV*A], or *vice versa*.

From: 429 megawatt

To: 429000 kilovolt ampere

Convert Clear

Result: 429 megawatt = 429000 kilovolt ampere

Megawatt to Kilovolt Ampere Conversion Table

Megawatt [MW]	Kilovolt Ampere [kV*A]
0.01 MW	10 kV*A
0.1 MW	100 kV*A
1 MW	1000 kV*A
2 MW	2000 kV*A
3 MW	3000 kV*A
5 MW	5000 kV*A
10 MW	10000 kV*A
20 MW	20000 kV*A
50 MW	50000 kV*A
100 MW	100000 kV*A
1000 MW	1000000 kV*A

EXHIBIT
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All Converters

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Light Converters
Electricity Converters
Magnetism Converters
Radiology Converters
Common Unit Systems

How to Convert Megawatt to Kilovolt Ampere

1 MW = 1000 kV*A
1 kV*A = 0.001 MW

Example: convert 15 MW to kV*A:
15 MW = 15 × 1000 kV*A = 15000 kV*A

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Popular Power Unit Conversions

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hp to watts
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kw to hp
watts to hp
Ton to BTU

Convert Megawatt to Other Power Units

Megawatt to Watt
Megawatt to Petawatt
Megawatt to Exawatt
Megawatt to Terawatt