Transmission Line Siting: A Quantitative Analysis of Transmission Demand and Siting Difficulty

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Abstract: Recent events, such as the California energy crisis, have focused national attention on the growing demand for electricity in the United States and the simultaneously lagging development of electricity transmission infrastructure. Although the nation's transmission grid began as a series of local connections for regional reliability, expanding interconnects and state deregulation have gradually transformed the system into a competitive superhighway for electricity trading. In spite of recent extreme examples of the nation's ailing grid and the widespread call for new transmission construction, transmission line siting is a difficult and time-consuming process often resulting in construction delays or cancellations of new lines. Problems with individual siting projects have been attributed primarily to public opposition, regulatory inconsistencies, geographic or topographical constraints, and lack of investment incentive; however, most of the information about siting difficulty is anecdotal and project-specific, and there is little comprehensive empirical analysis on the factors affecting transmission line siting.

This paper develops four unique measures of transmission line siting difficulty and based on these measures, presents a regression model for quantitatively evaluating the factors affecting siting at the state-level. The four measures of the dependent variable, siting difficulty, are 1) an economic measure based on variations in the marginal cost of electricity production, 2) a physical measure of the difference between proposed and actual transmission construction, 3) a geographic measure of the co-location of generation capacity and demand load centers within a state, and 4) a subjective measure from a survey of industry experts' perceptions. Using these four measures of siting difficulty, this paper also evaluates perceived and actual siting constraints using a series of regression analyses. The results from these measures and analyses parallel documented perceptions of siting constraints and serve as quantitative counterpart to existing anecdotal information on siting. Overall, the framework that this research provides for characterizing siting difficulty and siting constraints has the potential to serve as a tool for communication between siting agencies, foster a common understanding of the siting problem, and address existing issues with inter-agency coordination. In a field dominated by uncertainty and anecdote, this paper provides a guide for characterizing the demand for transmission construction, evaluating specific siting problems, and coordinating siting solutions.

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1 Introduction

As transmission line siting shows signs of becoming increasingly difficult, studies analyzing the demand for transmission capacity are rapidly increasing, and the call for immediate transmission construction by industry regulators, utilities, and other energy providers is nearly unanimous. (Edison Electric Institute, 2002) Although the United States has one of the most reliable electricity systems in the world, it can be argued that electricity transmission supply has not grown rapidly enough to meet the growing demand. (Hirst and Kirby, 2002) With examples of this shortage of transmission capacity like the California electricity crisis, the widespread concern over the transmission grid has even spread to the popular media.[1] Additionally, these growing media commentaries are paralleled by quantitative industry evaluations of the transmission crisis,[2] and the drop in transmission construction relative to both generation and consumer demand are clearly illustrated in the graphs below.

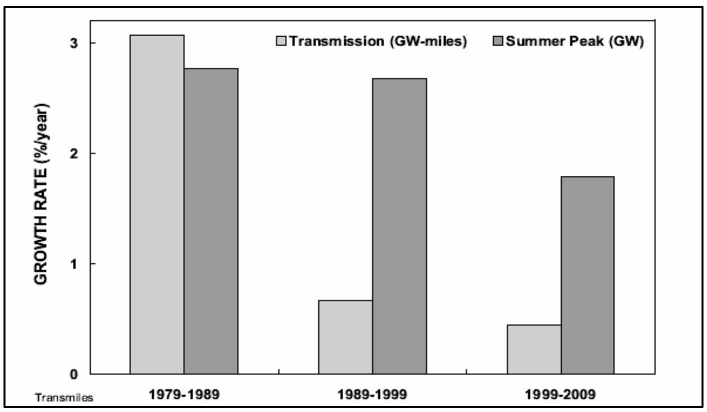

Figure 1.1 Average Annual Growth Rates of U.S. Transmission Capacity and Demand. (Hirst and Kirby, 2001.)

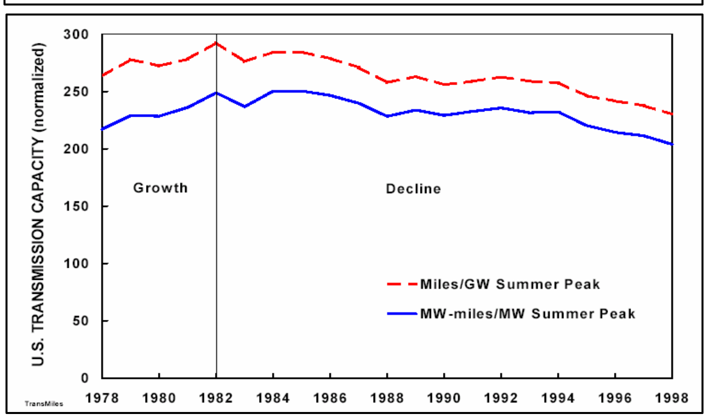

Figure 1.2 Relative Change of U.S. Transmission Capacity to Summer Peak Demand. (Hirst and Kirby, 2001.)

The demonstrable need for transmission projects, the awareness of the pressing need, and the continuing inability serve the need exemplify the problems with building new transmission infrastructure in the electric industry today. (Gale and O'Driscoll, 2001) Overall, the current

[1] In August 2001, Spencer Abraham, U.S. Secretary of Energy, was quoted widely in the media saying, "The shortage of transmission lines is nationwide and will worsen as the demand for electricity grows if corrective steps are not quickly taken." Similarly, Scott Horsley, a reporter for National Public Radio, observed "The problem is, building new transmission lines isn't very profitable, and would-be builders often have to contend with opposition from neighborhood residents. As a result, the country invested less than half as much in new transmission lines in 1999 as it did in 1979." (EEI, November 2001)

[2] Karl Stahlkopf, vice-president of EPRI, notes more precisely "Electric demand increased about 30 percent in the last decade, while transmission capacity rose only about 13 percent." (EEI, Nov. 2001)

attitude toward transmission construction is summarized in a single statement by William McCormick Chairman of CMS Energy Co., in criticism of federal rules that limit the stake that energy firms can hold in transmission projects "You can't build it and even if you could, you wouldn't want to invest in it." (Levesque, 2001)

2 Characterizing Siting Problems

Like McCormick, the majority of research studies and media articles on transmission line siting propose two main theories of why transmission infrastructure is not being built. First, there is little or no economic incentive to build new transmission. (Reuters, 2002; Levin, 2001) Second, siting is simply so difficult that the construction of new lines becomes economically infeasible because of the additional cost incurred by confounding factors. (Kuhn, 2002; Howe, 2001) These hypotheses, while widespread, are supported in most cases only by anecdotal information. Since data on transmission line siting suffers from being largely project specific, even the existing anecdotal information is rarely compiled or aggregated at a regional level.[3] Overall, the problems associated with expanding the transmission grid are compounded by the lack of substantial data on siting issues.

While many experts in the field argue that significant variations among transmission projects within the same local area make any aggregate analysis of siting practices and problems impossible,[4] the majority of existing regulations and associated proposed siting policies focus on regional or national grid approaches to managing reliability, congestion, and competition. (DOE, 2002; Barton, 2001; FERC, 2000) The recent push toward Regional Transmission Organizations (RTOs) by the FERC exemplifies this trend toward larger units of transmission planning and management. This significant difference between the perception of industry experts and siting regulators of the scale of the transmission problem is a fundamental issue for any siting research. In order to develop analyses and policy proposals that are applicable to both local siting issues and regional policy development, this paper focuses on quantifying and analyzing siting difficulty at the state-level. Focusing on the state as the unit of analysis also addresses the current structure of regulation in the electric industry where state agencies have the primary authority over permitting and construction of electric infrastructure. (Resource Strategies, 2001) Quantitatively defining the siting problem at this intermediate scale of analysis allows for the simultaneous consideration of both the local and regional implications of transmission demand and difficulty for the transmission grid and the electric industry as a whole.

2.1 Economic Incentive

In order to explore the issue of transmission line siting at a state and regional level, this research first looks separately at the two primary constraints on transmission construction, economic incentive and siting difficulty. While there are locations between which there is no economic incentive to build new transmission, the more important question is “Are there lines for which there is the economic incentive to build a new line, but the line is neither proposed nor being considered for construction?” This question addresses the two-part nature of the transmission construction problem, where economic incentive is a fundamental consideration in transmission planning, and siting difficulty occurs only after a project is already deemed economically viable and necessary, if at all. This distinction between transmission costs and siting costs is ignored in many of the studies and articles on siting. For this research, transmission

[3] While there is a large body of data on transmission reliability and congestion, such as the Transmission Loading Relief Logs from NERC, none of the existing data sets associated with the transmission grid focus on siting issues, siting difficulty, or constraints within and between regions in the United States.
[4] Based on conversations and interviews with siting engineers and routing designers at Allegheny Power, the Edison Electric Institute, Duquesne Light, the Georgia Transmission Corporation and GAI Consulting.

costs are defined as the generally predictable costs such as land, equipment, materials, and labor associated with the construction of towers and lines. Siting costs, on the other hand, are defined as the potential high-variability costs associated with obtaining approvals, acquiring rights-of-way, proposing alternatives, conducting public meetings, and addressing environmental issues. Separating transmission economics from siting economics allows for an independent evaluation of the two main components of the transmission problem.

To determine if there is preliminary economic incentive for new transmission construction in select electricity markets, a simple analysis of potential transmission profits and costs is presented below. Using data from the Energy Market Reports (Economic Insight, 2000) daily price publications, the graph below illustrates the estimated profits of building a dedicated 230 kv transmission line[5] between all possible pairs of markets in the database.[6] This analysis assumes that a transmission owner can collect rents for a line between any given pair of markets equivalent to the average annual peak price differential in the year 2000 between those markets.[7] Using this algorithm, the profits associated with lines connecting 55 pairs of Western markets and 6 pairs of Eastern markets are plotted as points on the graph plotted below. Three different cost estimates[8] for transmission construction are then overlaid on the plot below to indicate which market pairs have higher estimated annual profits than costs.

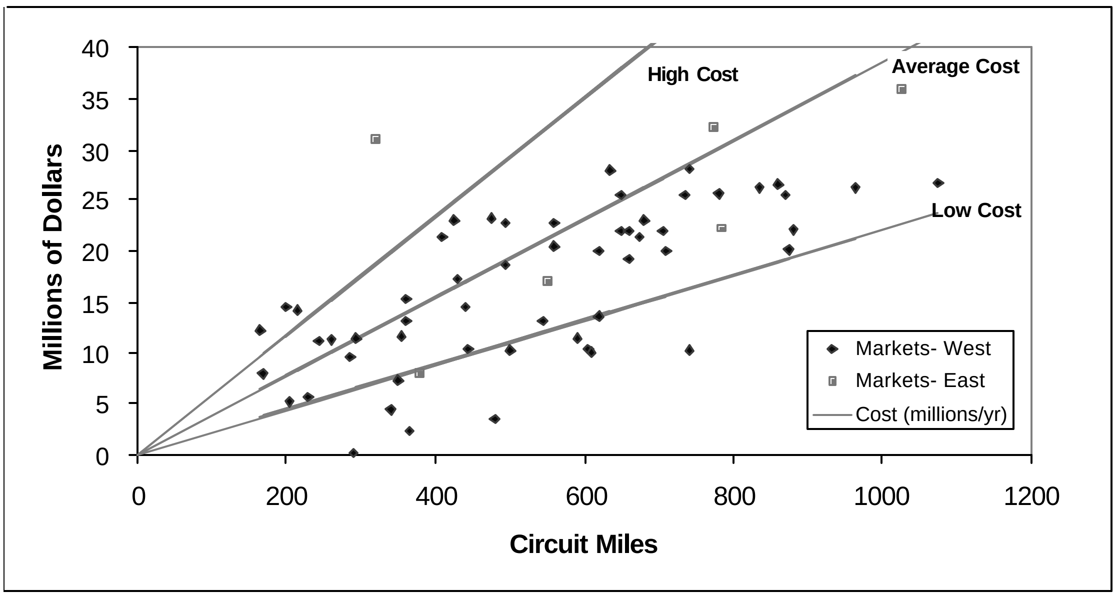

Figure 2.1 Potential Transmission Market Profits and Costs (Calculated from 2000 market prices with cost estimates per circuit-mile for a 230kv line from CSA Consultants, 1995.)

From the graph at the average cost for transmission construction, profits exceed costs for approximately 30% of all possible lines. This analysis does not attempt to suggest that the lines shown above are profitable at a more detailed level of evaluation where the costs of construction

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[5] Each of the proposed 230 kv transmission lines is assumed to have an effective capacity of 796 MW.

[6] The length of all proposed lines between market pairs is estimated as the straight-line distance in miles between market centroids.

[7] Market transactions are assumed to occur for 12 hours a day and 250 days per year at the average peak price differential for all profit calculations, and an investment period of 25 years at a 10% discount rate is assumed for the annualized cost calculations.

[8] Cost estimates include only transmission construction costs as defined above, not siting costs, and low cost = $200,000/circ. mile, average cost = $350,000/circ. mile, and high cost=$500,000/circ. mile.

in different environments may vary drastically; however, it is simply meant to serve as the motivation for further analysis of transmission economics in the face of siting difficulty.

As a simple answer to the initial question of economic incentive, this analysis indicates that in the current market structure opportunities for transmission investment and profit appear to exist. Since none of the lines in this analysis are currently under consideration for construction, other factors must contribute to increasing costs and making lines unprofitable. (Transmission Working Group, 2001) Both anecdote and analysis over the past decade focus on the expense and uncertainty associated with siting difficulty as the reason for lack of transmission investment.

2.2 Siting Difficulty

Siting difficulty in transmission planning is unique because of the amount of space required and the number of people potentially affected by transmission lines. While generation plants are associated with only a single location, transmission lines like gas pipelines can span multiple states and regions. Unlike gas pipelines however, the majority of transmission lines are highly visible overhead lines that are unregulated by a single federal agency with eminent domain authority. (Willet, 2002) These basic differences between transmission infrastructure and other major energy infrastructure are universal causes of siting problems; however, additional factors affecting siting difficulty such as environmental barriers, public opposition, and regulatory constraints vary drastically within and between states.

3 Quantifying Siting Difficulty: Indicators of Transmission Demand and Siting Difficulty

Given these variations in the factors affecting siting, numerous media articles qualitatively compare transmission issues and siting difficulty between individual projects and entire states. The most common example of siting variation is the comparison between California and Texas, where siting in California is described as “notoriously difficult” or “nearly impossible”[9] while siting in Texas is thought to be “fairly easy.”[10] (Sweeney, 2002; Texas PUC, 2001) These qualitative descriptors, while useful for conveying the extremes of the siting problem to the general public, provide little insight into the complex nature of siting practices and issues in either California or Texas.

In order to build a deeper understanding of siting difficulty and its causes across the United States, this paper proposes and examines four unique quantitative indicators of siting difficulty. These four measures of siting difficulty are 1) an economic measure based on variations in the marginal cost of electricity production, 2) a geographic measure of the co-location of generation capacity and demand load centers within a state, 3) a physical measure of the difference between proposed and actual transmission construction, and 4) a subjective measure from a survey of industry experts’ perceptions. Since there is no single perfect measure

[9] In December 2000 the California Independent System Operator (CAISO) was forced to declare several stage one and two power emergencies because of the extreme bottleneck along the transmission line Path 15 connecting southern and northern California. In spite of the recognized problem, the expansion of Path 15 is still currently being opposed. Overall, California experienced a several year period in which both transmission and generation construction completely stopped because of siting difficulties and local uncertainties about the impacts of deregulation on the industry.

[10] Unlike California, Texas had completed construction of 14 new generation plants in 2001 and begun the construction of 13 more plants that upon completion would represent more available electric capacity in Texas than the capacity additions of the last six years combined. Both the Texas Public Utilities Commission and local Texas newspapers attributed the boom in generation construction to the abundance of wide-open spaces in Texas and the relaxed zoning laws in some areas, and anticipate that electric power related construction would continue to increase for the next several years.

of siting difficulty, this paper uses these four measures to bound the siting problem. Each of these indicators is presented in detail below and used to evaluate comparative transmission congestion, construction demand, and siting difficulty for all the states in the continental United States.[11]

3.1 Economic: Variations in Cost of Generation and Production

With the recent focus on competition and deregulation, the transmission grid is being reevaluated for its ability to support competitive markets and transactions. Many high-level executives and government officials have raised serious concerns that existing transmission infrastructure is inadequate. In September 2001, Pat Wood then Chairman of the FERC observed that "The [transmission] grid increasingly is pushed to its operational limit, and transmission constraints frequently prevent the most efficient use of generation facilities." (EEI, November 2001) Similarly David Cook, general counsel of NERC, notes that "The lack of additional transmission capacity means that we will increasingly experience limits on our ability to move power, and that commercial transactions that could displace higher-priced generation with lower-priced generation will not occur." (EEI, November 2001)

Both Wood's and Cook's observations indirectly address the issue of siting difficulty: states that are currently unable to use their existing generation capacity efficiently have higher demand and greater economic incentive to build new transmission capacity. This economic measure of siting difficulty is based on the hypothesis that high variations of generation costs in a state relative to other states indicate transmission congestion and/or a lack of available capacity associated with siting difficulty in that state. In order to examine this hypothesis, cost of production data for 1,500 generation plants[12] across the U.S. are analyzed by state and presented in Table 3.1 below.

The data are sorted by size of plant, baseload and peaker,[13] to illustrate the variability in the mean, minimum, maximum, and standard deviation of cost of production in each state. The final column in both the baseload and peaker categories entitled "Savings 1000$" is a measure of the potential savings that could be realized from reallocating the distribution of generator load hours to an optimal schedule that minimized cost of production by assuming perfect transmission among all generators within a state.[14] Stated otherwise, this is a measure of the savings from running the cheapest generators for the longest number of hours until all demand in a state is met using existing generation capacity. From Table 3.1, states with high potential savings are currently operating sub-optimally by utilizing higher price generators a longer number of hours per year than existing lower price generators. Savings at the baseload vary from $36,500,000 in Texas to $7,000 in Alabama, and peaker savings range from $126,525,000 in Pennsylvania to $16,000 in New Hampshire. As expected states such as Wyoming that export a large percent of the total electricity generated in state, have low costs of production and low potential savings associated with generation portfolios dominated by relatively cheap baseload plants.

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[11] Because of lack of data, Alaska and Hawaii are not included in any of the analyses in this paper.

[12] The database of generation plants was compiled from a UDI Cost of Production database for all non-hydro generation plants and an RDI Generation database for all hydro plants.

[13] The baseload size category includes all hydro plants, all nuclear plants, and all other plants that ran for greater than 7,445 hours load in the year 2000 or 85% of the total possible hours in a year. The peaker size category includes all plants that ran fewer than 1,315 hours in the year 2000 or less than 15% of the total possible hours load in a year.

[14] The model for this optimal allocation analysis again separates baseload and peaker plants, but removes all hydro plants from the baseload category since it is assumed that hydro plants, though they may be the cheapest generators in a state, are already run at their maximum capacity and could not be run for any additional hours in a year.

	Baseload Cost of Production ($/Mwhr)				Peaker Cost of Production ($/Mwhr)			
State	**Mean**	**Difference (Max-Min)**	**Standard Deviation**	**Savings (1000 $)**	**Mean**	**Difference (Max-Min)**	**Standard Deviation**	**Savings (1000 $)**
Alabama	$14.74	$33.27	$6.97	$7	$40.47	$8.27	$5.85	$0
Arizona	$26.82	$54.04	$16.13	$137	$198.18	$764.29	$236.58	$5,480
Arkansas	$21.56	$9.74	$3.07	$4,376	$76.40	$71.95	$50.87	$142
California	$22.97	$67.63	$12.46	$9,131	$165.52	$1,701.79	$305.64	$59,320
Colorado	$18.50	$22.67	$6.52	$4,723	$219.01	$621.67	$259.93	$11,055
Connecticut	$34.07	$40.38	$12.72	$0	$216.75	$343.36	$111.27	$1,849
Delaware	-	-	-	$0	$387.51	$966.56	$377.45	$120
Florida	$24.68	$20.33	$5.94	$16,890	$276.77	$4,355.58	$941.38	$14,946
Georgia	$19.41	$15.09	$4.89	$212	$61.80	$90.57	$22.63	$1,552
Idaho	$16.06	$38.20	$10.64	$0	-	$0.00	-	$0
Illinois	$28.42	$70.90	$15.51	$8,081	$117.54	$332.15	$67.26	$12,211
Indiana	$19.51	$24.16	$6.20	$1,845	$80.06	$163.90	$54.81	$601
Iowa	$22.29	$51.80	$14.03	$7,273	$77.14	$96.79	$32.24	$560
Kansas	$17.17	$11.08	$4.69	$2,809	$75.04	$169.36	$51.13	$1,765
Kentucky	$14.80	$12.98	$3.79	$4,686	$87.82	$226.56	$68.84	$1,183
Louisiana	$25.94	$18.25	$6.05	$17,023	$183.73	$35.89	$25.38	$0
Maine	$17.27	$22.93	$11.20	$0	$1,125.20	$0.00	-	$0
Maryland	$19.27	$10.19	$3.45	$680	$73.16	$76.04	$25.85	$68
Massachusetts	$34.03	$31.56	$18.18	$0	$213.92	$624.98	$214.64	$6,606
Michigan	$21.29	$19.32	$5.69	$2,925	$119.99	$406.50	$109.65	$3,447
Minnesota	$26.19	$44.94	$15.16	$1,289	$159.14	$663.09	$168.00	$1,840
Mississippi	$20.25	$8.83	$3.61	$4,320	$152.58	$751.77	$254.73	$404
Missouri	$17.67	$15.63	$5.34	$3,200	$89.65	$227.76	$58.08	$4,939
Montana	$12.07	$19.84	$6.16	$0	$38.73	$5.98	$4.23	$0
Nebraska	$16.14	$27.40	$9.42	$3,487	$72.64	$139.15	$42.09	$928
Nevada	$18.68	$6.13	$3.07	$875	$78.80	$76.88	$35.04	$0
New Hampshire	$20.01	$13.17	$5.57	$1,217	$332.84	$366.47	$167.09	$16
New Jersey	$28.76	$22.34	$8.30	$3,093	$105.42	$252.03	$66.51	$5,336
New Mexico	$27.26	$12.86	$7.23	$36	$54.14	$0.00	-	$0
New York	$27.81	$84.20	$19.68	$35,760	$351.20	$3,251.01	$801.97	$7,258
North Carolina	$15.42	$39.30	$8.23	$6,272	$103.30	$142.40	$46.84	$1,000
North Dakota	$16.00	$10.93	$5.26	$0	$92.46	$0.00	-	$0
Ohio	$18.94	$16.73	$4.51	$15,666	$175.33	$401.36	$117.41	$519
Oklahoma	$20.55	$21.63	$6.75	$4,945	$49.60	$16.24	$7.09	$0
Oregon	$18.79	$41.77	$10.20	$0	$45.87	$0.00	-	$0
Pennsylvania	$21.52	$29.16	$7.54	$2,913	$82.27	$229.52	$49.21	$126,525
Rhode Island	$32.26	-	-	$0	-	$0.00	-	$0
South Carolina	$18.91	$28.53	$6.61	$1,971	$96.94	$100.11	$30.73	$2,439
South Dakota	$14.45	$19.82	$8.16	$0	$66.21	$60.56	$22.71	$85
Tennessee	$13.46	$27.81	$6.48	$2,129	$58.25	$36.35	$18.51	$0
Texas	$22.52	$33.33	$7.08	$36,530	$196.95	$1,511.50	$393.23	$31,516
Utah	$19.47	$21.13	$7.66	$325	-	$0.00	-	$0
Vermont	$21.65	$28.24	$14.22	$0	$119.43	$87.52	$34.73	$11
Virginia	$18.37	$13.74	$4.32	$1,190	$82.19	$83.12	$30.25	$78
Washington	$14.67	$27.26	$6.29	$5,825	$32.72	$11.19	$7.92	$0
West Virginia	$15.51	$3.26	$1.05	$998	-	$0.00	-	$0
Wisconsin	$20.59	$19.21	$7.69	$1,599	$90.25	$250.62	$74.04	$4,497
Wyoming	$12.69	$7.18	$2.73	$292	-	$0.00	-	$0

Table 3.1 **Economic Measure of Transmission Demand and Siting Difficulty**

3.2 Geographic: Distribution of Generation Capacity and Demand

Just as economic variability in generation indirectly indicates the need for new lines, a second measure of the demand for transmission capacity is the geographic relationship between the location of existing generation capacity and the location of demand load centers in a state. Using a Geographic Information Systems (GIS) model for all generation plants in the United States,[15] footprints based on 1 mile, 5 mile, 10 mile, 15 mile, 20 mile, and 25 mile radii are plotted around each plant as shown in Figure 3.2 to the right. These footprints are overlaid on census zipcode population data, and the percent area of each zip code contained within a footprint is calculated for each state. Assuming the population within a zipcode is uniformly distributed across that zipcode, the total population within each footprint radius is then determined for every state. If the population within a given footprint of a plant is greater than the total population potentially served by the plant,[16] then only the population able to be served by the plant generation is counted as served. In order to avoid double counting of populations near adjacent plants, overlapping footprints are merged as shown in the figure. The population served is then calculated from the sum of the total population potentially served by all plants in the joined footprint. Finally, the total population actually served within a given radius of all the plants in a state is calculated as a percent of the total population potentially served and shown in Table 3.3 below.[17]

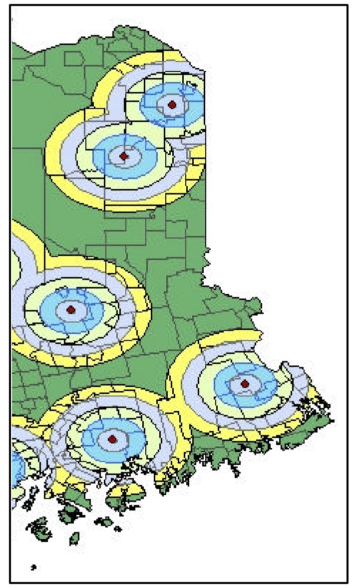

Figure 3.2 Illustration of GIS footprint model for plants in Eastern Maine.

From the table, a high percentage population served within a small radius indicates a close proximity of generation plants and population loads, and suggests a low demand for transmission lines, and vice versa. These data are also used to calculate the slope of a regression line that indicates the rate of increase in population served as the distance away from a plant increases across the six given footprint radii. For example, North Dakota with a low slope of 0.015 and less than 40% of the potential population served within a 25-mile radius, has a high demand for transmission lines; while New Hampshire with a high slope of 0.047 and 100% of the potential population served within a 25-mile radius has a low need for transmission lines. Overall, the percent of the total population unserved (100%- the % population served within each radius) is an indicator of the need for transmission to serve both populations outside all plant footprints and populations within footprints that are not served by the plants within the same footprints.

[15] The GIS model is based on latitude-longitude coordinates and plant net generation data from the EPA E-Grid database of all generators in the United States.

[16] The population potentially served by each plant is calculated by dividing the net annual generation of a plant (Mwhrs) by the state average annual per capita electricity consumption (Mwhrs/person).

[17] It should be noted that plant net annual generation data do not include capacity imports and exports from a state to provide a realistic picture of the need for transmission lines.

Percent of Total Population Served within Footprint Radius							
State	**1 mile**	**5 mile**	**10 mile**	**15 mile**	**20 mile**	**25 mile**	**Slope**
Alabama	0.4%	7.4%	30.0%	56.6%	74.7%	87.3%	0.039
Arizona	0.9%	4.7%	5.9%	59.8%	60.7%	61.7%	0.031
Arkansas	0.5%	4.7%	14.9%	37.1%	56.9%	82.6%	0.035
California	0.7%	14.2%	23.0%	31.3%	49.1%	55.4%	0.023
Colorado	0.8%	10.4%	19.7%	26.6%	51.1%	92.6%	0.035
Connecticut	1.9%	32.5%	47.8%	81.9%	98.2%	99.2%	0.042
Delaware	1.5%	26.8%	44.6%	83.9%	99.2%	100.0%	0.044
Florida	1.2%	17.2%	49.6%	62.9%	87.1%	90.3%	0.039
Georgia	0.6%	10.0%	37.5%	57.2%	88.0%	94.3%	0.043
Idaho	0.1%	3.9%	13.1%	24.5%	44.6%	85.1%	0.033
Illinois	0.9%	11.5%	32.7%	86.0%	95.2%	98.8%	0.047
Indiana	0.6%	12.7%	19.4%	68.9%	80.6%	91.4%	0.042
Iowa	0.9%	11.8%	26.0%	68.3%	83.0%	89.0%	0.041
Kansas	1.0%	17.2%	38.4%	56.9%	89.2%	95.7%	0.042
Kentucky	0.7%	15.3%	38.7%	48.4%	55.2%	81.5%	0.031
Louisiana	0.9%	19.3%	47.9%	61.9%	80.2%	87.7%	0.037
Maine	0.4%	8.4%	30.4%	40.1%	74.4%	82.8%	0.037
Maryland	1.7%	22.1%	46.1%	74.2%	95.1%	97.5%	0.043
Massachusetts	2.4%	30.9%	50.0%	72.1%	91.5%	95.6%	0.039
Michigan	1.1%	13.9%	37.2%	89.3%	96.6%	96.8%	0.046
Minnesota	1.4%	13.9%	44.7%	75.5%	87.9%	91.3%	0.041
Mississippi	0.3%	6.7%	18.6%	38.9%	51.3%	62.7%	0.027
Missouri	0.9%	15.4%	40.7%	73.8%	81.4%	91.5%	0.040
Montana	0.1%	5.1%	13.3%	18.0%	30.6%	48.4%	0.019
Nebraska	0.9%	5.8%	48.0%	72.4%	83.8%	91.5%	0.042
Nevada	1.1%	11.1%	34.3%	39.2%	58.0%	71.5%	0.029
New Hampshire	0.6%	11.0%	42.4%	79.7%	99.2%	100.0%	0.047
New Jersey	2.2%	19.9%	51.2%	81.0%	98.4%	99.3%	0.044
New Mexico	0.3%	2.4%	4.6%	7.3%	12.2%	14.9%	0.006
New York	5.7%	24.7%	48.3%	78.7%	94.7%	95.8%	0.041
North Carolina	0.7%	11.5%	40.0%	67.4%	86.5%	92.7%	0.042
North Dakota	0.1%	1.9%	8.8%	15.5%	19.3%	38.8%	0.015
Ohio	0.9%	6.9%	31.2%	56.5%	87.0%	91.2%	0.042
Oklahoma	0.7%	12.7%	22.0%	40.9%	52.0%	87.2%	0.034
Oregon	0.1%	1.8%	6.4%	14.1%	38.7%	50.6%	0.022
Pennsylvania	1.5%	15.8%	58.4%	89.1%	95.5%	98.4%	0.044
Rhode Island	2.3%	45.2%	80.0%	84.2%	98.5%	100.0%	0.038
South Carolina	0.9%	9.4%	31.2%	78.7%	94.4%	99.9%	0.047
South Dakota	0.3%	5.7%	10.5%	15.3%	30.4%	34.5%	0.015
Tennessee	0.5%	6.7%	25.9%	47.3%	66.1%	84.0%	0.036
Texas	1.1%	14.2%	37.8%	52.6%	80.0%	83.5%	0.037
Utah	0.5%	4.0%	6.1%	7.6%	88.2%	92.3%	0.042
Vermont	2.2%	13.1%	22.5%	75.9%	98.9%	99.0%	0.047
Virginia	1.3%	14.7%	36.3%	75.0%	93.4%	96.5%	0.044
Washington	0.4%	2.2%	6.1%	22.9%	38.4%	50.3%	0.022
West Virginia	0.6%	12.0%	39.5%	60.1%	72.0%	82.9%	0.036
Wisconsin	2.2%	13.7%	39.2%	83.0%	94.4%	94.8%	0.044
Wyoming	0.1%	1.4%	4.8%	11.0%	30.6%	41.1%	0.018

Table 3.3 Geographic Measure of Transmission Demand and Siting Difficulty

3.3 Physical: Variations in Transmission Growth and Construction

A third indicator of siting difficulty is the physical difference between proposed and actual miles of transmission construction, where proposed lines may remain unbuilt because of siting difficulty. Although this indicator is perhaps the most intuitive and direct measure of siting difficulty, existing data on transmission construction is extremely limited at the state level and of poor quality because of frequent changes in data collection and reporting.[18] (EEI, 2001; NERC, 2001) In order to work around these data limitations, this measure instead evaluates the rate of growth of transmission capacity in a state relative to the growth of generation capacity, net annual generation, electricity sales, and electricity consumption as a surrogate indicator of siting difficulty. (EIA, 2001) The data for this measure were compiled for a ten-year period from 1988 to 1998, normalized to 1 for the first year[19], and the percent relative increase was calculated for each future year. Then the slope of a regression line, or the average annual growth rate, was calculated for transmission, generation capacity, net generation, and sales in each state. The graph below illustrates the relationship between the selected data for the entire United States where the growth rate of transmission capacity is 1.71% per year compared to the steeper regression slopes and higher growth rates of 2.02% and 2.51% for annual generation and sales respectively. Similar data for absolute growth rates and differences in growth rates between generation capacity, net generation, sales and transmission capacity are presented in Table 3.5 below. For example from the table, the large positive growth of 9.43% per year of net generation relative transmission capacity in Mississippi indicates a lag in transmission construction associated with the need for additional transmission capacity, while the negative growth rate of –16.24% in Delaware indicates far greater growth in transmission construction than net generation.

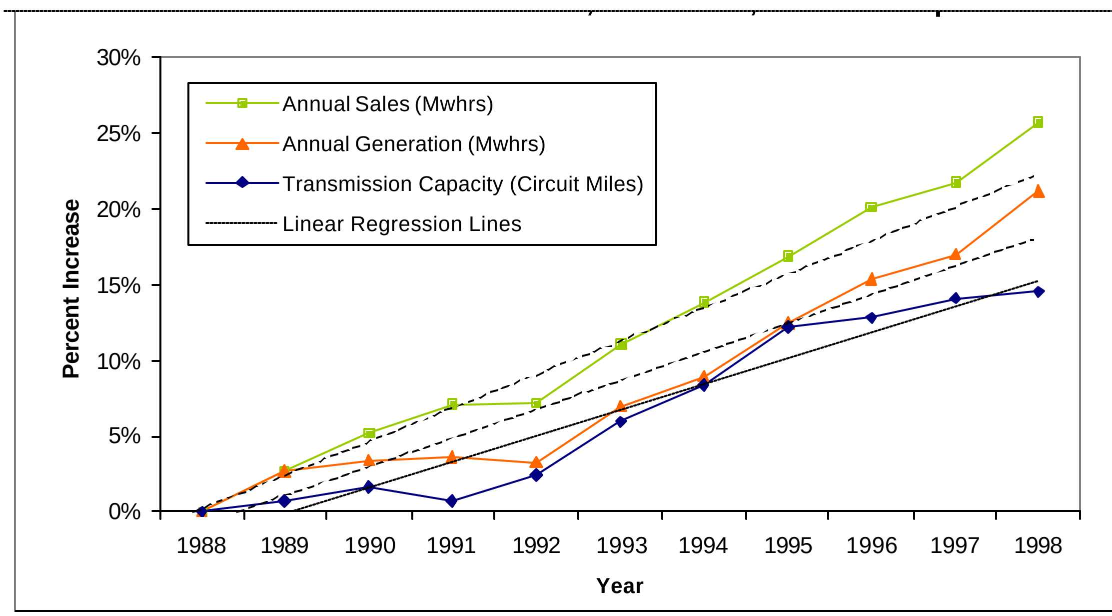

Figure 3.4 Annual Growth Rates in U.S. Transmission Capacity, Net Generation, and Sales

[18] Exsiting proposed and forecast transmission construction data from both NERC and EEI do not differentiate between cancelled and delayed lines producing numbers for actual construction that oscillate wildly relative to proposed miles of line because of construction delays for a given year in a state.

[19] All the data is normalized to 1988 values assuming that transmission capacity in that year adequately served generation capacity, net generation, sales; and future growth in any generation would require an equal percentage of growth in transmission capacity to maintain adequacy and reliability.

	Annual Average Growth From 1988-1998				Difference in Rate of Growth		
State	**Transmission Capacity (Circuit Miles)**	**Net Generation (Mwhrs)**	**Generation Capacity (MW)**	**Sales (Mwhrs)**	**Net Generation - Transmission**	**Generation Capacity - Transmission**	**Sales - Transmission**
Alabama	7.06%	7.01%	1.27%	3.86%	-0.06%	-5.79%	-3.20%
Arizona	1.83%	3.43%	0.47%	4.40%	1.60%	-1.36%	2.57%
Arkansas	1.24%	2.89%	0.02%	5.62%	1.65%	-1.23%	4.38%
California	1.52%	0.36%	-0.24%	1.15%	-1.16%	-1.75%	-0.37%
Colorado	1.48%	1.99%	0.85%	3.48%	0.51%	-0.63%	2.00%
Connecticut	7.43%	-4.90%	-1.39%	0.70%	-12.33%	-8.82%	-6.74%
Delaware	14.76%	-1.48%	2.32%	3.55%	-16.24%	-12.45%	-11.22%
Florida	1.30%	3.93%	2.28%	3.99%	2.64%	0.99%	2.69%
Georgia	4.77%	2.22%	2.13%	4.66%	-2.55%	-2.64%	-0.11%
Idaho	1.54%	7.92%	1.71%	2.52%	6.38%	0.16%	0.98%
Illinois	2.35%	1.32%	0.15%	2.02%	-1.03%	-2.20%	-0.33%
Indiana	0.92%	2.95%	0.35%	3.02%	2.03%	-0.58%	2.10%
Iowa	3.50%	3.06%	0.60%	3.11%	-0.43%	-2.89%	-0.38%
Kansas	0.25%	2.78%	0.33%	3.05%	2.53%	0.08%	2.80%
Kentucky	-2.29%	2.71%	0.54%	4.31%	5.00%	2.83%	6.59%
Louisiana	2.80%	1.19%	0.48%	3.03%	-1.61%	-2.32%	0.23%
Maine	-0.16%	-4.18%	-2.01%	0.39%	-4.01%	-1.85%	0.56%
Maryland	-2.45%	2.99%	1.96%	2.21%	5.45%	4.41%	4.66%
Massachusetts	0.85%	-0.21%	0.00%	0.76%	-1.06%	-0.85%	-0.09%
Michigan	5.72%	0.35%	-0.16%	2.39%	-5.37%	-5.88%	-3.32%
Minnesota	-0.18%	0.88%	0.86%	2.61%	1.06%	1.04%	2.79%
Mississippi	-5.85%	3.62%	0.36%	4.85%	9.46%	6.20%	10.69%
Missouri	-0.70%	2.48%	0.85%	3.23%	3.18%	1.55%	3.93%
Montana	0.03%	0.80%	0.26%	0.13%	0.77%	0.22%	0.09%
Nebraska	1.93%	4.02%	0.72%	3.53%	2.09%	-1.20%	1.61%
Nevada	0.04%	3.13%	2.46%	8.16%	3.09%	2.42%	8.12%
New Hampshire	1.90%	8.60%	5.00%	0.30%	6.69%	3.10%	-1.60%
New Jersey	0.91%	-1.24%	1.03%	0.88%	-2.14%	0.12%	-0.03%
New Mexico	1.00%	1.85%	0.46%	4.27%	0.85%	-0.54%	3.27%
New York	0.84%	0.00%	1.07%	0.39%	-0.84%	0.23%	-0.45%
North Carolina	1.66%	4.24%	0.90%	3.28%	2.57%	-0.77%	1.62%
North Dakota	0.87%	1.54%	0.11%	2.07%	0.67%	-0.76%	1.20%
Ohio	2.84%	1.48%	0.34%	1.89%	-1.36%	-2.51%	-0.96%
Oklahoma	-0.36%	1.62%	0.00%	2.24%	1.98%	0.37%	2.60%
Oregon	0.85%	1.36%	-0.26%	1.66%	0.51%	-1.11%	0.81%
Pennsylvania	4.52%	1.68%	0.49%	1.51%	-2.83%	-4.03%	-3.00%
Rhode Island	-0.78%	6.86%	3.06%	0.84%	7.64%	3.84%	1.63%
South Carolina	1.43%	2.56%	1.90%	3.63%	1.13%	0.47%	2.20%
South Dakota	2.34%	5.19%	1.40%	2.92%	2.85%	-0.95%	0.58%
Tennessee	-2.76%	4.78%	0.41%	2.30%	7.54%	3.16%	5.06%
Texas	4.05%	2.58%	1.17%	3.31%	-1.47%	-2.88%	-0.74%
Utah	2.24%	1.61%	0.75%	4.54%	-0.63%	-1.49%	2.29%
Vermont	2.55%	0.38%	-0.60%	2.10%	-2.17%	-3.15%	-0.45%
Virginia	2.01%	3.84%	1.96%	2.97%	1.83%	-0.05%	0.96%
Washington	1.27%	2.73%	0.70%	0.17%	1.46%	-0.57%	-1.10%
West Virginia	1.48%	1.17%	-0.13%	1.98%	-0.31%	-1.61%	0.51%
Wisconsin	3.17%	1.87%	1.53%	3.13%	-1.29%	-1.64%	-0.04%
Wyoming	3.06%	1.17%	0.59%	0.30%	-1.89%	-2.47%	-2.76%

Table 3.5 **Physical Measure of Transmission Demand and Siting Difficulty**

3.4 Subjective: Documentation of Industry Perceptions and Opinions

The final measure of siting difficulty is a survey of siting experts. Transmission planning and site selection are influenced not only by objective factors such as economics and geography, but also perceptions of siting difficulty. (IETPP, 1995) An area known for its siting difficulty is likely to be avoided during the process of site selection; therefore, it is equally important to consider both perceived and actual siting difficulty in any quantitative analysis. (CECA, 1990; Casper, 1981) In order to create a subjective indicator of state siting issues, an Internet survey[20] consisting of 154 multiple choice questions was administered to siting experts and professionals across the United States in order to elicit respondents' familiarity with siting projects,[21] perceptions of siting difficulty[22], and opinions of siting constraints[23] for each of the 48 states in the continental United States. A total of 400 potential survey respondents were randomly selected[24] from public and investor-owned utilities, regulatory agencies, research institutes, and consulting companies in each state. They were individually contacted by email during a period between November 1, 2002 and January 1, 2003 and each provided a link to the survey website and a unique password to access the survey.

All surveys were completed online and data was collected automatically for a total of 55 respondents from 31 states. The data from the survey are compiled and illustrated in Table 3.7 below. Respondents' ratings of siting difficulty in a state are weighted based on their familiarity with siting in that state, where respondents with greater siting experience in a state receive a higher weight and higher numbers indicate greater siting difficulty in a state. Interestingly, the perceptions of siting difficulty and the causes of siting difficulty vary drastically between respondents affiliated with different agencies. These variations are discussed further in the next section.

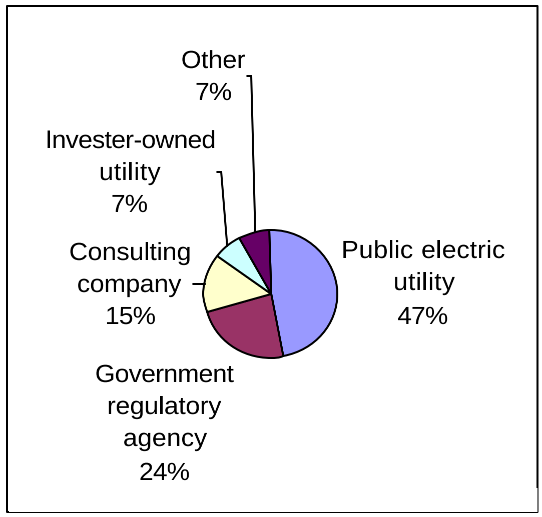

Figure 3.6 Percentage of Survey Reponses by Respondent Agency of Employment

[20] To access the survey for your reference, go to http://www.ece.cmu.edu/tlss, and enter the administrative password 484030 to view the survey.

[21] Familiarity with siting was rated on a five points scale where the categories "No familiarity with siting difficulty"=1, "Information from media / literature"=2, "Information from friends / colleagues"=3, "Worked on 1-3 siting projects"=4, and "Worked on more than 3 siting projects"=5. The "No familiarity" category was included as a level of familiarity after survey pre-testing showed that a significant number of respondents who felt they had no expert familiarity with siting in a state still had an opinion on siting difficulty in that state.

[22] Siting difficulty was rated on a ten-point integer scale where 1 is easiest and 10 is hardest.

[23] Based on survey pre-tests and interviews with siting experts, the five main identified causes of siting difficulty are public opposition, state regulation, federal regulation, topography/environment, and inter-agency coordination. From these five provided categories, respondents were asked to select the primary cause of siting difficulty in a state based on their opinion and experience.

[24] A email database of potential respondents was gathered from personal contacts, members of the CEIC Advisory committee, utility siting web pages, the Edison Electric Institute State Siting Directory, and the 2002 Platts Directory of the Electric Power Producers and Distributors. A minimum of 5 siting officials were randomly selected and contacted for each state.

State	Weighted Average of Siting Difficulty by Respondent Employment						
	Total Number of Reponses	All Survey Respondents	Consulting Company	Gov't. Regulatory Agency	Public Electric Utility	Investor-Owned Utility	Other
Alabama	20	5.66	6.79	3.63	7.20	5.64	4.50
Arizona	17	6.18	9.00	8.00	6.00	5.67	3.80
Arkansas	20	5.75	6.58	5.00	6.60	5.20	5.00
California	24	7.72	9.56	8.17	6.00	7.65	5.63
Colorado	19	7.32	8.62	8.00	8.00	5.45	6.80
Connecticut	23	7.64	8.40	8.00	7.60	6.94	7.85
Delaware	21	6.55	6.18	8.00	8.00	6.13	5.67
Florida	21	8.15	9.18	8.00	8.50	7.48	7.63
Georgia	21	6.62	7.69	4.00	7.20	6.91	4.56
Idaho	19	6.13	8.22	7.00	6.00	5.25	4.75
Illinois	25	6.36	6.85	5.00	8.00	5.68	5.56
Indiana	19	7.07	8.43	5.00	7.33	7.08	4.67
Iowa	24	6.28	7.27	5.43	7.83	5.71	5.80
Kansas	20	6.11	7.75	5.40	6.60	4.80	5.00
Kentucky	22	6.19	6.47	5.50	7.20	5.93	6.14
Louisiana	20	6.13	8.25	7.00	7.20	4.69	5.83
Maine	24	6.48	7.23	7.00	7.00	6.00	5.67
Maryland	24	7.80	8.29	9.00	8.00	7.63	6.29
Massachusetts	22	7.34	9.00	7.60	8.00	6.39	6.22
Michigan	20	6.59	6.75	4.00	7.67	6.73	6.30
Minnesota	26	7.22	8.33	7.10	7.88	6.70	6.20
Mississippi	20	5.92	8.00	8.00	7.20	4.39	6.00
Missouri	23	6.17	8.30	5.80	7.64	4.73	5.40
Montana	22	6.28	8.00	5.86	7.50	5.38	6.60
Nebraska	18	5.95	7.15	3.00	7.17	4.75	6.20
Nevada	20	5.82	7.89	5.33	6.00	5.27	5.60
New Hampshire	22	7.05	7.63	7.20	7.25	6.94	6.00
New Jersey	25	7.41	7.75	8.75	7.67	6.62	7.30
New Mexico	21	6.81	8.60	7.38	8.00	5.67	6.00
New York	30	7.87	8.71	8.25	8.33	7.30	8.23
North Carolina	21	6.04	6.43	5.00	7.20	5.77	5.11
North Dakota	23	4.92	5.85	2.54	6.88	4.92	5.60
Ohio	23	5.73	6.21	3.00	7.50	5.29	5.17
Oklahoma	18	6.03	8.11	4.00	6.20	4.89	5.40
Oregon	18	6.82	8.40	6.50	6.00	6.80	6.00
Pennsylvania	27	6.58	7.20	8.89	7.17	5.63	6.20
Rhode Island	21	7.12	8.67	8.25	7.75	5.93	7.40
South Carolina	20	6.29	7.71	5.00	7.20	6.36	4.80
South Dakota	22	5.24	6.75	3.69	6.43	4.50	5.20
Tennessee	21	6.28	7.43	3.00	7.20	5.79	5.71
Texas	23	5.65	7.18	2.20	7.00	5.28	4.25
Utah	20	6.75	8.30	8.00	8.00	5.27	6.60
Vermont	20	7.27	7.64	8.75	7.25	6.33	7.00
Virginia	25	7.14	8.31	5.25	8.00	6.76	7.33
Washington	18	7.14	8.80	8.00	6.00	6.75	6.00
West Virginia	20	5.45	5.23	4.00	7.00	4.87	6.50
Wisconsin	28	7.59	8.52	7.44	7.88	7.26	6.11
Wyoming	22	5.78	7.78	5.80	6.67	4.53	6.40

Table 3.7 **Subjective Measure of Siting Difficulty by Agency**

4 Evaluating Siting Constraints: Analyses Of Siting Difficulty

Based on the siting survey discussed above, the primary perceived constraints on any siting project are topography and natural environment.[25] state regulation,[26] federal regulation, inter-agency coordination,[27] and public opposition.[28] (FERC, 2001; IETPP, 1995) While there is some overlap among constraints, these constraints generally affect a siting project in the order listed above during the timeline of transmission planning and construction. A siting project generally begins with preliminary economic feasibility, necessity, and routing analyses internal to the company considering the project, then continues with the submittal of applications for construction permits and approvals to the required state, local, and federal regulatory agencies, and finally concludes with any public hearings and participation processes prior to construction. (CEC, 2000) The order in which siting constraints occur and are addressed during this timeline has interesting implications for the perceived importance and difficulty associated with different siting constraints. Figure 4.1 below shows the variation in perception of the overall importance of siting constraints relative to one another for respondents from investor-owned utilities, consulting companies, other siting companies,[29] government regulatory agencies, and public electric utilities. Each bar on the graph represents the average across the United States of the percentage of total respondents from a given agency who selected a cause of siting difficulty (public opposition, state regulation, topography/ environment, inter-agency coordination, and federal regulation) as the most important factor contributing to siting difficulty in a state.

Since respondents in each of these five categories of employment become involved in siting projects at different phases along a project timeline, the perception of the contributing factors of siting difficulty varies with exposure to and consideration of siting constraints. Although public opposition is the dominant constraint across all agencies, only 4% of respondents from public electric utilities perceive topography and environment to be the primary siting constraint across the United States compared to 28% of respondents from government regulatory agencies. Similarly, far fewer government regulators perceive state regulation as the dominant

[25] Examples of topographical and natural environmental constraints include steep terrain, locations of parkland, endangered species habitats, protected vistas, etc.

[26] Regulations governing transmission line siting require that any company interested in building a transmission line indicate a clear need for the line based on changes in existing and projected consumer demand and/or generation capacity by filing a Certificate of Public Convenience and Necessity or an equivalent letter of intent. This initial step is common to all states and is followed by a series of detailed permit applications, reviews and public hearings that are specific to each state and the affected local areas. Based on the EEI State Siting Regulations Directory 6 states have no state-level oversight of transmission line permitting except with regard to specific geographic attributes such as river crossings, 39 states have a single permitting agency with the overriding authority to approve or deny construction permits, and 6 states have multiple state-level permitting agencies.

[27] Federal agency involvement occurs only after state agency permitting has already begun, and often federal agencies with jurisdiction will simply defer to an affiliated state agency as is common with the EPA and state departments of environmental protection or natural resources.

[28] Public opposition to power line construction has typically centered on issues of health and safety of EMF exposure, aesthetics, environment, safety, and equity. Current siting regulation allows interested members of the public to participate in the siting process by filing applications of intervention; however public involvement in siting projects generally occurs after many details of a proposal have already been carefully considered and decided simply to file the required permits. Therefore, citizens often feel as if they are being presented with an inflexible and complete proposal against which there is no alternative but to vigorously defend, and acronyms such as NIMBY (not in my backyard), LULU (locally unwanted land use), and even BANANA (build absolutely nothing anywhere near anything) are becoming increasingly common in the siting vocabulary to characterize the nearly unanimous opposition to public facility construction.

[29] On the graph below, the category "Other" includes respondents from electric transmission technology and manufacturing companies.

siting constraint than public utility respondents. These significant variations in the perception of siting constraints between the five groups of respondents can be associated with an agency's control or involvement with a given constraint. For example, utility siting officials begin a siting project by eliminating economically or physically infeasible terrains or environments along a route, whereas government regulators working with topographical or environmental issues are involved in the siting process only after utilities have already selected preliminary route proposals and limited the decision options. Based on these variations, one can hypothesize that public opposition is the primary focus of media and research attention to siting constraints since public involvement occurs relatively late in all siting projects and at that points siting agencies have only limited control over the decision-making in a project.

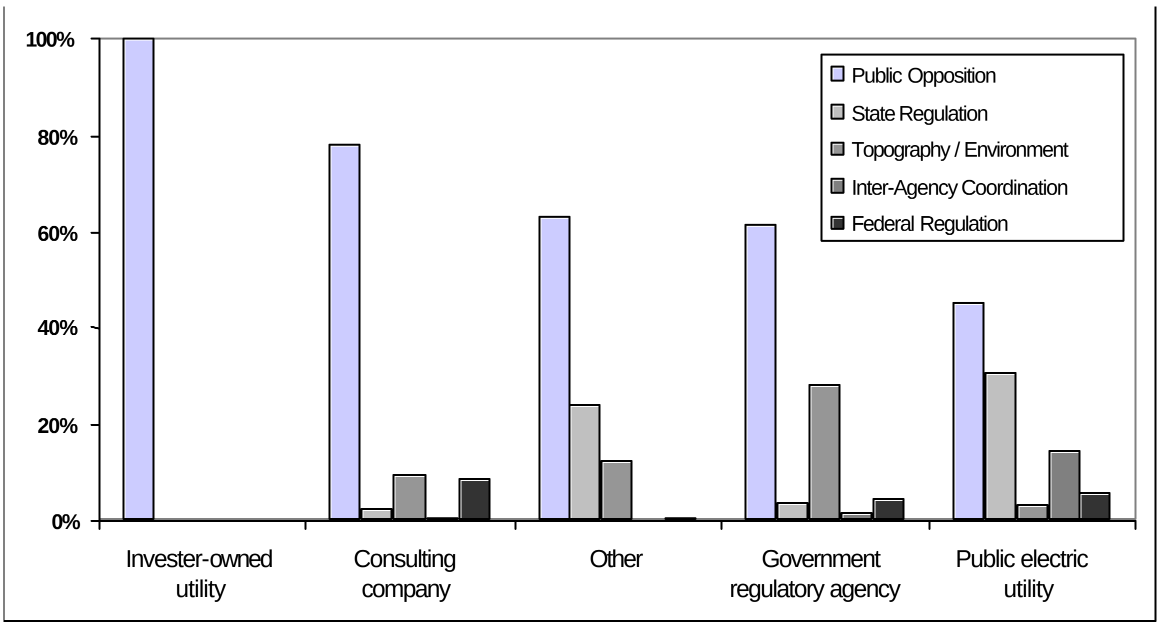

Figure 4.1 Agency Perceptions of Siting Constraints.

4.1 Selection of Regression Variables

Both perceived and actual factors affecting siting can be grouped into categories of public, regulatory, and environmental constraints. Using these three categories as a guideline for the selection of regression predictors, over forty potential predictor variables were gathered and evaluated. Then, from a correlation matrix of all possible predictors and all measures of siting difficulty from the data tables in Section 3, eight predictor variables and five dependent measures of siting difficulty were selected for use in a regression model. Each of these selected variables is defined and described below with a hypothesis of how the variable influences siting difficulty.

Independent Variables

1. Number of siting regulatory agencies.[30] As the number of siting agencies increases, siting difficulty is anticipated to increase because of problems with redundancies in regulation and inter-agency coordination.

[30] From the EEI State-Level Electric Transmission Line Siting Regulations Directory, states are categorized as having no state siting agencies, one single siting agency, or multiple siting agencies.

2. State size in total acres of land area. Larger state sizes are associated with a decrease in siting difficulty because of easier access to open space and right-of-ways.
3. Percent agricultural land area of total state area. High percentages of agricultural land are associated with a decrease in siting difficulty because of limited environmental and topographical variations of agricultural land and easier access to open spaces for siting.
4. Percent wilderness area of total state area. As the percent of wilderness area increases, siting difficulty is also anticipated to increase because of increased number of environmental permits, variability of terrain and topography, and public opposition associated with environmental concerns, species protection, and vista pollution.
5. Population density. High population densities are associated with increased siting difficulty greater public opposition along proposed routes and limited availability of urban space.
6. Total state generation capacity per capita. Large state generation capacities per capita are associated with ease of generation facilities siting and a related decrease of transmission line siting difficulty.
7. Percent electricity imported of total electricity consumed in state. States that import high percentages of the total electricity consumed are associated with greater siting difficulty because of the increased distances between out-of-state generation plants and internal population centers and demand loads.
8. Percent electricity exported of total electricity generated in state. Similar to percentages imported, high percentages of electricity exported are associated with increased transmission distances and greater siting difficulty.

Dependent Variables

1. Baseload saving (1000 $). High savings from reallocation of baseload generation indicate transmission congestion limiting competitive transactions in a state and are associated with greater siting difficulty.
2. Peaker saving (1000 $). Similar to baseload savings, higher peaker savings also indicate transmission congestion and greater siting difficulty in a state.
3. State population unserved within a 15-mile footprint radius. A greater percentage of a state's potential population unserved within a 15-mile footprint radius indicates a separation of population load centers and generation plants associated with increased siting demand and difficulty.
4. Annual growth of net generation relative to transmission capacity. High percentages of this measure of annual growth denote low transmission capacity growth rates relative to net generation growth and are associated with increased siting difficulty.
5. Perceived siting difficulty. The higher the rating of siting difficulty from the survey the greater the perceived siting difficulty. This dependent variable is presented in the analyses below for all survey respondents, and also broken down by stakeholder groups.

4.2 Summary of Regression Results

Using all of the dependent and independent variables described above, regression analyses of the relationships between the five dependent variables and the eight independent variables are summarized in Table 4.2 below. Of the variables included in each analysis, the regression equations below include only those that are significant at the $\alpha < 0.1$ level.[31] For many of the independent variables, these regression analyses support the hypothesized relationships

[31] Regression analyses were also performed to evaluate the relationships among dependent variables; however, the only the survey and geographic measures of siting difficulty were correlated with any significance, therefore these results are not included here.

between each of the predictors and siting difficulty described above. Based on the signs of the coefficients in each of the regression equations, certain predictors affect siting difficulty consistently across all dependent measures of siting difficulty as hypothesized in selection of the variables section. For example, Population Density and % Export of Generation have consistently positive coefficients where an increase in either predictor is associated with a related increase in siting difficulty. Another interesting insight from the regression equations is the relationship of predictor variables to the perceptions of siting constraints from the survey. For each of the perceived difficulty equations below, the variable % Wilderness Area affects the dependent measure differently. Referring back to Figure 4.1, a high percentage of government regulatory agency survey respondents perceived topography/environment to be the dominant siting constraint, and the positive sign and high relative magnitude of the % Wilderness Area coefficient in the government regulatory regression equation parallel and support this perception. Similarly, public electric utility respondents felt topography /environment was a far less important siting constraint, and the corresponding regression coefficient for %Wilderness Area is negative and of smaller magnitude. Overall, these analyses and insights provide fundamental quantitative evaluations of the interactions among siting constraints and their relative contributions to siting difficulty that parallel existing anecdotes and perceptions of the causes of siting difficulty.[32]

	Independent Variables									
Dependent Variables	Intercept	No. of Siting Agencies	Total Land Area	Population Density	% Non Agricultural Land	% Wilderness Land	MW/capita	% Import of Consumption	% Export of Generation	R-Square
Baseload Savings	381.7	—	0.00016	—	—	—	—	—	—	0.35
Peaker Savings	—	—	—	—	—	—	—	—	—	—
Population unserved within a 15-mile footprint radius	0.49	—	2.59E-09	0.0003	—	—	—	—	—	0.25
Annual growth of net generation relative to transmission	—	—	—	—	-0.0517	—	—	-0.1718	—	0.24
Perceived siting difficulty- all survey respondents	6.23	—	—	—	—	25.1	-133.43	—	1.34	0.35
Perceived siting difficulty- public electric utility	6.87	—	—	—	—	-16.97	—	—	—	0.29
Perceived siting difficulty- consulting company	7.28	—	—	—	—	-34.15	—	—	—	0.19
Perceived siting difficulty- investor owned utility	5.50	—	—	—	—	-32.83	—	—	—	0.32
Perceived siting difficulty- government regulatory agency	5.09	—	-2.00E-07	—	—	48.89	—	—	5.06	0.37
Perceived siting difficulty- other	5.93	—	—	—	—	—	-195.43	—	2.46	0.24

Table 4.2 Summary of Regression Coefficients and Results

32 While these regression analyses provide unique comparative assessments, the total variability of siting difficulty predicted by the regression equations is less than 40% from the R^2 values in the table. This indicates that there are other factors that influence siting difficulty, and in order for any regression model to effectively serve as a predictive tool of siting difficulty additional variables need to be explored and added to the model.

5 Informing Siting Policy

The policy implications of the measures of siting difficulty and evaluations of siting constraints presented in this paper are threefold. These analyses have the potential to influence state-level strategies for interagency coordination, regional-level management of state siting, and national-level proposals for federal eminent authority. The variations in perceptions of siting difficulty and the relative importance of siting constraints outlined in this paper have the potential to serve as the basis for coordinating between siting agencies at all three levels of planning. For example, public utility perception of state regulation as a dominant siting constraint suggests that the interaction between state regulatory agencies and utility siting officials needs to be streamlined and made more effective. Similarly, the consolidation of transmission and siting management by the FERC into RTOs has the potential to simply create umbrella organizations for siting difficulties[33] if RTOs are unable to characterize the problems associated with individual states within their region and coordinate siting solutions. (McNamar, 2002) Without a framework for understanding agency perceptions of siting issues, the binding siting constraint of one state has the potential to become that of the region as well. Lastly, recent eminent domain proposals also have the potential to compound existing siting constraints by attempting to address public opposition to siting in spite of documented opposition to eminent domain itself.[34] (Lindsey, 2001; Eckert, 2001; EEI, September 2001) Overall, the framework that this research provides for characterizing siting difficulty and siting constraints has the potential to serve as a tool for communication between siting agencies, foster a common understanding of the siting problem, and address existing issues with inter-agency coordination.

6 Conclusions

Overall, this research addresses the three fundamental questions of the transmission line siting problem: How difficult is siting? What makes it difficult? And finally what can be done to ease the problem? The analyses in this paper provide the basis for influencing the timeline of siting projects to address and mitigate siting constraints. These changes in siting policy in combination with a sound strategy for encouraging transmission investment are imperative for the success of the electric industry today.

[33] An examination of state siting issues reveals that California with a single primary siting authority is among the state with one of the most difficult and prolonged siting processes. Therefore, consolidating siting authority in one large agency may compound existing siting difficulty.

[34] Historically, public opposition to eminent domain has been as prominent as NIMBY-based siting protests. Although comparisons have been made with the siting of natural as pipelines by the FERC using eminent domain authority, the natural gas industry still faces delays and cancellations of projects because of public opposition. Additionally, both Bonneville Power Association (BPA) and the Tennessee Valley Authority (TVA) currently have eminent domain authority, but based on conversations with members of TVA's siting division the authority is used very rarely and only for surveying purposes.

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