

# **Guide for Successful Transmission Line Siting**

**3002001188**

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**3002001188**

Technical Update, December 2013

EPRI Project Manager

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# ABSTRACT

As described in the Federal Energy Regulatory Commission (FERC) Permit Process, eminent domain proceedings are not the preferred method of obtaining rights-of-way for transmission lines. The permitting process is rather one of engaging the public through meetings and education to develop siting consensus. This approach requires an in-depth understanding of the primary technical issues by everyone involved in the siting procedures. The applicant must demonstrate due diligence in justifying the new line as the best choice when compared to alternatives. Technical depth of understanding is crucial in obtaining permits from State or Federal regulators.

The first version of the Guide for Successful Transmission Line Siting (EPRI report 1023754) was published in 2012. The guide was based on materials presented at the workshops on transmission line siting conducted by EPRI staff in 2010 and 2011 and documented in reports: “Transmission Siting Integrating National Corridor and NERC Compliance Requirements” (1019881) and “Economic and Environmental Challenges of Transmission Lines - An Engineering Perspective” (1022164).

In 2013, the Guide for Successful Transmission Line Siting was updated to include new information on recent changes in the federal legislation, additional information on the environmental factors addressed in siting transmission lines, a new chapter on public involvement, and a new case study to further the understanding of the siting process.

The Guide provides the readers an overview of the complete transmission line siting process with emphasis on technical issues involved in transmission line decisions. Technical issues impact decisions on whether to build new overhead lines or opt for alternatives such as voltage upgrading, thermal upgrading, underground transmission, or the conversion of AC to DC lines. It is important for everyone involved in such decisions to share an understanding of the technical options and their limitations.

The Guide is intended to be useful and interesting to a broad range of users such as those involved in the planning of transmission systems, those involved in the engineering design of overhead lines, the environmental engineers who must evaluate wildlife impact and soil drainage, those involved with land owners, and those who must operate and maintain the resulting transmission system.

## **Keywords**

Transmission line siting  
Rights of way  
Regulatory process  
Environmental impacts



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# 1

## INTRODUCTION

This report is an update of the Guide for Successful Transmission Line Siting (1023754) that was published in 2012. The Guide for Successful Transmission Siting summarizes the information from the transmission line siting workshops conducted in 2010 and 2011. The materials in the Guide were based on EPRI publications “Transmission Siting Integrating National Corridor and NERC Compliance Requirements” (PID 1019881) and “Economic and Environmental Challenges of Transmission Lines - An Engineering Perspective” (PID 1022164). These materials were organized and new information added to form the first version of this technical Guide for Successful Transmission Line Siting.

In 2013, the Guide for Successful Transmission Line Siting was updated to include new information on recent changes in the federal legislation, additional information on the environmental factors addressed in siting transmission lines, a new chapter on public involvement and, a new case study to further the understanding of the siting process.

The Guide provides to the readers an overview of the complete transmission line siting process with emphasis on technical issues involved in transmission line decisions. Technical issues impact decisions on whether to build new overhead lines or opt for alternatives such as voltage upgrading, thermal upgrading, underground transmission, or the conversion of AC to DC lines. It is important for everyone involved in such decisions to share an understanding of the technical options and their limitations.

The Guide is intended to be useful and interesting to a broad range of users such as those involved in planning of transmission systems, in engineering design of overhead lines, the environmental engineers who must evaluate wildlife impact and soil drainage, those involved with land owners, and those who must operate and maintain the resulting transmission system.

### **Objective of the Project**

This multi-year project develops a guide to assist system planners, line designers, environmentalists and route selectors in the understanding of the technical basis for various regulatory requirements that must be met in justifying and siting new transmission lines and in finding approaches that gain public and regulatory acceptance with a minimum of cost and delay.

The primary goal of this project is to provide useful technical information to all those who may get involved in this process from the utility side. Transmission developers need to be knowledgeable and responsive to questions regarding the choice of line voltage, the system planning basis justifying the new line’s impact on load reliability, the practical limitations on tower height and right-of-way width, and the economics and environmental impact of underground cable alternatives to new overhead lines.

A secondary goal is to provide illustrative examples of various technical issues that can be used to communicate technical aspects of line siting to the public and to regulatory bodies. To this end, the project involves the development of a guide to line siting technical issues which covers all of the main technical issues, explains them in language that can be understood by the various

stakeholders and which is accompanied by power point slide files which can be customized to help the developer in explaining these issues.

The useful and practical information developed in this project will therefore allow system planning, line design, and environmental engineers and scientists to understand and explain the need for new transmission lines and obtain approval for the preferred route that it must follow. The information developed will be useful in the preparation and justification of any license application for a new transmission line or for modification of existing lines. The information will also be useful in addressing enquiries that may arise during the environmental licensing process, ensuring that regulatory requirements are met and that all mitigating measures are evaluated in a systematic and effective manner.

Case studies to illustrate and support process discussions are included at the end of the Guide. These case studies range from successful siting of a straight forward to a complex transmission line. A transmission line siting failure is also included.

## **Scope of Research**

The project involves studying the major challenges involved in the siting of new lines, and in identifying the range of mitigating measures that can be applied. It covers the following research activities:

- A review of regulatory documents and requirements for the justification and siting of new transmission lines.
- Identification and explanation of underlying technical issues involved in line siting.
- An investigation of new line alternatives and the limitations of modification of existing lines.
- A review of compact line technology that allows adequate power flow while minimizing visual impact.
- A review of key technical issues involving rules on wildlife and on electric and magnetic fields.

The project does not cover:

- Process in dealing with public and regulators.
- Methodology in selecting a preferred route.

It provides technical solutions to assist in siting transmission lines by better understanding:

- The system planning process that leads to new lines.
- Alternatives to a new line and when to choose them and,
- Technologies, both new and being developed that may facilitate right-of-way acquisitions.

## **Guide Development**

The need for new transmission lines is usually identified during regular power transmission system planning studies. Documentation and explanation of these system planning studies is an essential part of new line justification and often provides a basis for evaluation of alternatives

such as reinforcement of existing lines and use of underground cable and alternative line connections.

As part of this project, EPRI held workshops in 2010 and in 2011 to promote a broad technical overview of the transmission line siting process and to test the usefulness of the materials developed for this purpose. The first version of the transmission siting guide was developed last year based on the materials from the workshops. The workshops explain the basic challenges, tools, and needs of the others. Case studies are used to provide members with a broad overview of technical aspects of the siting and design process. As a result of participation in these workshops, the various personnel involved in siting, designing and justifying new lines, are more likely to find an approach which gains public and regulatory acceptance quickly, with a minimum of cost and delay.

Based on inputs from the workshops and those received subsequently, the materials were refined to produce a useful and practical document for the industry. The final guide allows each major group involved in new line siting projects to understand the major issues faced in successfully meeting environmental, power system, and line design limitations. By providing each group with knowledge of the basic challenges, tools, and needs of the others, the regulatory and public acceptance of new lines is made more likely. Those justifying the need for new facilities are more able to explain the underlying necessity for the addition to the power system.

The orientation of the guide is toward the technical aspect of transmission line siting. That is, demonstrating to environmentalists, line design, and system planning engineers how new materials and processes can influence the siting process and determine the success or failure of gaining regulatory approval. The primary issues that need to be considered when proposing a new line such as: Can it be made less visible? Can I utilize underground cable in certain sections? - are part of the guide.

## **Report Organization**

The Guide is organized sequentially from the inception of the project to its construction. Chapter 2 of this report firstly provides an overview of the process in building a new transmission line, starting from planning, siting, approvals, design, acquisition, construction to operation. Chapter 3 provides an overview of the power system planning and operations. The reliability of a power system is studied by planners who identify deficiencies in the system. Recommendation such as a new transmission line is made. Chapter 4 provides some basic information on the design of a transmission line. It discusses the major components of an overhead transmission line, their behaviors and constraints. Chapter 5 outlines alternatives to building a new transmission line, their applications, advantages and limitations. Chapter 6 describes the major alternative to an overhead line i.e. underground transmission. The emerging HVDC alternative is also discussed.

Chapter 7 identifies the factors that must be considered in the siting process and the approach to be taken in siting a preferred route for the future transmission line. A sample Table of Contents for an environmental impact report and examples of best practice to select a transmission corridor are also included. Chapter 8 details issues and strategies to be considered when developing a plan for public involvement and public outreach. Chapter 9 outlines typical approvals that are required for transmission siting, including the State, Federal and other agencies. Chapter 10 describes mitigation measures that a utility may adopt to enhance public acceptance of a transmission line. Chapter 11 provides a flow diagram for a typical transmission line siting process. A fictitious example of a successful siting of a new transmission line is also

provided for reference. Chapter 12, the last chapter, includes five case studies, three successful cases ranging from siting a straight forward to a complex transmission line, a failure and one that falls in between.



# 2

## OVERVIEW OF THE PROCESS TO BUILD A NEW TRANSMISSION LINE

In this chapter, we will present an overview of the entire process needed to build a new transmission line. This overview will be educational for those new to the industry, or for someone with limited experience, beyond their portion of the project. As with all significant projects, the process involves many groups, with various levels of responsibilities, background and professional experience. The team's goal is to successfully optimize the overall transmission line project. As such, communication between groups is imperative so that they do work collaboratively to achieve the same goal while optimize any single portion of the project to the determinant of another.

This chapter reviews the planning, siting, approvals, design, acquisition, construction and lastly the maintenance issues necessary to successfully build a new transmission line. While these processes are frequently managed by different groups of individuals, any decision within the group impacts the overall project. With this in mind, decision making should be based on an iterative process since decisions made by one group can have a great impact on another group's process. The impact must be analyzed and evaluated with regard to the overall impact on the project. Examples of this iterative process will be discussed later.

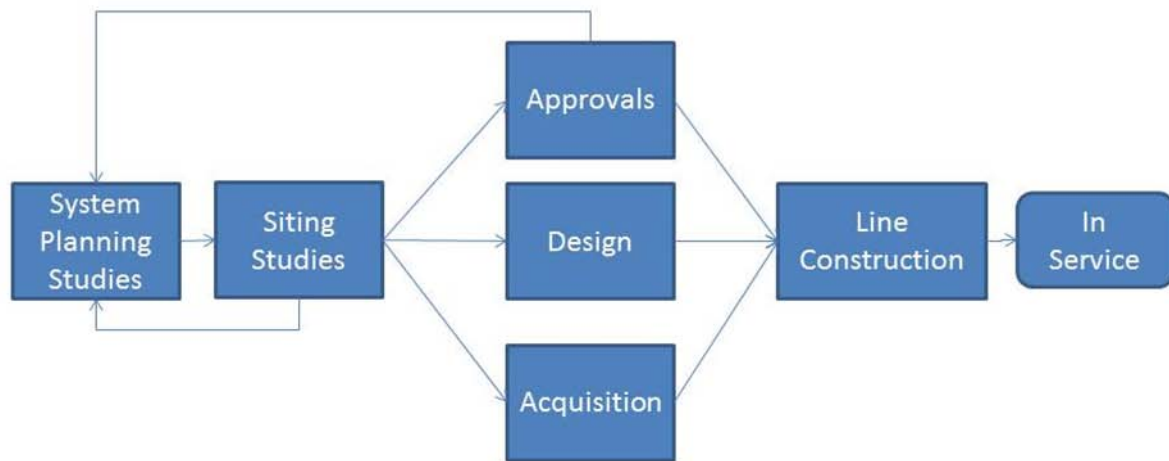
The one basic challenge that most new transmission line projects face is that generally they are unpopular with the public. In fact, utilities could often experience significant opposition to these projects. As a result, new transmission line projects are very difficult, can be quite expensive, and need a very long lead time to bring a new line in to service. In many instances the general public opposition has delayed projects going into service, or in some cases the projects failed completely.

### Generic Flow Diagram

The order of the various processes needed to successfully build a new transmission line project varies from project to project. If "speed to completion" and "in service" are the driving decision factors, then decisions will be made to take on additional risk within the project. This is done to shorten the duration of the time it takes to complete a process.

For example, it might be feasible for a utility to purchase land prior to obtaining approvals. This would certainly speed up the acquisition process, but if the project fails to obtain the needed approvals, large sums of money are expended that cannot be recovered.

A generic work flow diagram Figure 2-1 shows the overall phases of the project. Numerous decisions must be made regarding the details on how the project is executed. In actuality, many detailed steps will be taken, both sequentially and simultaneously, as the project progresses and no two transmission line projects ever proceed in exactly the same way.



**Figure 2-1**  
**Generic Work Flow Diagram**

## Planning

Transmission system planning studies are preformed and serve as the technical basis for the transmission line siting process. The transmission system planner's goal is to select a solution to a predicted inadequacy in the transmission grid. This planning process will be discussed in more detail in Chapter 3.

In general terms, the purpose of these planning studies is to justify the need, identify alternatives and to select the voltage level and the terminal locations of the newly proposed transmission line. It may include other details such as, required electrical transfer capacity, which has a direct bearing on the engineering design.

Load flow studies are carried out. These load flow analyses *are the foundation for every other study and decision made in order* to successfully complete the new transmission line project.

## Siting

The siting process is the main topic for this guide and will be discussed in much greater detail in Chapter 7. In general terms, after the transmission system planners have selected a solution to a predicted inadequacy in the transmission grid, the project is turned over to the Siting Team. The Siting Team plans for the optimum location for the new facility. For example, the system planner may determine that a new single circuit, 138 kV transmission line is needed between Substation A and Substation B, but the siting team will perform the study to selects the actual route to be taken. If it is determined that no reasonable routes can be found between these end points, this may mean that the project is sent back to the system planners for re-evaluation and may need a different solution.

In addition to location of the new facility, the siting team may also recommend structure types and other items such as mitigation measures that will facilitate the later approval processes.

## Approvals

Most new electric facilities will need some types of approval before construction can begin. These approvals may be needed from federal, state or local authorities and are a significant

milestone in the successful completion of a new transmission line project. It is in this phase of the project where most transmission line project failures occur.

The approvals vary significantly depending on the location of the project. The most typical scenario would involve a State license frequently called a “Certificate of Public Convenience and Necessity” (CPCN) or abbreviated to just the Certificate. In addition, environmental approvals and construction permits will also be required from various federal, state and local agencies.

A more detailed discussion of the approval process is in Chapter 9.

## **Design**

The design of the transmission line could be complex. In order to fulfill its purpose, the transmission line must be designed for its electrical requirements, and its strength, as well as aesthetics. Each of these areas dictates characteristics for the basic layout of the structure. There are three main components to the design of the transmission line. They are:

- The wire
- The structure
- The foundation

Within these major components there are various sub-assemblies that must be designed to be compatible with all other components.

Decisions on these major components are made and a preliminary layout is designed showing where structures are to be located. This layout is completed by using sophisticated software programs that take into account all the required design parameters, such as the strength and safety codes. These preliminary designs are frequently used in the approval and acquisition processes.

Lastly, a final design is prepared and this design is placed on drawings for use in the acquisition process and during construction. Additional details on the transmission line design process can be found in Chapter 4.

In addition to the transmission line design, a review and preliminary design of the construction effort is necessary. Decisions regarding methods of construction, layout of access roads and other details may be needed. These decisions will most likely affect the transmission line design and the approval processes.

## **Acquisition**

The acquisition process is a broad topic that can include many items throughout the project. It can be one the earliest processes to start and continue to be one of the last items completed. It frequently involves many, if not most members of the project team. Generally speaking there are three broad topics for acquisition. The project team will need to acquire:

- Services – Planning, engineering, environmental, legal, and construction services are needed on a large project. Depending on the utility involved many/most services can be performed by internal staff, but some services may need to be provided by outside staff.

- **Material** – Most projects will have large lists of items that must be acquired in order to build the project. Much of this material may have fairly long lead times that must be built into the project schedule.
- **Land** – Every utility must have land on which to place the new transmission line. The land may be acquired in the form of an outright purchase, or sometimes a limited rights *easement* is purchased from the landowner. If the needed land cannot be purchased, a legal process called *eminent domain* is sometimes used to acquire properties through legal court hearings. This is usually done as a last resort, and is usually exercised in only a very small percentage of land acquisitions.

In summary, the needs of the project must be identified and a plan put in place to acquire all items needed for the completion of the project. The time required to acquire all these items must be factored into the project schedule.

## **Construction**

The transmission line construction is the last phase of the project and the point where all decisions made during the project are implemented. The construction of a new project typically follows the following sequence of events:

1. Current environmental law, in most jurisdictions, requires an extensive plan for control of construction and its related impacts. Frequently the first action on the construction site is to place environmental controls required by the design and approval processes.
2. Next, required access roads must be constructed.
3. Tree clearing will follow or happens concurrently with the access road construction.
4. Foundation construction (if needed) will follow.
5. The transmission structures will be erected next.
6. Followed by the wire stringing, sagging and clipping operation.
7. The rehabilitation of all land is completed.
8. After final inspection and testing, the line is put in service and turned over to operations for use.

## **Operation**

Transmission Operations as the name implies is concerned with the day to day running of the transmission system. This group deals with the system on a real time basis making adjustments to the system in order to handle issues, such as planned outages for maintenance, or unplanned outages caused by severe weather events.

Although the operations group is usually not included in the planning process, the input from this group should be sought during the project team decisions. Difficult siting decisions and the design of the transmission structures, frequently impact the future operations of the line. For example, if live line maintenance practices are planned, then these must be incorporated into the line design. Also, if any restrictions are placed on the line during approvals, then they must be able to be implemented during the later operations. Finally, this Operations group will determine the ability to take certain lines out of service if needed for construction of new facilities. So, their input is vital and should be included early in the process.

# 3

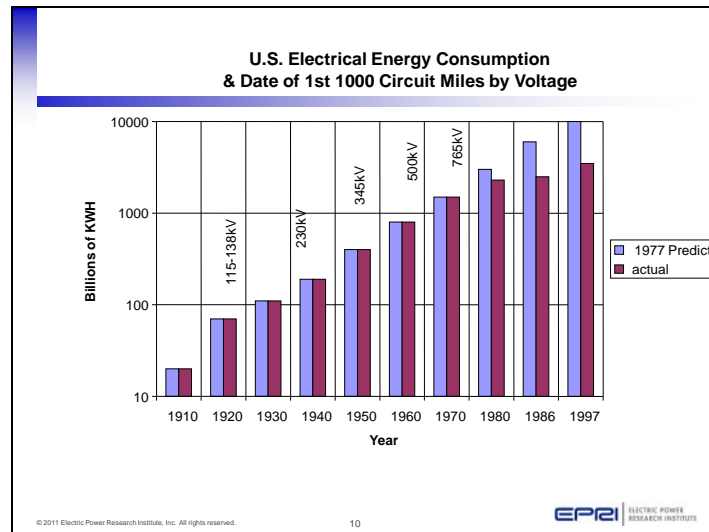
## OVERVIEW OF THE POWER SYSTEM PLANNING AND OPERATIONS

Transmission System planning studies serve as the technical basis for the transmission line siting process and all other decisions that flow to completion of the project. The voltage level of the new line and the terminal locations (end points) are selected in this analysis and become an essential part of the successful line siting process.

Transmission planners perform power system studies that identify inadequacies and evaluate alternative solutions. The goal of the planning studies is to create and maintain reliable power flow to load centers, under all system and environmental conditions, at minimal cost. This usually means that the transmission system should be operational even during periods when there has been a loss of one or more major generation sources or transmission circuits. Planners are not responsible for the physical design of the transmission lines, nor for their operation and maintenance.

This planning process is done through a series of electrical studies. First, there is an analysis of the transmission system as it currently exists. Worst case loading situations must be taken into account and analyzed. In other words, the time when the maximum electricity usage is flowing across the transmission system is reviewed. Frequently for southern based companies, this is the peak summer loading condition. For more northern based companies it may be the winter peak loading condition. Computer simulations are run to see how the system is currently moving the electricity under all operating conditions. In addition to the studies of the existing system, planning studies are needed to evaluate changes to the electric transmission system such as generation sources (wind farms, coal plants etc.) entering or leaving the system.

The next step is to predict the increase in electrical usage in the future and to determine where this increase will take place. This is a very difficult step as there are many variables involved when predicting future use. On a small scale, there are fewer variables and this could simply be a prediction of the number and location of new residential, commercial and/or industrial sites. But when a larger regional scale is taken into account, as is often the case in large transmission line projects, it is difficult to predict trends since there are many variables, and these variables change across the region. The general economy, and/or future legislation are two such dynamic variables and can have significant impact on electricity usage. For example, recent legislation has impacted generation trends by increasing the use of wind and decreasing the use of coal. This has had a tremendous impact on the supporting transmission system.



This model of future electric use, predicts into the future from 5 to as much as 15 years. Load flow studies are run to determine where the current transmission system will be inadequate in the future. Then alternatives solutions are analyzed to select the best solution, under all system conditions, and at minimal cost. The results of these studies may suggest the need for a new transmission line (s), and/or a new substation (s). The system planners will usually select the voltage for the new facilities, and may give added details such as the ampacity or conductor size needed to support the projected future electric load. These load flow analysis studies when completed, **are the foundation for every other study and decision made** to successfully complete the new transmission line project.

If these studies are done inadequately, or significant changes that directly impact the prediction models occur, a great deal of effort can be wasted on all the other processes. Chapter 12 reviews a case study where this planning process had a large impact on the overall success of a project.

These studies are usually re-run on an annual basis, so that the predictive future data used in the studies can be replaced by actual electric usage measurements, thereby making the analysis stronger. This annual review of the load flow studies sometimes “change the answers”, which could also have a large impact on the project.

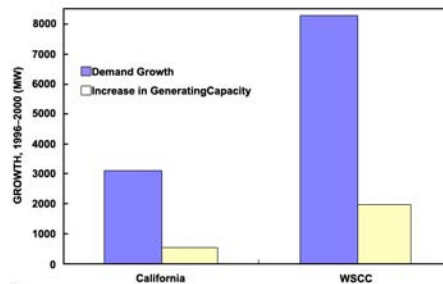
## System Planning Example

### Planning Often Involves Sequential Actions – Path 15

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### Bulk Power Transfer on a Critical Path in CA is Limited by Contingency Overload of 230 kV Lines

- As a result of the Western Area blackout in 1996, the loss of two 500 kV lines was defined as an n-1 contingency.
- The power flow on these lines had to be limited to avoid overloading “parallel” 230 kV lines.
- The most straightforward planning response would have been to build an additional 500 kV line in “parallel” but this was delayed by regulatory processes.
- System planners developed a “temporary” solution by dynamically rating the 230kV lines and by invoking an automatic load shedding scheme.
- When the 500 kV line was built the need for these complex and temporary planning solutions ceased.

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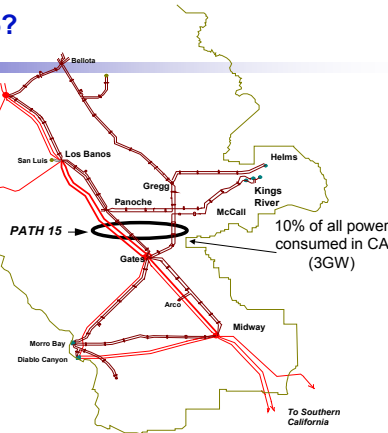
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## What is Path 15?

### Lines in Path15

- Los Banos-Gates 500 kV (1.5GW)
- Los Banos-Midway 500 kV (1.5GW)
- Gates-Panoche #1 230 kV (400MW)
- Gates-Panoche #2 230 kV (400MW)
- Gates-Gregg 230 kV (400MW)
- Gates-Mc Call 230 kV (400 MW)



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This 230 kV double circuit line limits Path15 power transfer though the normal load is typically less than 200 amps per conductor.

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## Summary Points – System Planning

- Transmission planners perform power system studies that identify inadequacies and evaluate alternative solutions (e.g. add a new Line, uprate an existing line).
- The goal of planning studies is creating and maintaining reliable power flow to load centers, under all system and environmental conditions, at minimal cost.
- Planners are not responsible for the physical design of lines, nor for their operation and maintenance.
- Beside performing regular annual reviews, system planning studies may be required to evaluate the need for system reinforcements in response to new generators (e.g. wind farms) or new load centers (commercial or residential development).

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## Main Points – System Planning (cont)

- Planning involves both short term (relieving a specific transmission constraint) and long term goals (determining the need for a new voltage class or use of DC).
- It also involves both economic decisions (choosing to build a new line to gain access to low cost generation) and non-economic decisions (replacing old equipment to improve reliability).
- Planning decisions are often complex involving long term goals and sequential actions intended to achieve them.
- The impact of decisions taken concerning one circuit may influence other circuits and future actions.

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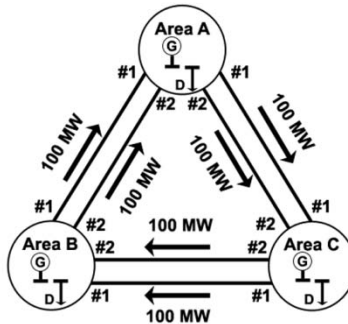
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The following is an example of a simple power flow diagram that illustrates the complexity of planning studies. All relevant components of the power system must be considered. The line that requires upgrade to enhance power flow to a load area may not be directly connected to the area itself as demonstrated in this example. The load flow can also change due to changes in the market condition.

## Chapter 1 – Power System Flows

### Base Conditions – Example 1

Zero Scheduled Transfers  
Among Areas A, B, and C

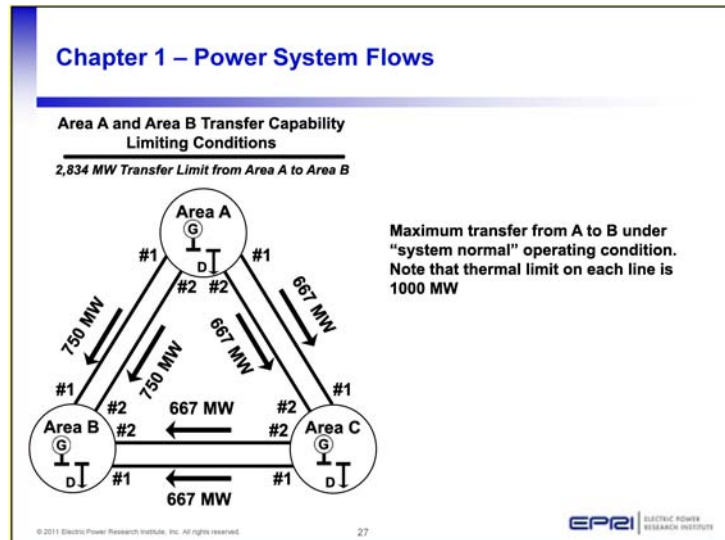


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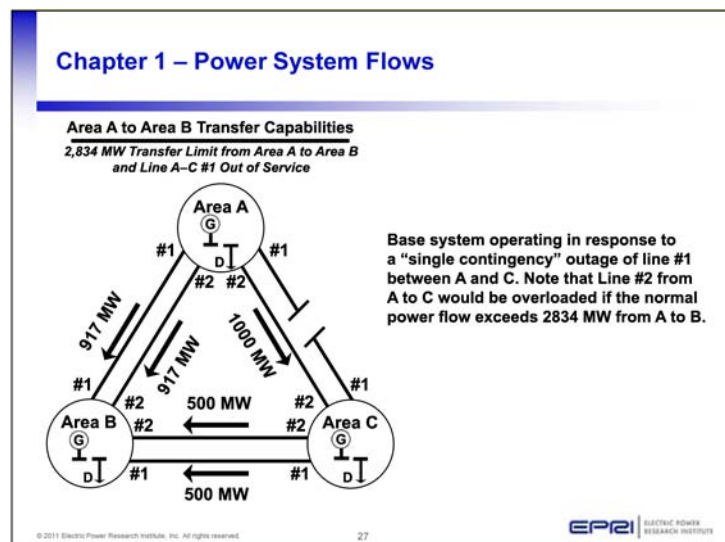
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There are three load areas (A, B, and C). Each load area has sufficient generation to supply the local load. With the system operating “normally,” there is no net power transfer between load areas; nonetheless, as a result of the available electrical paths connecting the load areas, the diagram shows a “loop” flow of 200 MW. This loop flow occurs even though there is no net power transfer to any of the areas.



Consider the situation where power generated in load area A is considerably less expensive than local generation in load area B. Therefore, power customers in load area B buy power from the generators in load area A. In doing this, the power transmission system operator sets a transfer limit of 2834 MW from A to B even though each line is capable of handling 1000 MW. The reason for this limit is to provide emergency margin as shown in the next slide



As shown in the Figure, if the normal net power transfer from A to B with all lines in service had exceeded the transfer limit of 2834 MW then, under this single contingency loss of line #1 between A and C, the power flow in line #2 from A to C would have exceeded the line's emergency thermal limit. Note that transfer limit could be increased if the power flow limits on both of the lines from A to C were increased.

## Observations on System Operation

- Economic power transfers between locations can be limited by circuits that do not directly connect them.
- A 5% increase (50 MW) in the emergency rating of lines #1 and #2 connecting A and C would allow a similar 5% increase (141 MW) in the power transfer limit.
- A 5% increase in the emergency rating of either line #1 or #2 between A and B would not allow any increase in power transfer from A to B.
- Long-term value of upgrade projects on particular circuits depend on changes in the cost of generation and the power flow limits and electrical impedance of interconnected power circuits.

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Note that these observations do not depend on the reason for the power flow limit in any of the circuits. They would be equally valid whether the limitation on power flow is due to equipment temperature limits, limits on voltage drop or electrical phase shift stability issues. Note also that doubling the thermal limit of both lines connecting A to C would simply make the lines connecting A to B the new limiting elements which determine the transfer limit.



# 4

## TRANSMISSION LINE DESIGN BASICS

### Introduction

In this chapter, we will review the basic process used to design a new transmission line. In general, designs of overhead lines in the USA vary widely, and there is far less standardization than in Europe and Asia. This lack of standardization may be the result of geographic variability, and/or be due to the fact that there are many individual utility owners in the USA, who tend to follow their own internal standards rather than a regional standard.

Transmission line design could be complex. In order to fulfill its purpose, a transmission line must be designed to meet its electrical requirements, its needed strength, and the aesthetics must be considered. Each of these items dictates characteristics of the basic layout of the structure. There are three main components to the design of the transmission line. They are:

- The wire – (both conductor and shield wire)
- The structure
- The foundation

Within these major components there are various sub-assemblies that must be compatible with all of the other components. For example, the connections and insulators between the wire and the structure must be compatible. We will discuss each of these in more detail below.

### Wire Design Basics

Normally, the conductor wire is selected first to accommodate the requirement set by the System Planning Study and/or the design standards set by the utility. The choice of conductor type and size largely determines the electrical capacity, electrical losses, thermal capacity, and corona noise of the line. The conductor type also has a major impact on the total capital cost as it has a direct bearing on the structure configuration and spacing.

There are many choices in conductors but most of them that are currently used in overhead transmission line construction, use aluminum as the base material to carry the flow of electricity. The center core of the wire can be made from other materials that reinforce the strength of the wire. These traditionally were steel wire strands, but in recent years other more exotic composite core materials have been utilized in special situations.

When determining the conductor wire that will be used on higher voltage lines, in some cases multiple conductors have been used for each phase of the line. This process, known as conductor bundling, means that a smaller size wire may be used but more conductors per phase is added to meet the design requirements. In the United States 2, 3, 4 and 6 bundle conductors have been used for each of the three phases. The design of this bundling arrangement impacts the electrical losses, thermal capacity, & corona noise of the line.

Many transmission line designs include one or two wires placed higher on the structures over the conductors called shield wires. Their purpose is to protect the line from lightning strikes.

Lightning is the largest source of outages after vegetation and has the most effect on line reliability. These shield wires will take the lightning strike and transfer the energy safely to the ground.

Lastly, in some cases a fiber optic communication wire is placed inside the core of a shield wire. This is referred to as an OPTical Ground Wire (OPGW).

## Wire Sag, Tension, and Clearance Basics

Transmission line conductors are designed for both electrical capacity and mechanical properties such as strength and sag characteristics. The fact that the wire moves under various weather conditions is also a major factor in the design. Depending on the voltage and features, different clearances are dictated by the National Electric Safety Code (NESC). Examples of these clearances are shown here:

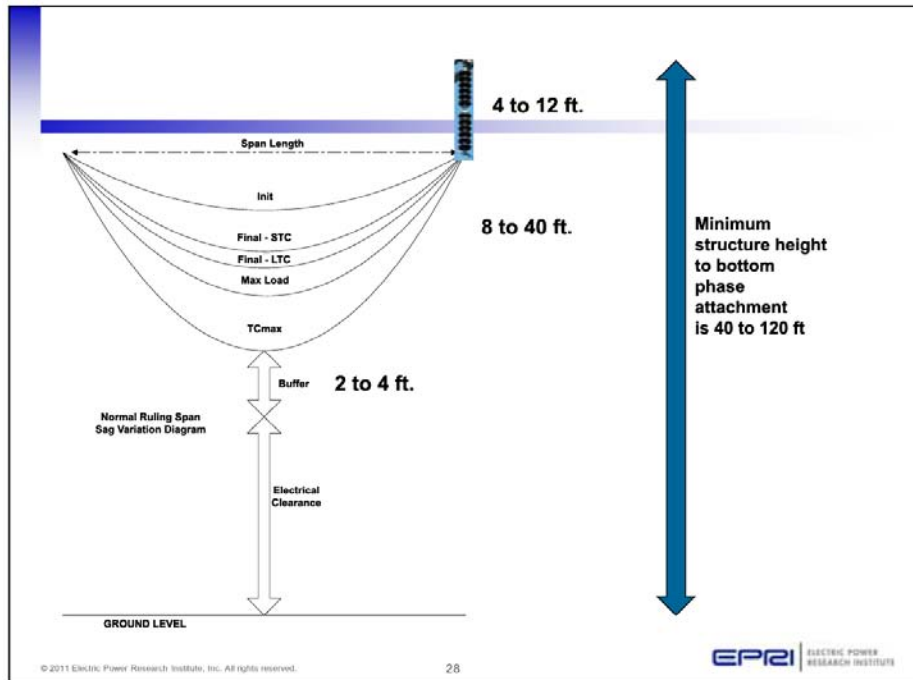
L-L/L-G	Basic Clearance @ 22kV		Clearance Added for Voltage	Streets	
	ft	m		ft	m
69/40	18.5	5.6	0.7	19.2	5.8
138/80	18.5	5.6	2.1	20.6	6.3
161/93	18.5	5.6	2.5	21.0	6.4
230/133	18.5	5.6	3.9	22.2	6.8
345/200	18.5	5.6	7.0	25.5	7.8
500/290	18.5	5.6	9.9	28.4	8.7
765/440	18.5	5.6	15.5	34.0	10.4

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As the temperature of the wire rises, the sag in the wire increases, thereby lowering the clearance from ground. Therefore, all expected weather cases must be planned for during design. This sag effect is a major determining factor in the ultimate height and location of the structures.

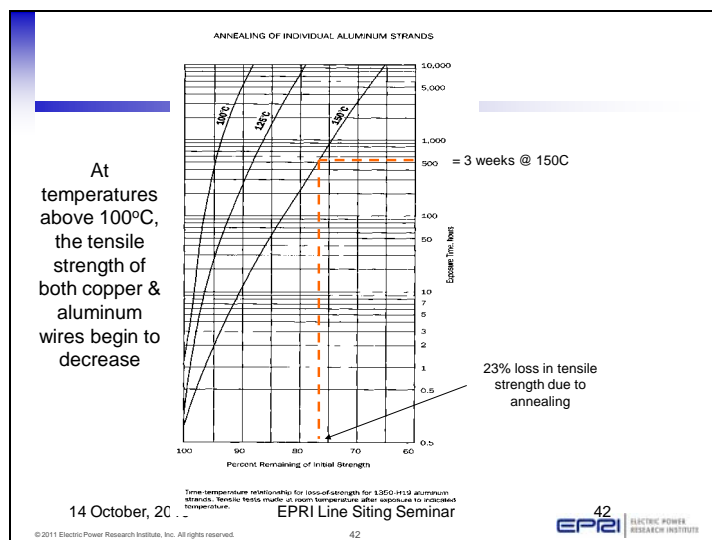
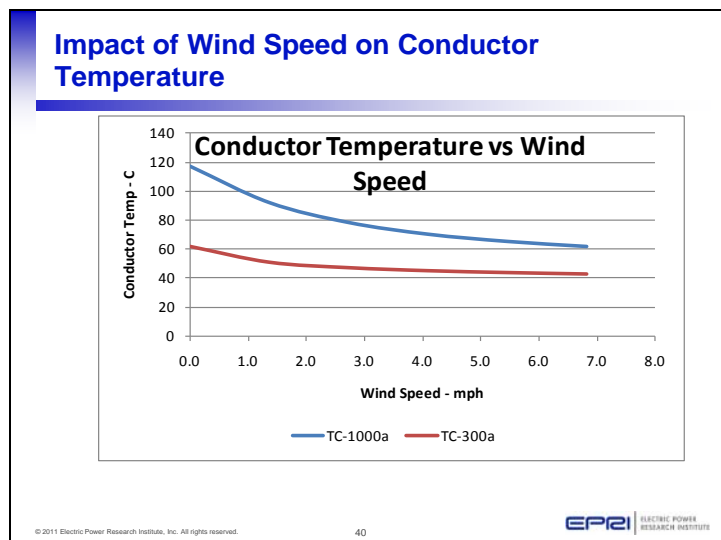
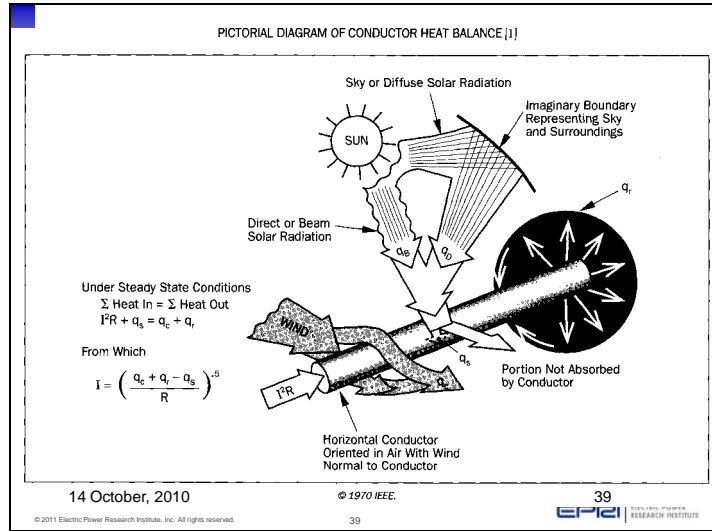


Note: STC – Short Term Creep; LTC – Long Term Creep

Throughout their expected life (40 years+), electrical clearances must be maintained under all conditions including, high ice and wind load, and high electrical load. Note that the maximum sags (minimum clearances) usually occur for max electrical loads. This means the sag at that time is even greater than that during high ice and wind loads. Sag can also increase due to creep (long term stretching of the wire) or plastic elongation during high mechanical loads such as wind or ice loads.

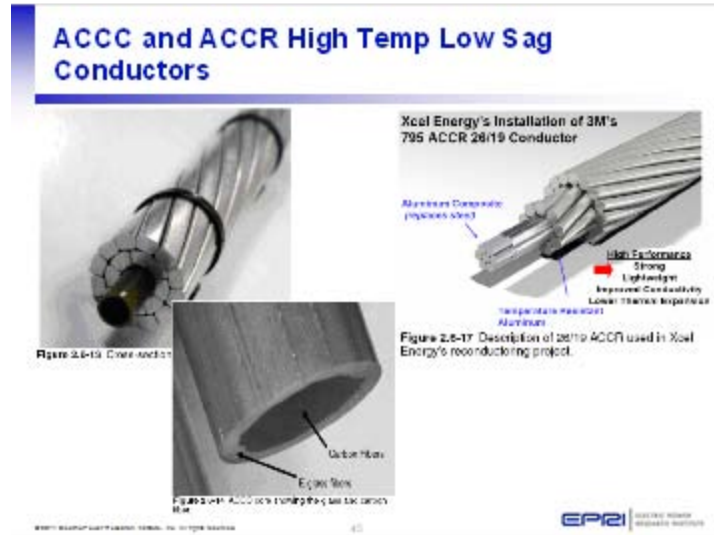
Maintaining electrical clearances is frequently the limiting factor on the amount of electrical capacity the transmission line can carry. As electrical current increases, the temperature of the line increases, and the resulting sag lowers to such a point where safe electrical clearances cannot be maintained. Another limiting factor is that the maximum operating temperature of the wire may be exceeded. This could cause permanent damage to the conductor. Utilities usually have design standards for the maximum operating temperature allowed for various conductors.

Weather also affects the temperature of the conductor. Maximum operating limits are frequently higher in the winter when the effects of air temperature, sun exposure and wind cooling are more beneficial.

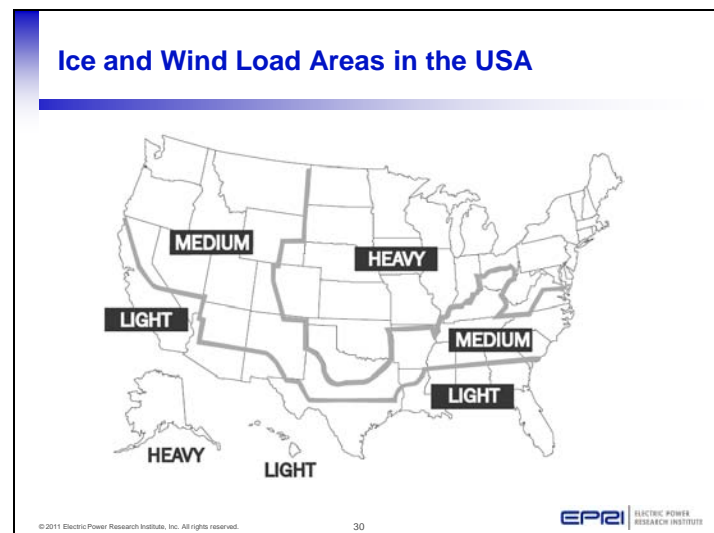




Newer conductors have been designed to use composites in place of steel for the conductor core, in order to minimize the effects of temperature rise on sag. The ACCR (3M) conductor employs a multi-strand metal (aluminum-aluminum oxide fiber) composite core. The ACCC (CTC) conductor uses a single strand core with carbon and e-glass fibers in resin. Both conductors are lighter than ACSR and have lower rates of thermal elongation.

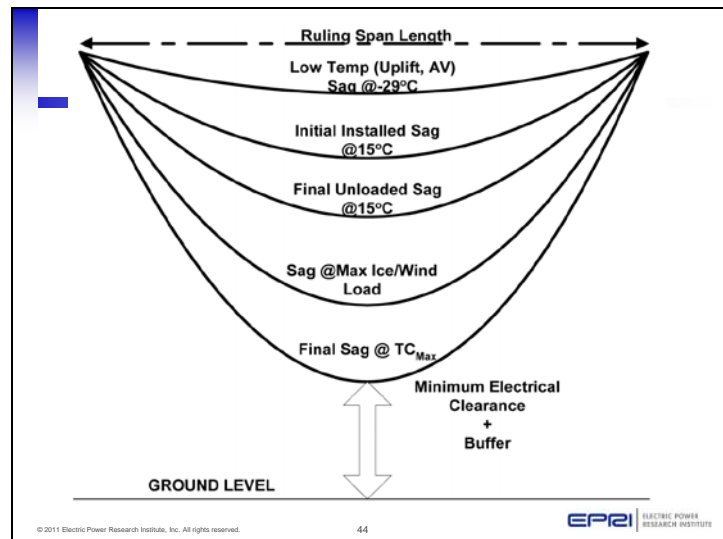


Ice and wind also affect the wire sag design. These loads can be designed using NESC suggested loading or by the utility owners design guides. For example, the local utility may consistently attempt to design their transmission lines for a minimum of 1.5 inches of radial ice and a 90 mph wind speed.



Wire tension must also be reviewed. This design tension is based on a combination of the mechanical characteristics of the chosen wire, the strength of the chosen structures and the maximum sag allowed for ground clearances. The tension will be determined during the line

design phase and must not exceed the strength of the wire. Examples of the various effects on the conductor are illustrated below.



## Structure Design Basics

Next, the basic structure configuration must be selected. The two basic structure designs use either poles or lattice towers. The poles can be combined into frame structures such as the simple H-frame design used frequently for horizontal conductor arrangements. Poles can also be designed using various materials. Wood, concrete and steel are the primary materials, although fiberglass has been used in some smaller transmission line designs.

The basic structure configuration is heavily influenced by:

- System Planning Requirements
- Siting recommendations
- Geography
- Utility standards
- Land (Rights of Way) requirements
- Permit/approval requirements.

The first design consideration is to determine whether structures will carry 1 or 2 circuits although there are cases when more circuits have been used. The remaining decisions are usually based on other details of the project.

Structures are broken into two distinct types no matter what the line configuration is. They are suspension or tangent and strain or dead-end structures. A suspension structure, as its name implies, merely suspends or props up the wire. It is designed to pass the tension of the wire through the structure and only needs to be strong enough to handle the weight of the wire and associated loads from weather such as ice and wind. These are almost exclusively found along the tangent (straight) sections of the line and perhaps at very light angles. They can usually be identified by the fact that the insulators hang down vertically and are able to swing in line thereby equalizing the tensions as the conductor temperature changes.

A strain structure must also take either a partial or total wire tension load. Therefore, they must be much stronger and are found at most all angle points along the line route and perhaps at intermediate points as well. These can usually be identified by the fact that the insulators are frequently horizontal and transfer the conductor tensions to the structure.

Examples of various structure configurations:



Single circuit, wood H-Frame design with standard and curved cross arms. (suspension)



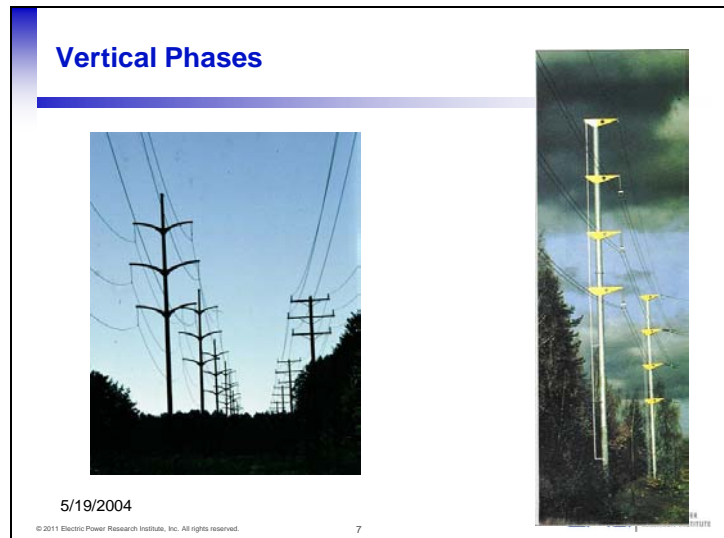
Single circuit, steel H-Frame design with underbuilt alongside a single circuit steel tower (suspension)



Double circuit steel tower (strain)



Single circuit steel tower (suspension)

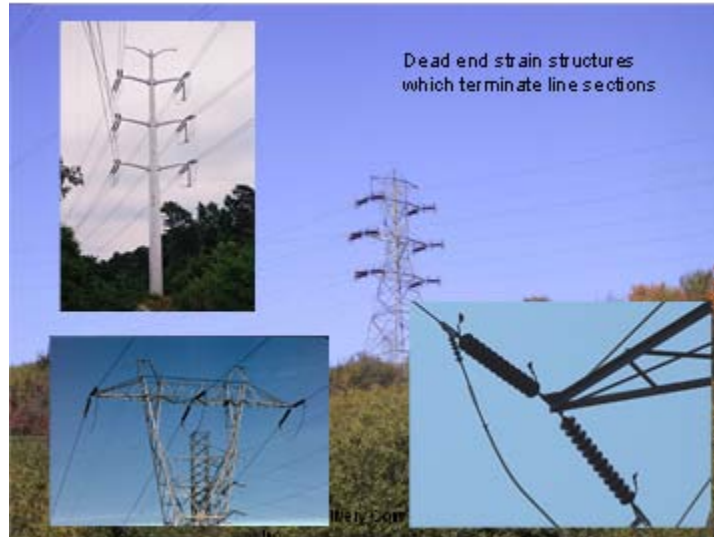


Double circuit, single pole (left) and Single circuit, single pole (right) (suspension)



Single circuit delta arrangement with distribution underbuilt (suspension)





It is beyond the scope of this guide to review the large number of decisions needed for a detailed structure design. However, all transmission line structures should be designed to meet specific project requirements and must satisfy all the applicable design codes. The most important of these is the latest edition of the National Electric Safety Code (NESC). The NESC dictates the minimum requirements for line design. Most utilities, however, have more stringent design parameters than the NESC requirements. These may be items such as higher ice or wind loads than required by the NESC.

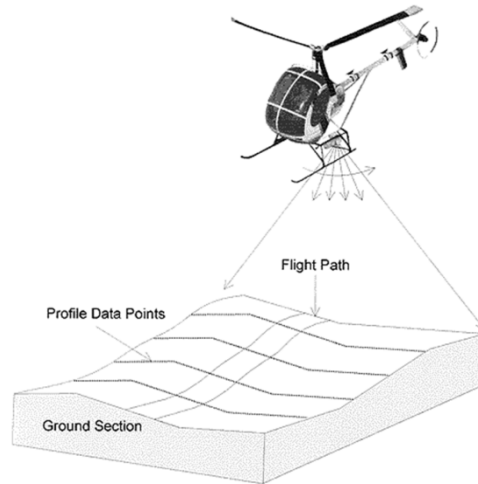
As discussed in the section on Wire Design, the conductor has a great impact on the structure design. Each structure location and size must be selected to ensure that the conductor maintains proper clearances from the ground, under all weather conditions. However, side clearances from other objects must also be maintained per the NESC for safe operation of the line.

The design of a transmission line is complex. This complexity is evident when considering the 3-dimensional problem of clearances, along with varying conditions of temperature, wind and wire movement. Most transmission line engineers today use a design program to assist in this process known as PLS-CADD © 2012 Power Line Systems, Inc. to complete this task. The basic steps are:

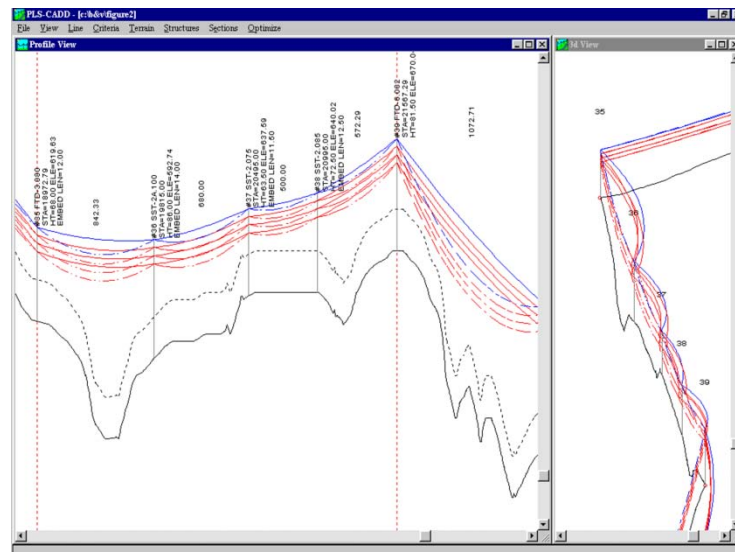
- Prepare the design criteria – such as line capacity requirements, reliability needs, and lightning protection requirements. This criterion will help to guide selection of wire, structures and other design factors.
- Obtain ground information - usually through ground survey crew measurements or through an aerial contractor using the more modern laser detection technique known as LIDAR.
- Select wire (or wires if different choices want to be analyzed.)
- Select structure configuration(s) to be used.
- Determine preliminary structure locations - using the PLS-CADD design software for review by the design team and other interested parties. This software will determine wire positions under all weather conditions and ensures that the proper clearances are maintained.

- Only after necessary reviews and approvals (sometimes both internal and external) do these preliminary designs move to final design.
- Final design of the structures and ordering materials.

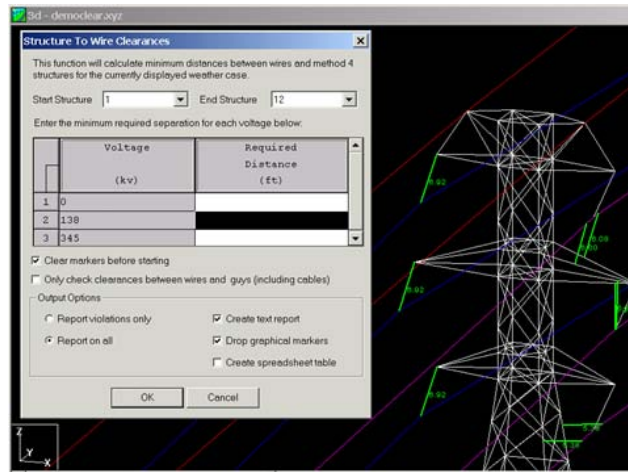
Preliminary Design Examples:



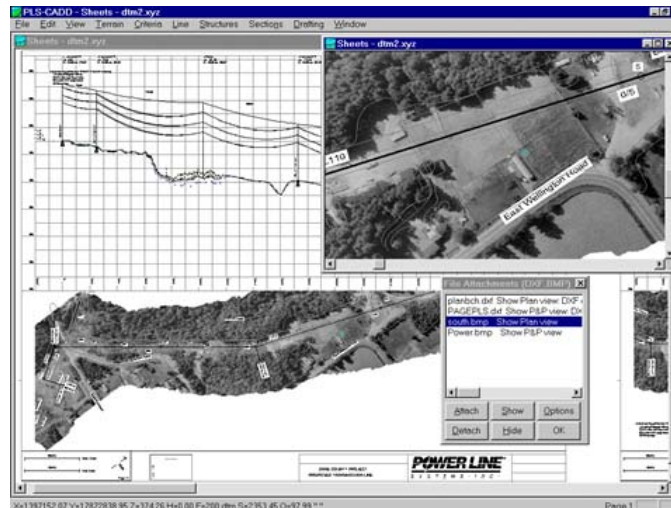
LIDAR Survey



Preliminary Line Design in PLS-CADD



Check clearances in PLS-CADD



Prepare preliminary design drawing in PLS-CADD

Once the project moves into final design, all the exact details must be determined for each structure. The specific strength, size, and materials must be determined and a detailed bill of materials prepared for the acquisition of all parts.

## Foundation Design Basics

The last major component is the sub-surface foundation design. This decision is frequently made late in the final design process, after a sub-surface investigation is complete. However, it may need to be selected earlier, depending on approval requirements. There are many choices for foundation design. Frequently, a similar design is used throughout an entire line; however, this is not always the case. On some projects, if the sub-surface conditions warrant it, the detailed foundation design is made on a structure-by-structure basis.

Different types of foundations range from the simplest, direct burial of a pole, to the more complex reinforced concrete drilled shaft design. These are the two most common foundation



types used in the US. Other examples include grillage, driven pile, vibratory foundations or even micro-piles.



Example of a concrete drilled shaft foundation under construction and complete.

In order to properly design the most appropriate and economical foundation, a subsurface exploration program must be developed. Borings must be taken and analyzed to determine the soil and rock parameters so that the transmission structure foundation can be completed.

EPRI has sponsored extensive research on the design of foundations for transmission line structures. The FAD tools programs are the result of some of that research. These programs are quickly becoming the industry standard for transmission line foundation design.



what are **FAD** Tools

FAD Tools is a software package provides for the design and analysis of transmission foundations.

- **MFAD** for Single pole foundations
- **HFAD** for H-Frame structure foundations
- **TFAD** for Tower structure foundations

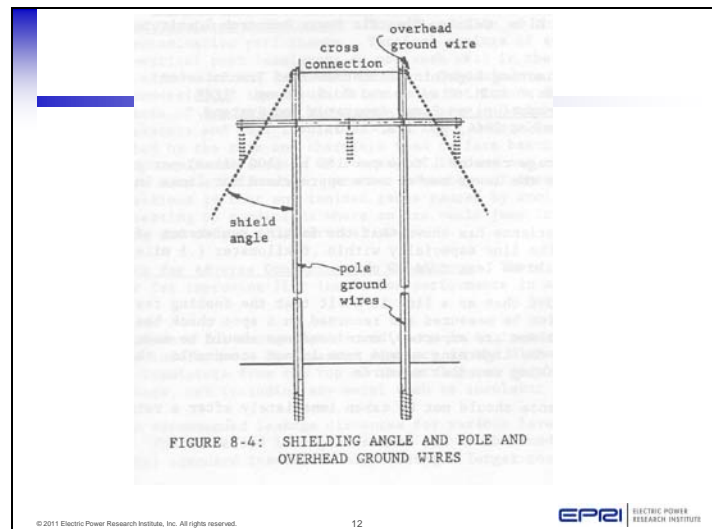
## Other Design Considerations

### ***Rights of Way (R/W) Requirements***

Another major consideration during design is the amount of land that is needed to support the design, or conversely, the amount of land available that restricts the design options. The land requirement is primarily in reference to the width of the required Rights of Way. Utilities frequently have set standards that are customarily used for various voltages and types of construction. The width of R/W needed is based on the ultimate location of the wire. If a transmission structure is designed to have a very large phase-to-phase wire spacing, a larger R/W width is needed to keep the wire within the R/W owned by the utility. If the distance between structures (span distance) is large, the wire will blow out a long distance from the center of the R/W during wind events which can increase the needed R/W width.

### ***Lightning Protection Design***

Another design consideration is the lightning protection requirements. This is important since lightning strikes are the second most prevalent cause of line outages, behind vegetation issues. The simplest design that is usually put into place is the installation of 1 or 2 static wires along the top of the structures. These wires are electrically connected to some type of grounding, such as a simple ground rod driven into the ground at each structure. The static wires take the lightning strike and dissipate it to the ground. If an area of high lightning activity or poor grounding is encountered then a more sophisticated Lightning Protection Design is warranted.



## Line Flashovers

- Overhead lines depend on insulators and lightning shield wires to avoid excessive flashovers of energized conductors to ground.
- Insulator flashover rates of 1 to 5 flashovers per 100 miles per year are typical in a well-designed line.
- Lightning flashes from cloud to earth are the largest source of electrical flashovers which can be limited by the combined use of insulators, structure grounding, and shield wires.
- Contamination of insulators can lead to flashovers at normal operating voltage & are avoided by insulator selection.
- Surges due to switching also require insulators that are long enough in combination with breaker design

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The design of these static wires has to meet similar strength and sag characteristics as the conductor wires discussed in section 4.1 to ensure proper clearances.

## Other Design Components

Other minor components and assemblies need to be compatible with the designs selected for the structures and wire. These include items such as insulators, clamps, splices and spacers, dampers and grounding systems. They must work appropriately with the other line components and meet design criteria.



FIGURE 8-1: A STANDARD PORCELAIN SUSPENSION BELL

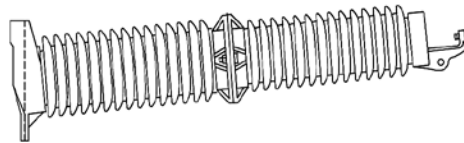


FIGURE 8-2: A TYPICAL PORCELAIN HORIZONTAL POST INSULATOR

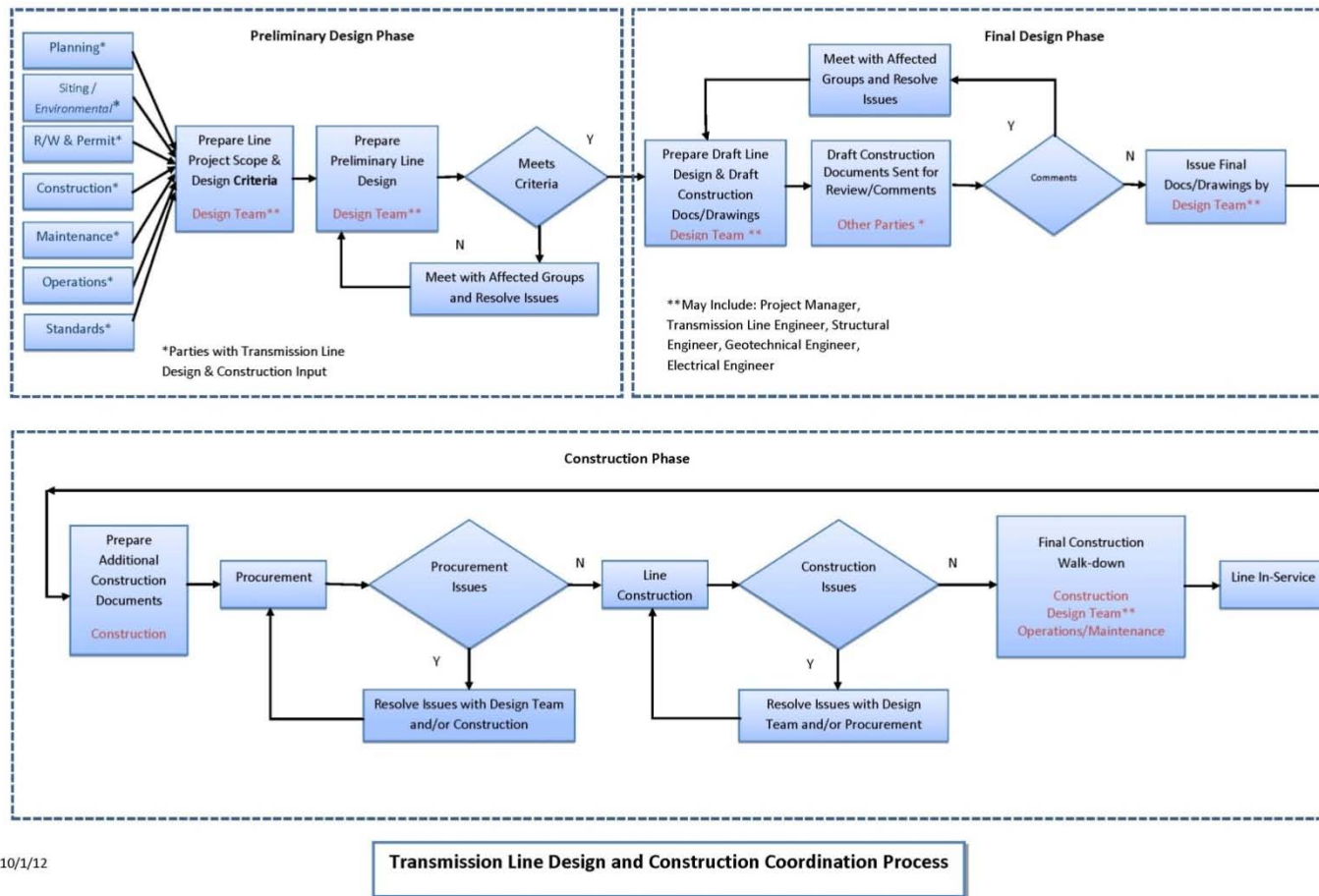
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## Transmission Line Coordination Process

As stated in Chapter 2, the transmission line design process should be accomplished with input from all transmission departments. The process flow diagram below graphically shows the interactive nature of this process and desired input from various groups.



**Figure 4-1**  
Transmission Line Design and Construction Coordination Process

# 5

## ALTERNATIVES TO SITING A NEW TRANSMISSION LINE

In this chapter, engineering alternatives that may be considered in order to solve issues found during the planning studies are discussed. These engineering alternatives can provide options, other than siting a new transmission line and building a new transmission project. These alternatives are frequently requested during the approval process, if they were not examined prior to the siting study. It is preferable to be proactive and to address these alternatives during the planning studies, and completed prior to filing for approvals, rather than as a reaction to an opposition request.

### Voltage Upgrading of Existing Lines

In certain cases, it may be possible to increase the operating voltage of an existing line without rebuilding the entire line. This usually requires that the existing line has generous spacing between phases, large conductors, and relatively long insulators. It is far less likely that a voltage upgrade can occur if the increased voltage on the line requires the use of bundled conductors where none currently exist.

Voltage upgrades generally involve one or more of the following modifications:

- Body Extensions
- Fiberglass arms with Porcelain Suspensions
- Braced Posts (Porcelain and Polymer)
- Air expanded conductors to get diameter without weight
- Tower top replacement

## Voltage Upgrade Examples in Western U.S.

- The 115-kV transmission line was upgraded to increase system reliability when another 230 kV line is out of service.
- The upgrade reduced the loading on an existing 230/115-kV transformer bank and provided additional voltage support to a major urban area during contingency conditions.
- A 230 kV line was upgraded in the BPA system to 345 kV to gain more capacity.

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## Conversion of 115 to 230 kV AC



Before Conversion  
115 kV



After Conversion  
230 kV

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## Conversion of 230 to 345 kV AC



Before Conversion  
230 kV



After Conversion  
345 kV

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## An Ideal Voltage Upgrade Project

Upgrading a line with an increase in voltage but without rebuilding, reframing, extensive modification of the existing line.

## Why Minimal Modification?

Full blown Voltage Upgrade generally requires a considerable amount of structural modifications and costs?

But what about the desire to perform minimal modification, what do we need to evaluate before deciding whether a “minimal modification” can be made or not?

We will consider

- Insulation modification and
  - Reconductoring (if still minimal modification)
- as Minimal Modification

## List of Issues

- Insulation Coordination
- Clearances
- Existing Asset Condition and Performance
- Right of Way Issues
- EMF
- Live-line Maintenance
- Schedule

## Deal Killers & Money Issues

### Deal Killers

- Insulation Coordination – Insufficient Geometry
- Clearances – Code Compliance
- Asset Condition – Too Costly to Retain/Repair

### Money Drivers

- Asset Condition – Ditto
- R/W Issues – Costs too much to gain rights
- EMF concerns if mitigation required, e.g., bigger conductor, shielding, new R/W

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## Thing to Remember

**Lifetime Costs Govern**

**Not Just**

**Capital Investment**

- Aged Asset cannot support 30-50 years of life extension
- Condition of assets push the replacement costs to a point where REBUILD is better in the new Life of the line
- Temporary can evolve into Permanent

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## AC-Voltage Upgrade Advantages

- Quick – (licensing & construction)
- Lower cost than a new line
- Doubling the AC voltage of an existing line, increases the power flow capacity by 2 to 4 times.
- Even if the conductors remain the same, electrical losses per MVA are reduced by a factor of 4.
- The structures and foundations may be re-used if the original line design was conservative.
- Voltage drop and phase shift under emergency loads are reduced, even if the line is not re-conducted.
- Magnetic fields are lower for the same MVA.

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## AC-Voltage Upgrade Drawbacks

- Substation costs may be driven by the total line capacity rather than the marginal increase.
- Substation construction may be required if existing capacity does not exist at the higher voltage.
- Electric fields will be higher.
- Corona (RI/TV noise) may be a problem if the conductors are not replaced.
- Longer insulators are usually required and may yield reduced conductor-structure clearances.

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## Conclusions – AC Voltage Upgrades

- AC voltage upgrades involve some risk taking since the designer must decide about re-using aged components.
- The success of a voltage upgrade depends largely on the condition of the original line.
- Lightning protection is seldom an issue but switching surge withstand can be.
- The upgraded line, capable of carrying much higher loads, may not be as reliable as a new line.

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### Manitoba Hydro's Experience With an Upgraded 230 kV Overhead Transmission Line

*John K. Chan, P.Eng. EPRI*

## Background

### Line upgraded

- 115 kV line in Southwestern Manitoba, Canada built in 1960's, going through an heavy icing area
- 31.9 miles in length
- 29 - 115 kV H-frame wood pole structures converted

### Schedule

- 1970 feasibility study initiated
- 1973 engineering studies completed
- 1976 upgrade implemented

## Changes Involved

- Replaced steel terminating structures at the line ends.
- Raised the cross arm of each structure by 2 feet
- Added bayonets to 6 structures
- Replaced existing 336.4 kcmil "Linnet" ASCR conductor with a 796 kcmil conductor for higher current capacity
- Selected a SD (Self Damping) Type 5 conductor to reduce conductor sag
- Trimmed cross-braces that are protruding towards the outside phases.

## Design Parameters

- Line loading:  $\frac{1}{2}$ ' ice and 8 lb/ft<sup>2</sup> (55 mph) wind & 15 lb/ft<sup>2</sup> (77mph) wind & without any ice
- Ruling span: 525'
- Pole used: 65' WRC Class 3 & 55' WRC Class 2
- Maximum switching surge assumed in the upgrade: 2 pu

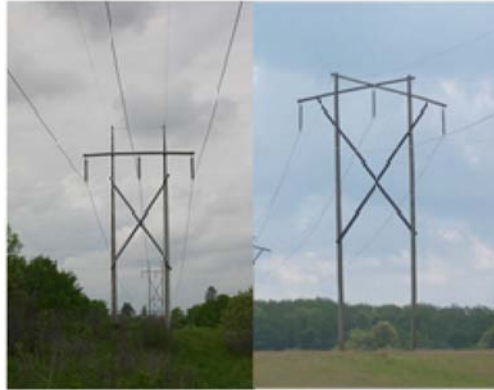
## Before Upgrade

- Structure Type: Standard H-frame wood structures
- Safety factor of structures: 3
- Line Configuration: Horizontal with 12' phase separation
- Conductor: 336.4 kcmil "Linnet" ACSR conductor strung to an initial tension of 20% RBS at -30oF
- Ground Clearance: 20'
- Insulators: Suspension string with 7 – 5 ¾" x 10" porcelain insulators
- Air gap: 68" when insulator string is at rest

## After Upgrade

- Structure Type: Modified H-frame wood structures (cross arms raised by 2'; 4' bayonets added to 6 structures)
- Safety factor of structures: 2 (Actual minimum was 1.88.)
- Line Configuration: unchanged
- Conductor: 795 kcmil SD conductor strung to an initial tension of 31% RBS at -30oF
- Ground Clearance: 25'
- Insulators: Two new insulators added to each string
- Air gap: unchanged

### Upgraded vs Standard 230 kV Structure



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### More than 30 Years of Experience

#### Advantages

- No line failure due to ice storms
- No obvious difference in line performance from other standard 230 kV transmission lines in the same area.
- Saved over 30% of capital cost

#### Disadvantages

- No live line work on line due to safety concerns
- Live line work not considered and procedure not developed

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## Thermal Line Upgrading

Of course, the simplest method of increasing the capacity of an existing overhead line involves re-using the existing conductors. When using existing conductors, the following apply:

1. Requires that there is sufficient electrical clearance to maintain minimum distances at the new higher temperature and any resulting annealing is acceptable.
2. Is easiest to do with multi-pole wood structures.
3. Re-tensioning is limited by the resulting increase in structure loads and Aeolian vibration.
4. Inevitable increase in temperature risk must be acceptable.

In order to avoid damage to conductor systems, and to avoid excessive conductor sag (which could result in inadequate electrical clearance along the line), the power flow on lines is limited. The relationship between electrical current, weather conditions, and conductor characteristics is explained below.



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## **New Line Alternatives - Thermal Upgrading of Existing UGC and OHL Circuits**



EPRI Line Siting Seminar  
29 Sept, 2011



John Chan                      EPRI Manager  
Dale Douglass              PDC, Inc

### **Main Discussion Points**

- Overhead lines and, to a lesser extent, underground cables can be thermally upgraded in a wide variety of ways at relatively low cost.
- In some situations, increasing the thermal rating of existing overhead and underground circuits can be a sensible alternative to building a new overhead line.
- Thermal upgrading of OHL normally concerns finding safe ways to operate existing or replacement conductors at higher temperature while maintaining electrical clearances and original design strength.
- Thermal upgrading of UGC normally concerns ways to reduce hot spots or average cable temperature in order to avoid premature insulation failure.

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### **Line Upgrading Options Which Avoid Reconductoring**

1. Increase the operating temperature of the original conductors.
2. Use less conservative weather conditions in calculating the thermal rating.
3. Increase the maximum temperature and use less conservative weather conditions.
4. Re-tension the line to decrease the high temperature sag.
5. Dynamically rate the line with tension monitors.
6. Use SLIM devices selectively to limit sag at high temperature.

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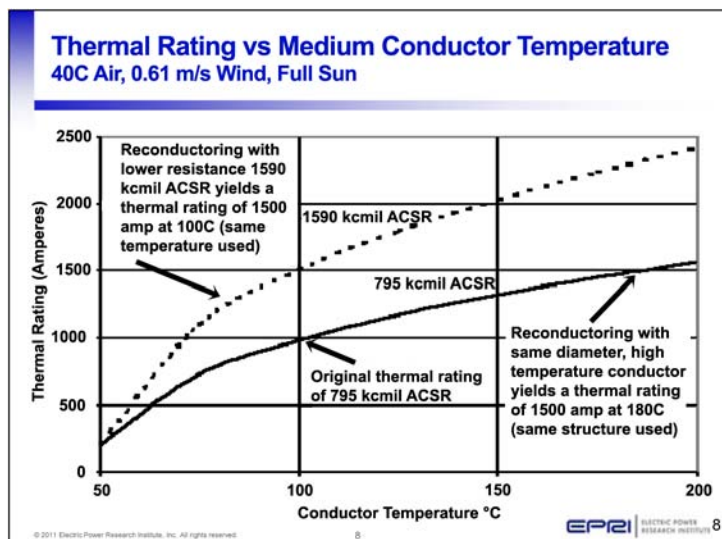
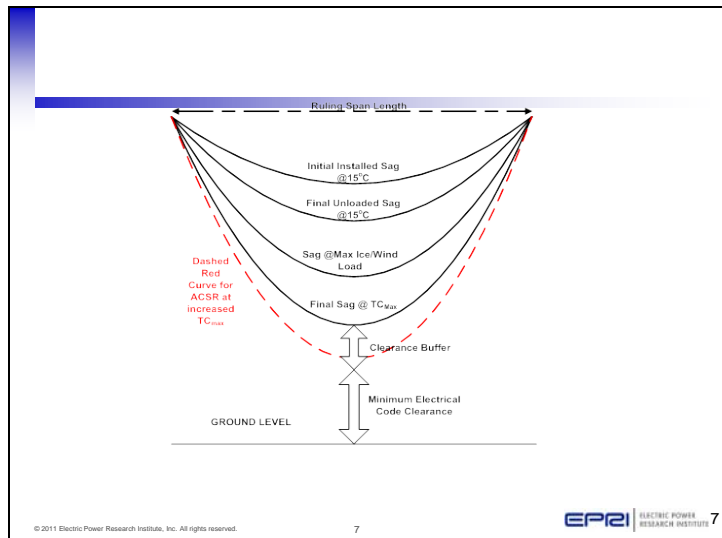
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## Candidate Lines

- ACSR with high steel content (30/19, 54/7, etc.) in excellent condition
- Structures in good condition.
- Splices need to be checked or shunted.
- No evidence of vibration fatigue
- For re-tensioning, few angle/dead-ends per km or mi

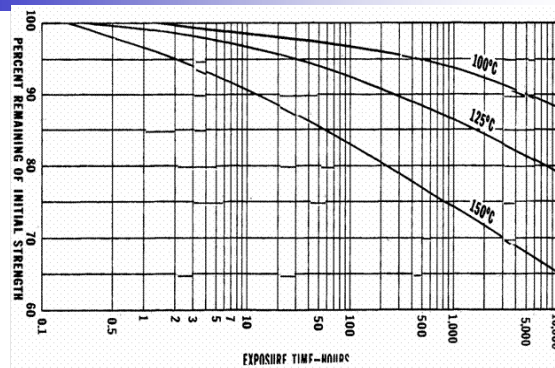
## Accept Reduced Clearance or Greater Loss of Strength

- Only applicable to lines having relatively low maximum allowable temperature (50C to 90C) and/or extra ground clearance.
- Annealing of aluminum negligible below 95C.
- Steel cored conductors are particularly attractive candidates since they elongate and anneal less than all aluminum or copper.



This graph shows how reconductoring with a high temperature conductor of the same diameter as the original, but tolerant of operation at 200° C, the rating of a line can be increased from 1000 amperes to over 1500 amperes. Note that since the new conductor has the same diameter as the original, the transverse wind and vertical ice loads on most structures are the same and extensive replacement of structures and foundations can be avoided.

## Annealing of Aluminum



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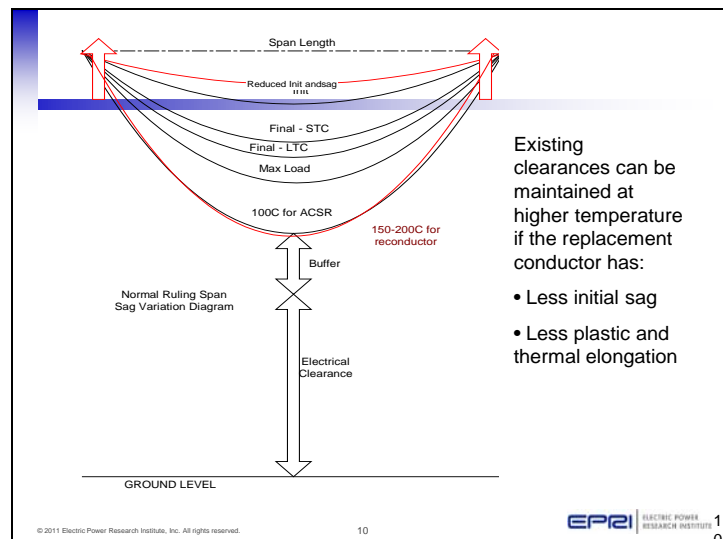
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Annealing of aluminum wires is similar to that of full-hard aluminum wires.

10% loss of tensile strength corresponds to:

- 5,000 hrs at 100°C
- 300 hrs at 125°C and
- Only 12 hrs at 150°C



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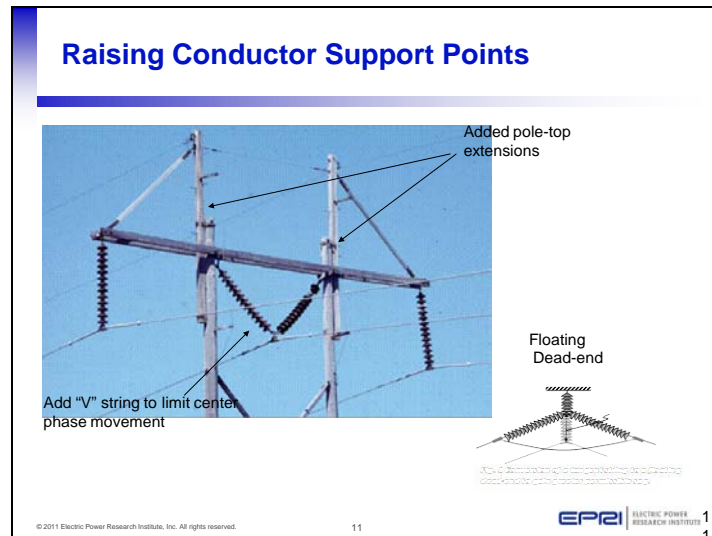
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As shown in the photo, the attachment points of this line were raised in order to increase the high temperature clearance to ground and because the line voltage was being increased, the movement of the center phase was restricted by the use of a V string. As a testament to this simple uprating approach, this line was uprated over 60 years ago and is still functioning reliably at 230kV. Notice the damaged insulator in the “V” string was probably due to gunshots.



This sort of radical raising of attachment supports causes a large increase in ground line moment. So even with the X-brace reinforcement, this method works best when in an area not subject to severe transverse loading by high wind or combinations of ice, and moderately high wind. This example was implemented in the southwestern US. It's important to note that raising some structures but not all may cause changes in conductor tension and thereby affect the conductor sag response to changes in load and temperature.

## Other Devices

- Example:
  - SLIM (Sag Line Mitigator: metal with negative coefficient of thermal expansion)



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HTLS conductors are capable of sustained operation at temperatures above 150°C with minimal change in mechanical properties and relatively low increase in sag.

The SLIM device reduces sag by contracting at a planned conductor temperature.

## Line Upgrading Options Which Require Reconductoring

1. Use of a larger conventional conductor which increases the surface area and reduces the resistance of the conductor.
2. Use of High-temperature, Low-sag conductors which are the same diameter as the original line conductors but which can operate at a higher temperature without losing strength or sagging excessively.

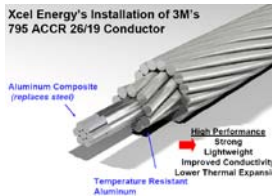
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## HTLS Conductors

- ACSS
- Invar
- GTACSR (Gap)
- ACCC (CTC)
- ACCR (3M)



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With the exception of ACSS (Aluminum conductor, steel-supported), these HTLS conductors have not been used extensively in North America or in Europe. A key goal of this project is to gain experience in stringing, sagging, and clipping these new types of conductors, as well as using the new materials with which they are stranded.

## Key Advantages of ACSS

- Operates up to 250°C with no reduction in conductor tensile strength.
- No creep elongation over time.
- High self-damping limits aeolian vibration.
- 20% - 50% less thermal elongation.
- Conventional installation and hardware

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## Ampacity of 26/7, 405/65 ACSS vs Conductor Temperature

Conductor Temp Tcdr [Deg C]	Ampacity@40Cair, 2 ft/sec wind, Sun
50	180
100	990
150	1330
200	1570
250	1770

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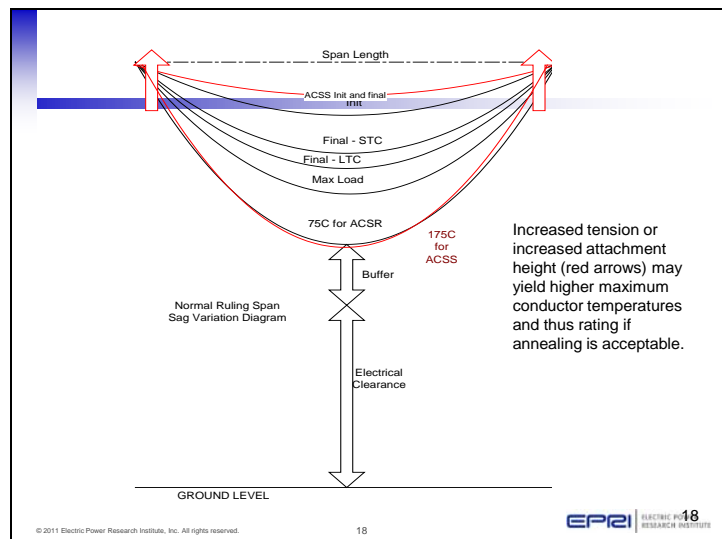
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An ACSR conductor is normally limited to temperatures in the range of 75C to 100C. Thus a 795 kcmil ACSR conductor would be rated at 990 amperes or less.

The ACSS conductor can be operated at temperatures of up to 250C without any change in conductor properties. Thus, for a conductor having the same electrical resistance, weight per unit length, and nearly the same cost, ACSS has a thermal rating nearly twice that of standard ACSR.



### Other Widely Available High-Temp Low-Sag Conductors

- (Z)TACIR – consists of (Z)TAL aluminum strands around a core of Invar steel wires.
- G(Z)TACSR – “Gapped ACSR” consists of (Z)TAL aluminum strands around a core of steel wires.
- ACCR – consists of (Z)TAL aluminum strands around a core of aluminum oxide fibers in an aluminum matrix.
- ACCC – annealed aluminum strands around a polymer resin core containing carbon fibers encased in fiberglass.

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### Dynamic Line Rating of Existing Lines

We live in an age where technology allows both remote monitoring and communications. Many think that if we were able to monitor our existing transmission lines more carefully, we could avoid building new lines. This presentation discusses the various methods of monitoring and dynamically rating overhead lines. We have concluded that these techniques are helpful, as they allow an increase in power flow of 5% to 15% but that they are not a substitute for physical uprating or new lines.

### Thermal Uprating – Smart Grid Choices

- Line monitors/sensors can communicate information about the actual state of transmission lines to determine their true capacities rather than having the operator assume the worst.
- This rating method can be applied to certain lines to delay new construction.
- This method is being widely tested in a few power systems.

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## Dynamic Thermal Ratings – Background

- Dynamic ratings requires real-time electrical load, weather, and sometimes equipment monitor data.
- The advantages of using dynamic ratings include postponement of capital investment, improved thermal models for critical equipment, and better guidance for operations during severe contingencies.
- Dynamics rating methods, if implemented properly, can both increase utilization and improve system reliability.

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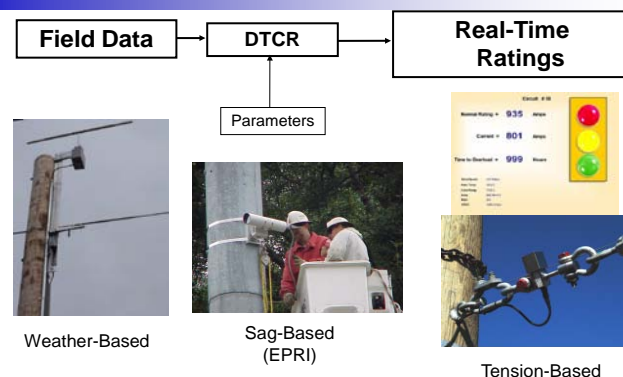
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In early substation field tests, the dynamic thermal rating calculation software was installed on computers placed close to the power equipment being monitored. In general, this was not a satisfactory arrangement. When real-time monitors are interfaced with the SCADA system, dynamic thermal ratings can then be calculated in an office environment, based on real-time data, and obtained through SCADA. The result of these calculations can be displayed according to the needs of each utility or utility function.

Without dynamic ratings, the system planner may need to upgrade the capacity of circuits once the line current approaches the static line rating. However, if the line is dynamically rated, it may be possible to postpone the upgrade. If equipment monitors are used, the equipment engineer's thermal model can be tested experimentally.

Dynamic monitoring is able to identify infrequent low rating periods that the operator could not otherwise detect. Load reduction action, during such periods, can avoid equipment damage that might otherwise occur. Usually, the dynamic rating is higher than the static rating and the equipment can be safely utilized at power flow levels 5% to 15% above the static limit.

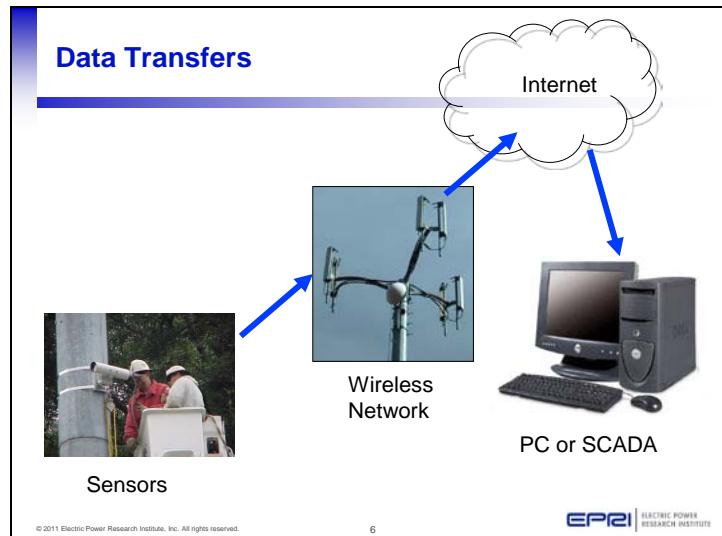
## Dynamic Thermal Circuit Rating (DTCR) Models



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## A Sensor Being Developed at EPRI

For

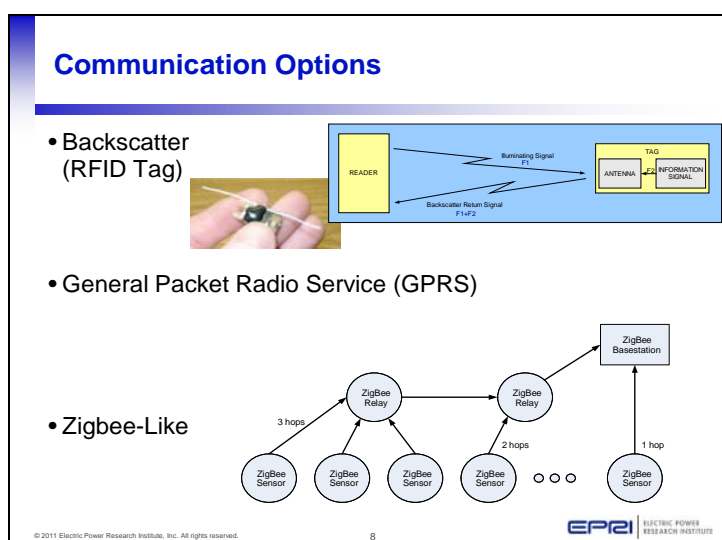
- Measuring Conductor Temperatures
- Identifying High Risk Connectors
- Detecting Conductor Motion

A close-up photograph shows a metallic sensor device clamped onto a power line conductor. The device has a circular opening and is secured with bolts. The background shows a blurred view of a power line tower and surrounding landscape.

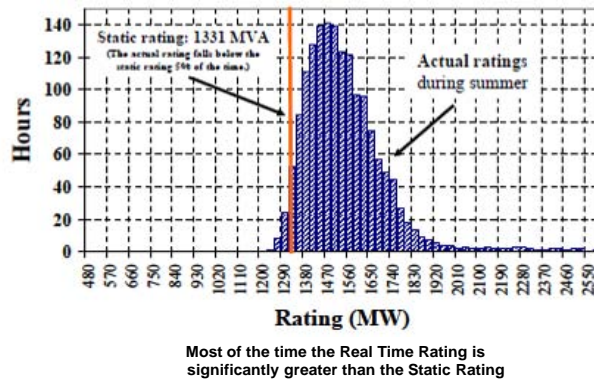
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## An Example of Traditional Line Rating Versus Actual Data Collected Using Sensors



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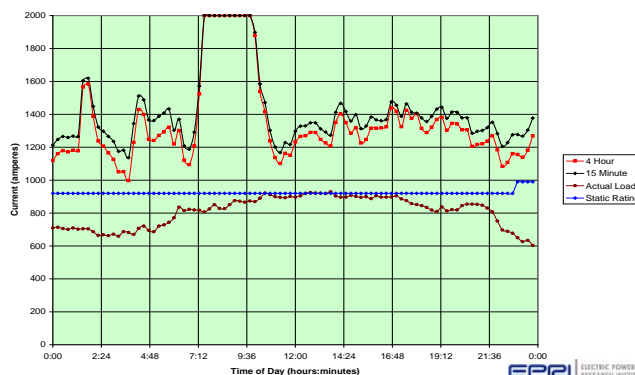
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This figure shows a statistical distribution of line currents and actual line dynamic current ratings. The static rating of the line is also shown. The area under the pink curve and to the left of the static rating represents the percent of time the line's dynamic rating falls below the static rating. The area to the right of the curve represents the percent of time the line's dynamic rating is above the static rating.

Without knowing the dynamic rating the operator must intervene to prevent the line load from exceeding the static rating. This is done via re-dispatch of generation, switching operations, series reactors, phase angle regulating transformers, or the last ditch effort of shedding load. If the operator knew the dynamic rating, intervention would probably not be necessary. Dynamic Ratings warn the operator of potential overload problems.

## Higher Rating Achieved through DTCR Technology



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## Operating with Dynamic Ratings - Challenges

- Dynamic ratings vary over time. Even if circuit loads remain constant, action may be required because ratings decrease. Especially when changes in ratings are rapid, more frequent operator actions may be required during heavy load periods.
- Dynamic rating methods are sometimes complex.
- Dynamic rating schemes are temporary, intended for use until a more conventional uprating solution can be implemented.

The IPF (Increased Power Flow) Guidebook developed by EPRI is unique. It provides more detail information on alternatives to siting a new transmission line and can be used as a training tool for new power delivery engineers or as a resource for experienced design, planning and operations personnel. New chapters are being developed over time.

## Examples of Dynamic Rating Applications

1. Temporary Uprating of a line about to be replaced or uprated.
2. Application to Wind Farm Generation Radial Feeds
3. Avoidance of Standby Generation Unit Start-up
4. Hydropower Radial Feeds
5. Underground Cable Load Shape
6. Reduction of Load Shedding at Path15

## Conclusions on Dynamic Ratings

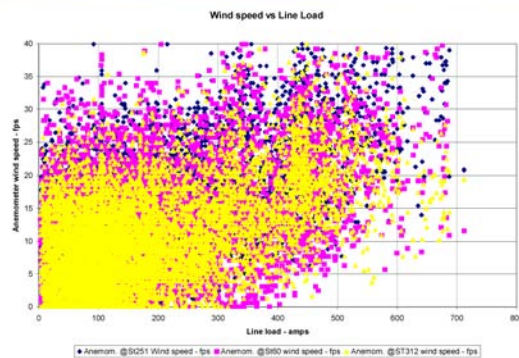
- May safely increased line capacity by 5% to 15%, resulting in both more economic operation and in postponement of equipment capital investment in low-growth areas.
- Allow time for remedial action, either manual or automatic.
- Wind is the most crucial factor in rating overhead lines. Because of the variability of wind along the line, multiple monitoring locations are required, especially for long lines.
- The most attractive candidates for dynamic thermal rating are those requiring the most capital to replace or the most time to obtain regulatory approval

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## Correlation of Wind and Line Current Near a Wind Farm



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Dynamic ratings (DR) can be helpful in increasing the thermal capacity of overhead line radial connections from wind farms to the rest of the power system. If the line current is entirely due to the wind farm generation, and the line is located near the wind farm in similar terrain it is likely to be successful. If the line carries power flow from other non-wind sources of generation or if segments of the line are far away (>20 miles) from the wind farm, or if the line is sheltered by terrain or foliage, DR may not be useful.

The Figure above is for a 138 kV line carrying load, produced nearly entirely by a local wind farm shows a typical chronological comparison of wind speed and load. Results show the line current falling rapidly as the wind speed drops suddenly.

# 6

## ALTERNATIVES TO TRADITIONAL OVERHEAD TRANSMISSION LINES

In this chapter, the single most requested alternative, underground transmission, to siting a new overhead transmission and the emerging HVDC alternative are discussed. Placing a new transmission line underground is almost always discussed at every approval hearing. It is imperative that any company going into public hearing for a new line be prepared to address this issue in detail. If not studied prior to the siting study, these alternatives can be requested during the approval process. It is always preferable to be prepared to address these alternatives as a part of the siting studies done prior to filing for approvals and not as a reaction to an opposition request.

Recently, there has been much discussion about HVDC (high voltage direct current) transmission lines. HVDC has become more popular due to the success of using submarine cables for off-shore wind power generation and its numerous other advantages.

### Underground Transmission Lines

Why can't transmission lines be put underground where no one can see them? In many cases it is possible but relatively expensive to do so. Underground cable circuits generally cost from 3 to 15 times as much as overhead lines. On the other hand, using underground cable in certain areas of high population density or critically important scenic tourist regions is not only practical but can simplify the siting process for an overhead line. The availability of transition structures as an alternative to conventional substations with cable potheads has simplified the concept of partial undergrounding of overhead lines.

#### Typical Line Siting Question on Cable

- A transmission line is to be built in a settled area. To reduce visibility, the use of underground cable is proposed as an alternative to the overhead line. What are the advantages and disadvantages of cables versus lines?

## Main Discussion Points

- Underground cable (UGC) is far more complex to manufacture and terminate than bare overhead conductor. Consequently, underground cables are almost always more expensive and slower to build than overhead lines (OHL).
- Once built, underground cable circuits are immune to weather, invisible to the public, highly reliable. They can be damaged by third party dig-ins and resulting repair and restoration times are measured in weeks rather than hours.
- Continuous thermal ratings for a given conductor size (e.g. 1000 mm<sup>2</sup>) are much lower for cables but emergency overload ratings are higher.

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## Main Discussion Points (cont.)

- The electric field outside a cable is zero but the magnetic field can be higher directly over the buried cables. The magnetic field of cables attenuates quickly with distance.
- OHL are far less disruptive to the environment in ecologically sensitive areas since OHL excavation is only required for structure foundations spaced 600 to 1200 ft apart while UGC requires a continuous trench.
- Once installed, UGC does not pose an electrocution or impact risk for wildlife or for the public.
- At 230 kV and below it is possible to combine UGC and OHL segments without the need for substations at the transitions.

ASCE Conductor Seminar 11  
November, 2009

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## Main Discussion Points (cont.)

- The electrical characteristics of UGC are quite different from OHL due to the difference in spacing of conductors. UGC may produce excessive voltage levels in lightly loaded circuits.
- Combining OHL and UGC segments in a common network can improve system stability and reduce the need for additional compensation.

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### Fluid-filled Cable System Types

- High-pressure fluid-filled (HPFF) or gas-filled (HPGF), pipe-type
- Self-contained Low-pressure fluid-filled (SCFF, SCLF, SCOF)

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Less common cable types include the following:

Mass Impregnated (MI) or Paper Insulated Lead Covered (PILC) cable, which is used up to 69 kV. MI cables are more common for HVDC submarine applications

Compresses Gas Insulated Transmission (CGIT) lines are very similar to gas insulated substation (GIS) bus. An aluminum tubular enclosure contains a hollow, rigid aluminum conductor, which is insulated using SF<sub>6</sub> gas. There are many issues with CGIT, but its most common application is for lines where very high ampacities are required (e.g., > 2000 amps).

### Extruded Dielectric Cable

- The three cables are installed in individual ducts
- No pressurization required
- XLPE used through 500 kV; EPR used through 138 kV
- EPR has higher dielectric losses, but is more forgiving of moisture

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Unlike the pipe-type and self-contained cables, the insulation for these cables is extruded onto the conductor core.

Cross-linked polyethylene (XLPE) is the most common type of extruded-dielectric cable. It has low losses, but is extremely sensitive to cleanliness and quality control during the manufacturing

process, and is extremely sensitive to the presence of moisture, which could lead to premature failure.

Ethylene propylene rubber (EPR) is more common at distribution voltages, but has been used as high as 138 kV. The insulation has higher dielectric losses compared to XLPE, but does not require a moisture barrier like the XLPE since it is relatively unaffected by moisture.

A less common insulation is Linear Low or Medium Density Polyethylene (LLPE or MDPE). Most installations of this type of cable were in France. This insulation has a low maximum normal operating temperature, which limits the power transfer for a given conductor size.

Typical installation:

### Load Flow Considerations for UGC

- Because a cable has significantly lower series reactance compared to overhead lines, the following can occur:
  - Uneven load sharing between parallel overhead and underground lines
  - Uneven load sharing between two parallel underground lines that are not identical

Parameter	Overhead Line	Underground Extruded-dielectric XLPE
Shunt capacitance, $\mu\text{F}/\text{mi}$	0.0189	0.279
Shunt reactance, megohm-mi	0.140	0.0095
Series inductance, mH-mi	1.56	0.234
Series reactance, ohms-mi	0.587	0.088
Charging current, A/mi	1.42	21.0
Dielectric loss per phase, kW/mi	Negligible	0.42
Reactive charging power, three-phase MVA/mi	0.849	12.6
Capacitive energy, kJ/mi	2.3	33.2
Surge impedance, ohms	287	29
Surge impedance loading, MVA	415	4110
Typical rating, Amperes	2500	1400

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Some methods which can be used to redistribute the power flows:

- Use capacitors in series with the overhead lines to reduce its total reactance,
- Use a phase-shifting transformer to artificially decrease the angle across the cable circuit,
- Increase the series reactance between the load point and the cable circuit.

## Upgrading Hybrid Circuits

- Hybrid circuits contain both overhead lines and underground cables.
- Underground cables are often the thermal “pinch point” of the circuit with regards to normal ampacity.
- Overhead lines are often the thermal “pinch point” of the circuit with regards to emergency ampacity.

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Hybrid circuits are becoming more and more common, used for water crossings, tunnels, airports, congested areas, etc.

## Attempt to Increase Thermal Rating of UGC May Yield Greater Construction Cost and Disruption

- Phase and Circuit Spacing – increased spacing reduces mutual heating which increases ampacity (except with multi-point bonded cables where the increased spacing can give higher sheath currents)
- Native Soil and Backfill Thermal Resistivity – the lower the thermal resistivity, the higher the ampacity
- Conductor Size – generally, the bigger the better

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This section briefly highlights the effects of various cable and installation parameters on ampacity. The range of variation is not applicable to all installed cable systems, but the trend is generally consistent for all cable installations.

## Joint Use of Overhead and Underground Transmission

- *New overhead transmission circuits are more likely to be approved if underground cable is used to solve esthetic and environmental problems at critical locations. Recent technical advances in solid dielectric cable and “transition” structures make this possible at voltages as high as 230kV.*
- *In a recent project in Connecticut, 29 miles of a new 63 mile 345kV circuit was put underground. This was the first large scale application of 345 kV solid dielectric cable in the US. Prior installations were on the order of a mile.*

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## Esthetic Limitations

- **Vermont Law Example:** A transmission circuit must not have an undue adverse impact on aesthetics:
  - (1) [Transmission circuit] projects impact on aesthetics is adverse if its design is out of context or not in harmony with its surroundings.
  - (2) If adverse, it is undue if:
    - (i) it violates a clear written community standard about aesthetics.
    - (ii) it would offend the sensibilities of the average person.
    - (iii) if the applicant has not taken generally available mitigating steps to improve the harmony of the project with surroundings.

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## Economics of Joint Use

- Materials & construction labor perhaps 3 to 15 times more for underground cable.
- ROW cost could be much less for underground cable.
- Impact on overall cost of circuit may be minimal if cable is only 10% of route.
- In certain system locations, getting the circuit built is worth a lot in terms of generation cost reduction.

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## Economics – Example in High Population Density Area

- In Fairfield County Connecticut approximately 100 miles of 345 kV to be built for system reliability reasons.
- In one section of 26 miles, 12 miles was built underground (mostly HPFF cable).
- In second section of 62 miles, 26 miles was underground XLPE cable.
- Costs of underground or overhead in the range of \$5-\$10M per mile.
- Advantages of underground are low magnetic fields, min. visual impact, use in areas where ROW not possible to obtain, & avoiding accidents.
- Advantages of overhead are cost, system stability, speed of construction, & rapid restoration.

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## Comparison of Overhead, Underground, and Hybrid Circuits

	Hybrid Circuit	Bare Overhead Line	Underground Cable
Reliability	Possibly Higher than Overhead	Lightning Outages, Ice and Wind Damage	Outages less frequent, not coordinated with overhead failures.
Fault Location	Distance relaying more difficult		Can't locate faults visually
Restoration Time	One reclose. Repair in hrs or weeks depends on location	Multiple auto reclose Repair in hrs or days	One reclose. Repair in days or weeks

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## Comparison of Overhead, Underground, and Hybrid Circuits (cont.)

	Hybrid Circuit	Bare Overhead Line	Underground Cable
Maintenance	Like overhead but transition structures may need special care	Corrosion, Weathering, Wind motion, etc.	Limited for extruded cable. Required for pressurized paper. Corrosion issues.
Voltage Support	Cable Sections offset need for line VAR support	Need for shunt capacitor support at high power load	Need for inductive compensation under low power load.
Switching transients	Special protection at transitions	Requires minimum electrical clearance	Concern about high stored capacitive energy

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## Comparison of Overhead, Underground, and Hybrid Circuits (cont.)

	Hybrid Circuit	Bare Overhead Line	Underground Cable
Ampacity – Steady state	Limited by cable sections	2.5 amps/mm <sup>2</sup> {4 amps/mm <sup>2</sup> for HTLS conductor}	1 amps/mm <sup>2</sup>
Ampacity – 15 min emergency	Limited by overhead sections	3 amps/mm <sup>2</sup> 5 amps/mm <sup>2</sup> for HTLS conductor	2 amps/mm <sup>2</sup>
Power Flow Limits	Long circuit limited by voltage & phase shift in line. Short by cable section ampacity.	Voltage drop & phase shift limits on lines longer than 25 miles	Thermal (charging current limits long AC cables )

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## Typical 138kV Transition Structure (No need for fenced substation)



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## 138kV Hybrid Example #2

Parameter	Media Description	
	Overhead	Underground
Voltage	138 kV	138 kV
System Type	ACSR	Cross-Linked Polyethylene
Load (Loss) Factor	n.a.	100%
Line Length	100 km	16 km (5 sections)
Conductor Size	400 mm <sup>2</sup> 795 kcmil	600 mm <sup>2</sup> (1250 kcmil)
Insulation Thickness	3m (10 ft)	15.26 (0.600 in)
Normal Rating	1090 A	1008 A
15 Min. Emergency	1450 A	1990 A
4 Hour Emergency	1250 A	1501 A
100 Hr. Emergency	1090 A	1300 A

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## Hybrid Circuit

- Using UGC in conjunction with overhead lines can increase the likelihood of new overhead line circuit approval.
- Cost impact is generally not large.
- Can reduce esthetic concerns in critical locations.
- Less attractive at high power flow levels.
- UGC can yield approval when a pure overhead solution does not.

## Main Discussion Points

- Underground cable (UGC) is far more complex to manufacture and terminate than bare overhead conductor. Consequently, underground cables are almost always more expensive and slower to build than overhead lines (OHL).
- Once built, underground cable circuits are immune to weather, invisible to the public, highly reliable. They can be damaged by third party dig-ins and resulting repair and restoration times are measured in weeks rather than hours.
- Continuous thermal ratings for a given conductor size (e.g. 1000 mm<sup>2</sup>) are much lower for cables but emergency overload ratings are higher.

## Main Discussion Points (cont.)

- The electric field outside a cable is zero but the magnetic field can be higher directly over the buried cables. The magnetic field of cables attenuates quickly with distance.
- OHL are far less disruptive to the environment in ecologically sensitive areas since OHL excavation is only required for structure foundations spaced 600 to 1200 ft apart while UGC requires a continuous trench.
- Once installed, UGC does not pose an electrocution or impact risk for wildlife or for the public.
- At 230 kV and below it is possible to combine UGC and OHL segments without the need for substations at the transitions.

## Main Discussion Points (cont.)

- The electrical characteristics of UGC are quite different from OHL due to the difference in spacing of conductors. UGC may produce excessive voltage levels in lightly loaded circuits.
- Combining OHL and UGC segments in a common network can improve system stability and reduce the need for additional compensation.

The following discusses the techniques to increase the capacity of an existing underground cable.

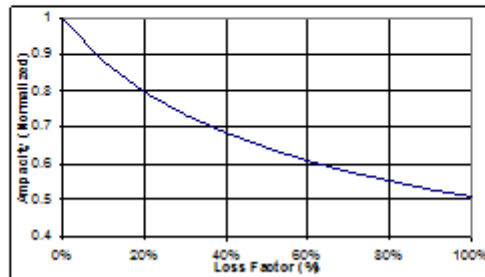
## Perform Route Thermal Survey



Thermal probe and property analyzer to determine the soil resistivity

## Re-evaluate Load Patterns

- Given the long thermal time constant of underground cable (35 to 150 hours), certain load patterns can allow large increases in rating, particularly emergency ratings.



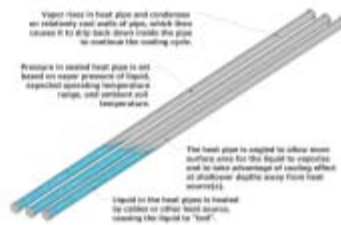
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## Remediation of Hot Spots along route

- Replace native with selected backfill in limited areas of route.
- Use of heat pipes (alcohol-water mix in partially filled buried pipe).



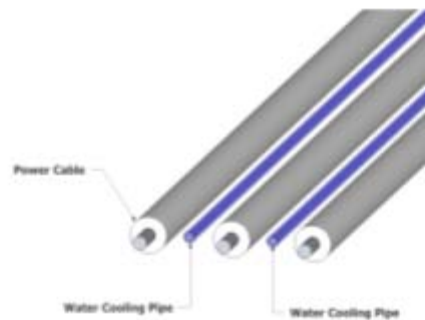
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## Forced cooling of cables

- Forced cooling of Extruded or Self-contained cables



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- Route Thermal Survey – incredibly valuable information can be gained from a survey like this, especially if the cable system is older.
- Review Circuit P&P (Plan and Profile) – A review of the as-built P&P drawings can show a variety of factors that could impact ampacity, including phase and circuit spacing, utility crossings, mutual heating, overburden, and depth of circuit.
- Load patterns have a more dramatic effect on underground cable than overhead cables due to the long thermal time constant of the surrounding soils.
- Temperature Monitoring, either using thermocouples or distributed fiber optic temperature sensing, can provide valuable feedback as to the actual temperature of the cable outer surface, or a point in close proximity to the cable. This can indicate the location of a hot spot, or possibly determine that a cable can run with higher current and remain within the acceptable temperature limits.
- Remediation of Hot Spots is possible if the scope of a hot spot is limited. It can include removal of overburden, replacement of backfill, or installation of heat pipes.
- Active uprating is generally applied to pipe-type cables, and includes filling HPGF cable pipes with fluid, fluid circulation or oscillation to smooth hot spots, and forced cooling of the fluid.
- Modify Shield/Sheath Bonding Scheme – there are three methods for grounding the shield/sheath on single conductor cable systems: multi-point bonding, single-point bonding, and cross-bonding.
- Multi-point bonding schemes have about 20-30% lower ampacity than single-point bonding or cross-bonding.
- A reconfiguration away from multi-point bonding may require changing out some or all joints since the joints must have shield interrupts, installation of a ground continuity conductor, and installation of link boxes

## **HVDC Lines and Cables**

DC lines are capable of carrying higher power flows and are also controllable. Why don't we convert existing AC lines to DC instead of building new lines? The following provides background information about HVDC technology and shows situations when a DC conversion could be an economically attractive option.

## Either New or Converted HVDC Lines Can be Alternatives to New AC OHL

- Background on HVDC Lines
- Advantages of HVDC Lines
- HVDC Examples
- Assessing Conversion of AC to DC
- Where it might work best

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## Traditional Applications of HVDC

### Bulk power transfer

- For distance of 600 km, was 800 km or longer

(cheaper DC lines + lower losses  
versus converter stations cost +  
converter losses)

### System Connections

- asynchronous power systems  
with different frequencies



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## What has Changed?

### Power grid

- More complex
- Increased power flow required

### Power sources

- Different characteristics
- smaller and larger number of generators
- renewables - wind, solar

### DC Converter Technology

- Lower cost, smaller size, more reliable
- Mercury Arc Valve > Thyristor > VSC



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## Advantages of DC

- Easily controlled, avoid loop flows
- Complement AC grid to prevent power failure cascading
- Smaller footprint for lines
- Magnetic field not a concern
- Lower line losses
- Operate single pole independently – enhance reliability
- DC cables carry power for long distances – no charging current
- Tie power sources of different characteristics



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## Disadvantages of DC

- Line not easily tapped off for power
- Additional converter costs
- Technology not as common as AC
  - Additional studies required on
    - components
    - electric charges
    - multi-terminal
    - integration into ac systems

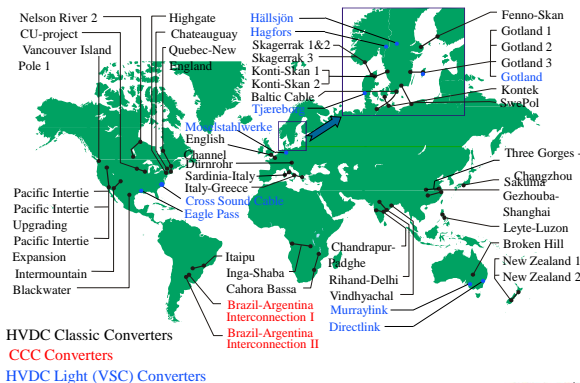


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## Examples of HVDC Projects Around the World



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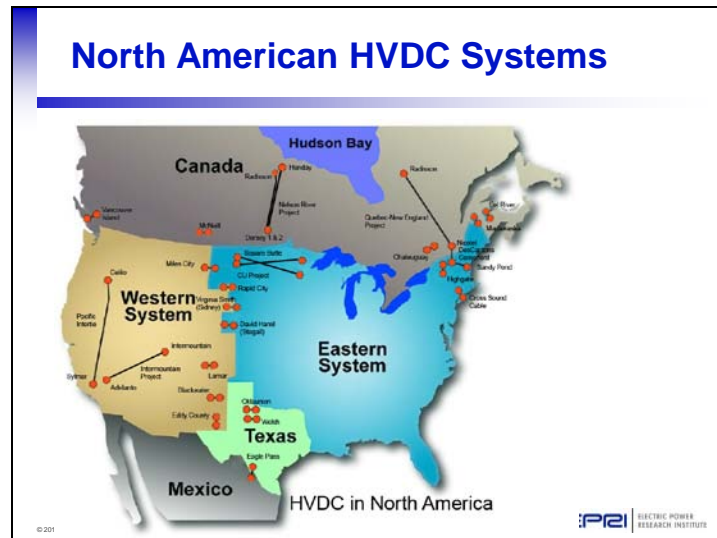
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ABB has over 50% of the installed HVDC base globally, and Siemens and Areva (ex Alstom) are the other major players.

Most applications of HVDC has been to transmit bulk power over large distances such as in the case of the Pacific HVDC 500 KV tie in the US, and to interconnect disparate AC systems such as the Regional Electricity Grids in India.



## Conversion of an Existing AC Line to DC

- This section discusses the impact of DC conversions on the existing AC structures and equipment - towers, insulators terminal equipment and conductors. Discussions could include, why insulators need to be changed from AC glass to DC glass, etc. The photograph shows a DC line next to an AC line, this can be used to illustrate how the outer phases can be used as the DC poles.

**What Does AC to DC Conversion Mean / Implications**

- Structures – No change
- Conductors – No change
- Insulators – Re-insulation is required
- Terminal substations – DC converter stations have to be built
- Re-permitting for DC

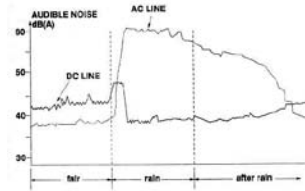
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## Options for Power Increase

### Voltage

- Increases in voltage level above peak of AC wave is possible
- Certain limiting factors need consideration
  - Corona
  - Insulation
  - NESC
  - Ground level E-fields



### Current

- Thermal limits only
- No Skin effect in conductors
  - Loss Reduction: Approx. 2/3 of AC
- Voltage constrained AC lines can be taken to thermal limits

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The above explains the options for increasing the power flow, voltage or current. Where Voltage is a limiting factor, current can be employed. AC lines may not be able to be pushed to thermal limits due to stability, but under DC operation the current can be pushed to maximum thermal rating.

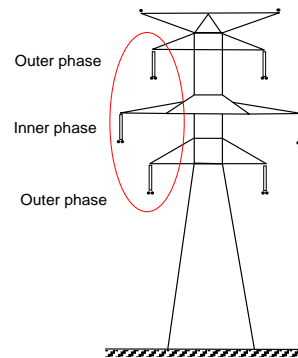
## Configuration Options

### Single Circuit

- Outer phases used as a traditional Bipole – centre phase used as emergency metallic ground return
- Tripole configuration

### Double Circuit

- One circuit converted – as above
- Three conventional Bipoles
- A single Bipole (3 bundles making up a single pole)
- Two Tripoles



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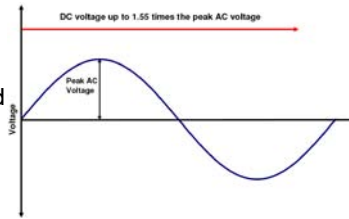
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The above details the conversion options for an AC line. The red circle indicates the single circuit case.

## DC Voltage Limiting Factors

- Conductor gradient
- Ground-level electric field
- Clearance for insulators at the structure
- NESC clearance to ground
- Live Working Clearances

A DC voltage of up to 1.55 times the AC l-g peak voltage can often be achieved.



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This above discusses the limitation on the level of DC voltage that can be applied. Too high a voltage will lead to excessive corona, and the static e-field at ground level will be too high (then of course that also the effects of space charge.)

## DC Power Also Depends on Max DC Current

While AC Current is limited by:

1. Surge Impedance of Line
2. Voltage Drop limits
3. Steady State Stability limits
4. Thermal Limits

*...DC Current is limited only by Thermal Limits*

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Power Gain Summary Table			
	Single Circuit - Bipole	Single Circuit - Tripole	Double Circuit – 3 Bipoles
DC Voltage = 1.5 * Peak AC I-g voltage	155%	213%	235%
DC Current = AC Current			
DC Voltage = 1.5 * Peak AC I-g Voltage	233%	320%	353%
DC Current = 1.5 * AC Current			

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EPRI has done extensive studies on conversion of an AC line to DC operation. Detail information is available in reports “AC to DC Line Conversion” (PID 1020114) and “Asymmetrical HVDC Line Design and Operation” (PID 1021760).

The objectives of the AC / DC line conversion studies are to:

- Guide utilities in converting some of their AC lines to DC lines where there is more power transfer needed on the same transmission corridor.
- Develop simulation tools necessary to make economic decisions whether to convert an existing AC right-of-way to DC or not.
- Develop new technologies to convert AC lines to DC lines – for example, (a) using two of the three ac lines as bipolar DC line and keeping the third ac line as a spare, (b) converting all the three ac lines into a tri-pole DC, (c) converting double circuit AC line into three bipolar DC lines, etc.
- Develop / adopt design methods necessary to the additional equipment such as converter stations which are needed to convert AC to DC.
- Develop cost versus benefits for each of the technical options for AC to DC conversion
- Demonstrate some of the AC to DC conversion technologies at the utility sites.
- Document the field experience of operating converted DC lines

### Advantages of AC-DC Conversion

- Increased power flow
- Lower % losses
- Power flow controllability
- Limitation of short circuit currents
- No line investment costs
- Asynchronous connections possible
- No new ROW – cost and environmental
- Other electrical advantages such as no concern of magnetic field, power transfer not limited by surge impedance.

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- Lower losses (cables and transmission lines) – in submarine cables, high capacitance causes additional AC losses. On overhead transmission lines,  $I^2R$  losses are reduced as well as corona losses.
- Controllability
- Limitation of short circuit currents (SCR) – stabilizing the AC grid without increasing the SCR.
- Line investment cost – HVDC lines require fewer conductors to transmit the same (or more power), e.g. a single bi-pole DC line compared to a three phase AC line.
- Long distance transmission – especially in where the line passes through remote regions with no tap off requirements.
- Asynchronous connections – power can be transmitted between two asynchronous AC systems i.e. 50 Hz and 60 Hz, or between asynchronous distribution systems.
- ROW – Environmental - for the same right of way as an AC line, a DC line can transmit more power.
- ROW – Cost – No new ROW required.

## AC-DC Conversion Advantages

- For long lines, conversion to DC removes the Surge Impedance Load limitation and costs of conversion are spread over a greater line length.

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## AC-DC Conversion Challenges

- Acceptance
- Less institutional knowledge / utility experience in DC
- Terminal station costs / justification
- The existing line must be in very good physical condition.

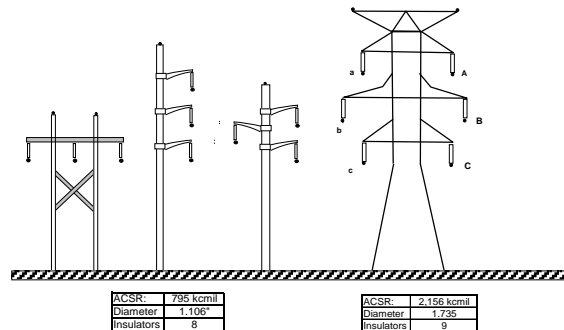
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November, 2009

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## Structures Reviewed: 138 kV

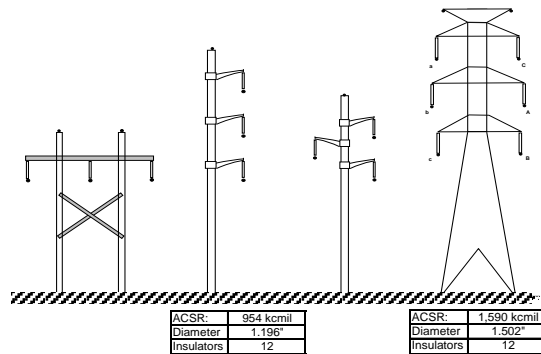


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## Structures Reviewed: 230 kV

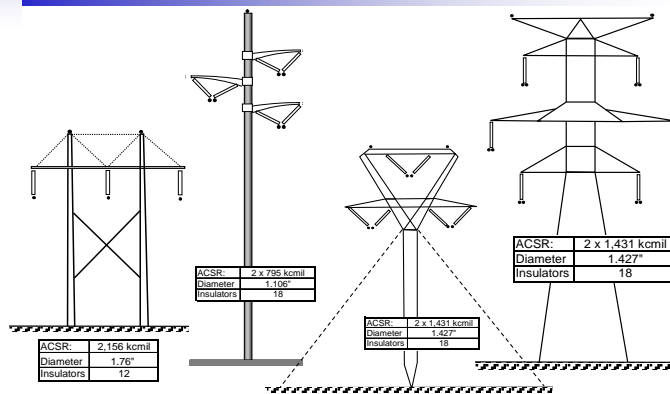


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## Structures Reviewed 345 kV

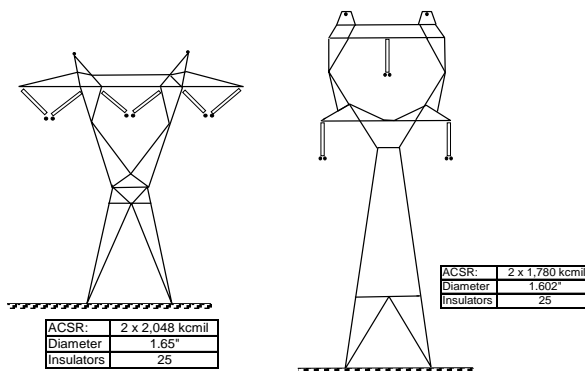


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## Structures Reviewed: 500 kV

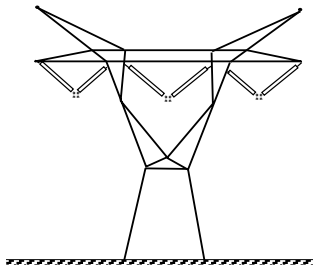


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## Structures Reviewed: 765 kV



ACSR:	4 x 1,585 kcmil
Diameter	1.602"
Insulators	32

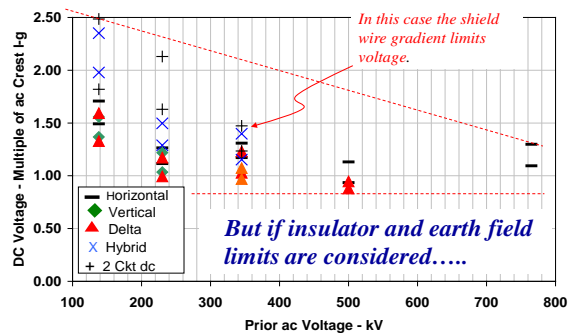
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## Sustainable DC Voltage

### Voltage constrained only by conductor gradient:



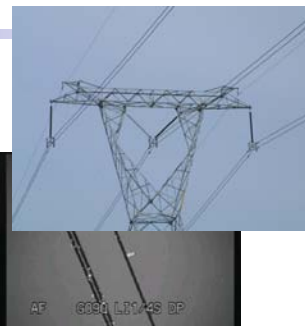
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## HVAC to DC Testing @ Lenox, MA Eskom

- **Opportunity**
  - 275kV AC → ±400kV DC
  - Potential Power Flow Increase:
    - 1.5 → 1.7
- **Issues**
  - Fair Weather Noise
  - E-field on Ground
  - Insulation
  - Pole to Pole Spacing
- **Approach**
  - Testing @ Lenox, MA
    - E-Field
    - Noise: AN / RI
  - Insulation Under Consideration



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- This is based on the conversion conventional single self-supporting structure into a bipolar configuration by using the outer two phases as the poles. Eskom are considering both 275 and 400kV. A picture of the self-supporting structure studied is shown above.


Issues that should be considered in DC conversion are:

1. What insulator type/material should be used?
2. What minimum specific creepage will be required for polymeric and ceramic insulators?
3. What is the required connecting length of the insulator string for pole-to-ground?
4. Will the pole-to-pole clearance be adequate at an altitude of 5000ft?
5. How will the power losses and corona performance be optimized?
6. On what basis should design limits for audible noise be set?
7. Under what conditions is audible noise the highest?
8. What is the design limit for the maximum ground level electric field?

### Conclusions

- Conversion allows major increase in voltage at low or intermediate voltages.
- Conversion of an existing AC line to DC is suitable for a relatively long, untapped line which is in very good physical condition.
- It is justified when the necessary increase in power flow capacity is >100% and the control aspect of DC lines is necessary to reliable system operation.
- Conversion may increase path flow more than an additional ac circuit of like rating.
- This option will become more attractive with time as the cost of electronic converter stations decreases.

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It's expected that this alternative will become more popular as right of ways are getting more difficult to acquire. HVDC will complement the existing AC grid and will be a component of the transmission system of the future.



# 7

## SITING OF TRANSMISSION LINES

Siting of new transmission lines and substations are almost always controversial projects in the United States today. In the early days of the electric utilities, the construction of a new transmission facility was thought to be a major benefit to a state or community, bringing promise of new jobs and new opportunities. While some individuals were often negatively impacted by a new power line, overall the project was viewed positively in the community. As we moved to the later part of the 20<sup>th</sup> century, this “world view” significantly changed. By the 1970’s most areas of the United States had access to electricity, had experienced the social changes of the 1960’s, and were now interested in environmental protection. The Threatened and Endangered species Acts of 1973 is an example of how society was evolving, and demonstrates that the people now wanted the opportunity to review and have an impact on environmental issues. Through this evolution came many state mandates that transmission line projects obtain a state license prior to construction.

In this chapter, factors that must be considered when siting a new transmission facility are discussed, and a review of methods for completing a siting study is presented. Approval requirements are discussed in Chapter 9.

### **Siting Feasibility Study**

In Chapter 2, we reviewed an overview of the process to build a new transmission line. In Chapter 3, we discussed the planning process and showed how the System Planners select a solution to solve an existing or future electrical problem. We also showed that if a new transmission line is required, the project is turned over to the siting team for a study in order to select the best route for the new project.

Later in this chapter we will give an overview of the long and detailed process involved in siting a new facility. Before a project solution is selected by the system planners, it is always a benefit to be sure the intended solution makes real world sense, outside of the world of electrical load flow studies. This can be accomplished by a quick Siting Feasibility Study where a small siting team (usually a couple people) reviews the general study area between the end points and gives an assessment of the practicality of this solution. The feasibility study would primarily look at existing land uses from readily available sources, create a table top review, and make a recommendation with no outside consultations.

For example, let’s say the need for a new line is less than 2 years away and a National Park would be crossed by all alternative routes. Since the NEPA process will take over 3 years, a very simple review by a siting expert, will determine that this is not a viable solution to the electrical problem and will need to be restudied.

This Siting Feasibility step is not always needed, but in congested areas where there may be multiple viable electrical solutions, there is a benefit to conducting some basic early siting reviews.

## **Siting Factors for Consideration and Evaluation**

The factors to consider in a routing study must be agreed upon at the onset of the study. In the early 1970's when siting studies became more prevalent, the majority of factors considered were related to engineering. The primary determining factors were length of line, number of structures, and/or cost of access road construction. The impact on the public and the environment were rarely considered. In today's world, where the approval process has become so complex and challenging, and where the general public now has a major voice in approvals, many siting studies no longer even include the construction costs and the associated engineering difficulties. So, the cost of the project is often not a factor in the final solution, and the route chosen can sometimes be the most expensive choice. Since utilities can pass-on most of these costs to the users in the form of rates, utilities are becoming more interested in getting the facility approved and moved into construction rather than building the least-cost facility.

Since environmental impact is such an important public concern, and the public is such a major factor in approval, we will focus on the environmental issues (design, construction and maintenance) needed in a siting study. Factors discussed in Chapter 4, regarding the design basics, construction and issues, will only be discussed in relation to environmental impact and will not be discussed here as separate factors for consideration and evaluation.

The various environmental factors are frequently grouped into four main areas, Natural Resources, Cultural Resources, Land Use, and Aesthetics. These four areas are discussed in detail below.

### **Natural Resources**

The Natural Resources category covers a large number of environmental components that should be considered during the siting study. It includes items such as:

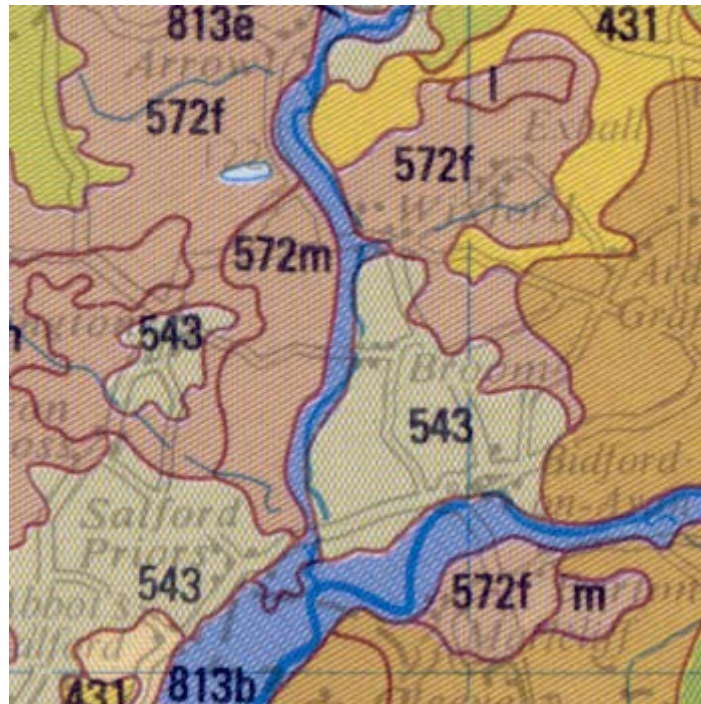
- soils
- geology
- water resources/hydrology
- aquatic habitats
- wetlands
- vegetation
- wildlife

Distinctions are made within these specific environmental areas. For example, a very important subset would be the rare, threatened or endangered wildlife and plant species. This designation can then be further subdivided into Federal or State listed species. Also, water resources and wetlands can be classified into subsets such as high quality and forested. Depending on the jurisdiction being studied, the impact on these subsets could have significant effect on the approval process.

### **Soils**

The types of soil throughout a project can be found by investigating various readily available sources. For example, the US Department of Agriculture has soils mapping that covers most of the entire US. This mapping shows a geographical representation of the diversity of soil types

and/or soil properties (soil pH, textures, organic matter, depths of horizons etc.) in the area of interest. Other state sources for this information can usually be found as well.



#### Example Soils Map

This is not usually a significant factor for consideration during routing studies, but items such as highly erodible soils, or high landslide/slip potential or high amounts of hydric soils can have an influence during siting.

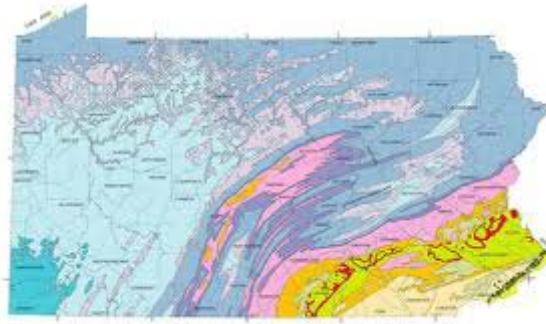
The soil mapping also provides the foundation engineer with information that could indicate where potential issues lie before the sub-surface investigation even begins.

For these reasons this information is usually made a part of the GIS data included in the siting study.

#### **Geology**

A geologic map is made to show geological features. Rock units or geologic strata are shown by color or symbols to indicate where they are exposed at the surface. Bedding planes and structural features such as faults, folds, and foliations are shown with strike and dip symbols which can give these features' three-dimensional orientations.

The types of geology that are expected to occur in a study area can be found and mapped as well. Geology can offer some level of understanding of where difficult or expensive construction would be required. A desk top study of geology can identify geologic hazards such as landslides, old mines and karst conditions in limestone and assist in planning the geotechnical investigation needed for foundation design and construction.



Example Geology Map

### ***Water Resources/Hydrology***

The water resources and hydrology factor that is of most interest to a transmission line route study is the surface waters. Ground water flows are rarely of concern. The United States Geological Service (USGS) has divided and sub-divided the United States into successively smaller hydrologic units, classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are nested within each other, from the largest geographic area (regions) to the smallest geographic area (cataloging units). Details of these units can be found on their web site under “Water Resources of the United States”.

GIS mapping information (digital spatial data sets) is also available from the USGS and other state level sources and should be included in the Project Siting GIS. This information is important to include in a line route study as streams and rivers are protected resources under environmental laws and therefore impacts must be minimized. The easiest of mitigation is avoidance during routing although this is rarely possible.

Water resources are frequently categorized by level of importance as well. While size of the bodies of water is important, there are also special designations such as “High Quality” or “Watershed of Special concern” so the level of importance is not based just on size. Navigable waters are also a designation by the Army Corps of Engineers that require special permitting. These should also be identified during the study.

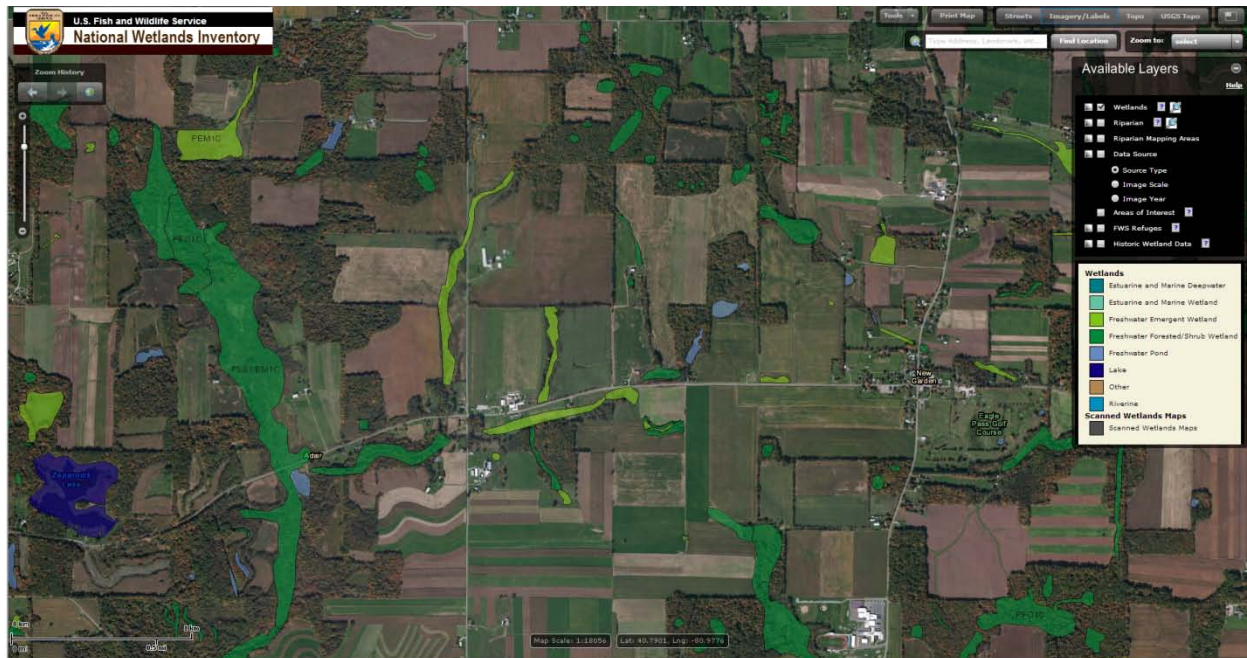
### ***Wetlands***

A wetland is a special subset of water resources/hydrology. It is a land area that is saturated with water, either permanently or seasonally. Wetlands are determined by the presents of hydric soil, aquatic plants, and the hydrology to support the water needed for the two previous items. The water found in wetlands can be saltwater, freshwater, or brackish. Wetland types such as swamps, marshes, and bogs are easily identifiable by most people, however, many jurisdictional wetlands, as defined by the Army Corp of Engineers, are very difficult to identify and must be determined by a wetlands expert.

Wetlands are important because they play a number of roles in the environment, principally water purification, flood control, and shoreline stability. Wetlands are also the most biologically diverse of all ecosystems, serving as home to a wide range of plant and animal life. In addition, wetlands can have an impact on the economy because of their role in hunting, fishing, agriculture and other recreational activities.



For these reasons, wetlands have become a very important factor in most transmission line route studies, and therefore mapping of all known wetlands is necessary for the Siting Project GIS. The US Fish and Wildlife Service (USFWS) maintains a national inventory of known wetlands (NWI), and digital data sets can be downloaded for inclusion in the Project Siting GIS. However, this NWI listing is not highly detailed and better information may be available from state or local sources for the project study area. Use of the best available information is always advised.



Example of NWI wetlands mapping

For most siting studies, readily available public sources should be used, however, in some states this wetlands data is deemed so critical that “on-the-ground detailed wetlands studies” by a certified wetlands expert must be performed. Sometimes this detailed study must be completed before a route is selected, or before a route is approved by a state review hearing. However it is more frequently though, these “on-the-ground detailed wetlands studies” are done during the permitting process prior to construction. A review of state regulations should be done to help determine the timing of these studies.

### ***Aquatic Habitats***

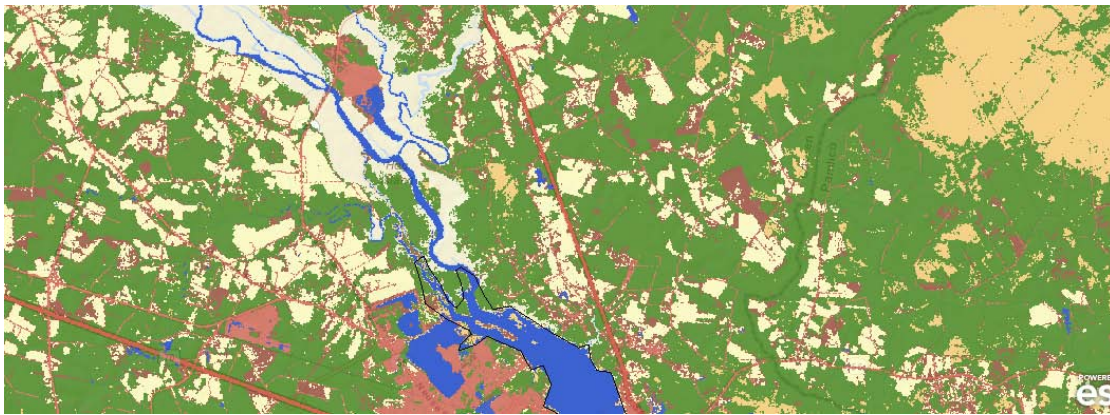
Aquatic habitat is a continuation of the hydrology of a study area, and focuses on the ecosystem and organisms associated with the water resource. The aquatic habitats, that are typically of concern to a transmission line route study are primarily freshwater habitats associated with rivers, streams, reservoirs, lakes, ponds, and wetlands, although coastal areas certainly contain habitats that may contain various levels of salinity.

Aquatic habitats may or may not be listed as a separate item in a transmission line route study. Some feel that aquatic habitats may be counting the same issue multiple times, since these items should be discovered when you reviewing the categories of hydrology and wildlife individually, and they may not need to be addressed separately. However, if areas of unique, special, or critical habitat are within the study area, they certainly need to be discussed in the project line

route documentation process or some will assume the siting team has missed this important environmental factor. Critical habitat is a designation of the US Fish and Wildlife Service (USFWS) and while this designation does not preclude development, it will certainly need to be carefully reviewed during any permit reviews, and will make things more difficult during the permit review phase for the project and should be avoided if possible.

### ***Vegetation***

The vegetation type in a study area can be determined from digital data sets, such as those available from the USGS, from field observations, or from careful review of aerial photography of the study area. This data is typically categorized and included in the study. Depending on the study area, vegetation can be an important factor in the selection of a transmission line route. For example, where all potential routes contain 95% deciduous forest, it can have little impact at all, but when one route may have only a small percentage covered by a deciduous forest, it can have a big impact on the final decision. In either case, for completeness, it should be mapped and included in the Project GIS.



Example of USGS Vegetation Land Cover Map

### ***Wildlife***

Traditionally, wildlife referred to non-domestic animals; however, more recently it has been expanded to include plant species as well. Using this broad definition, wildlife can be found in every environment. The wildlife concern when siting a new transmission line is to determine if the species of plant or animal, or their habitats, will be affected by the construction of the new transmission facility. The existence of very common plants or animals is usually not at issue. The presence of threatened or endangered species (those facing a high risk of extinction) could have a high impact on siting activities and needs to be mapped if possible.

A good source of information on wildlife is from the USFWS. They maintain information on all federally listed Threatened or Endangered Species (both plant and animal). In addition, many states maintain their own lists of Threatened or Endangered Species. Both should be reviewed and any known instances or locations of these species should be mapped into the project GIS system.





### Examples of Endangered Species

Because of the permit and approval issues surrounding endangered species, it is the best course of action to avoid these areas during the siting process. Many times the locations may be known to have a favorable habitat for endangered species, but without distinct expert, on-the-ground wildlife field studies, the effect of a transmissions line cannot be determined. These types of field studies are often done during the approval process and not during the siting phase of the project due to time, expense and access to the property.

### Cultural Resources

Cultural Resources cover a few environmental areas. The usual breakdown of this grouping is:

- Historic
- Pre-historic/Archeological



### Examples of Historic and Archeological Sites

It is possible for the historic sites to be further categorized into items such as Architectural standing sites, non- standing sites, battlefields, historic districts etc.

The level of importance is also frequently determined for these sites. For example, a site can be listed on the National Register of Historic Places or the State Register of Historic Places. Depending on the state involved, there are numerous other designations with varying degrees of significance. Sites can be designated as eligible for a register, potentially eligible, not eligible or even potentially historically significant but not yet studied. A discussion with the State Historic Preservation Office (SHPO) may bring some clarity and understanding of what is important in each state. This same SHPO office usually maintains the records of the sites of importance and is a good source for this type of information during the data gathering phase of the project. This information should be mapped into the project GIS system.

The existing status of these resources is needed during the data gathering work for siting a new line, and extensive field studies and recommendation reports may be required during the approval phase of the project. Frequently, siting approvals are made contingent upon successfully passing all studies by the SHPO. If this Cultural Resource information is ignored during the siting phase, it may prove to be very problematic during the approval phase.

If field studies are required, they must be done by SHPO approved consultants and may include items such as photo documentation of standing structures, viewshed analysis of standing structures, literature research and Phase 1 archaeology shovel testing of a line route. All studies will need to be documented into formal reports for SHPO review and approval.

## **Land Use**

Land Use covers the way man has made use of the land, and reviews how the land could be impacted by the new transmission facility. Land Use can include many different items, and in some cases, may just document that the land has not been used in recent years, and that there is no known current plan to be put into use. This non-use designation must be used cautiously, since many people may see this as a way of saying that the land is not of value or cause for concern.

In its simplest form, Land Use may simply document what can be seen such as forest cover, grassland/pasture, cultivation, and standing structures. However, this subject area is usually broken down into much more detailed categories for more qualitative analysis. Examples of the more detailed land uses and the ways to quantify these include:

- Forestry - can be further broken down by type deciduous/conifer etc.
- Agricultural - can be further broken down by type cultivated/pasture etc.
- Agricultural Conservation Districts/ Farmland Preservation etc. – areas legally set aside that does not allow development.
- Extraction – mining, gas wells, oil wells etc.



Example of Strip mining & Underground mining

- Urban/Development – usually incorporated towns and cities are included here.



- Residential – individual homes are sometimes identified when in a more rural area.
- Transportation
  - Airports
  - Railroads
  - Highways
- Utilities – significant utilities that can impact route siting studies.
  - Existing Transmission Lines
  - Existing Gas /Oil Transmission Pipelines
  - Existing Generation Facilities



### Example Utility that will Effect Siting

- Parks and Designated Recreation Areas – these can be developed areas such as a Park with facilities or undeveloped areas, such as a private hunting preserve. Other examples include scenic overlooks along a highway or a local hiking trail. These could be controlled by any or all forms of government or the private sector:
  - Federal
  - State
  - Local
  - Private



The land use designation is frequently the most reviewed of all mapped criteria in the Project GIS system and is deemed critical in the siting process. People want to know where their homes are located with respect to the remainder of the project. Routes frequently are selected or rejected based on proximity to these land use criteria.

### Aesthetic Resources

Aesthetics covers the overall visual impression of the views from roads, residences, towns and recreation areas in the transmission line study area. Aesthetics frequently overlaps with Land Use. For example, an area may already be designated as a park or scenic overlook due to its aesthetic value.

The aesthetics of the new transmission line need to be satisfying to long term local residents, pleasing to visitors and are frequently discussed during any approval hearings. The impact a new transmission facility has on the aesthetic resources is difficult to quantify during the siting study, but an effort to do so is important and should not be overlooked.

Computer analysis using terrain elevation models can show what is visible, and are available to attempt to quantify this area. These studies, sometimes known as view-shed analysis, can be easily run. However, these analysis maps often greatly overestimate the degree of visibility, due to vegetation cover. Even with this shortcoming, these analyses are helpful when trying to differentiate between alternative routes. Ultimately a more qualitative analysis is needed to adequately address this subject. It may include separating views from the foreground, middle-ground and background, and include frequency of viewing.

## **Siting Process**

We previously listed the items that need to be reviewed and cataloged during a complete siting study. In this section we will discuss how to conduct a siting analysis, and what can be done with this information.

This is not intended to be a step by step, detailed, “how-to” manual, but is intended to give the reader a good basic understanding of the overall process that all siting studies must follow. We will also suggest a few alternative methods including a manual method, and some computer modeling methods like the one offered by the Electric Power Research Institute (EPRI). It is important to note that approval process requirements vary between different jurisdictions, so some studies may need to include items that others do not.

## **Study Area**

The first decision in a siting study is to select and identify the area to be studied. Although this seems obvious, much care must be taken to ensure that the area is large enough to encompass all possible alternative routes, and that no pre-conceived notions on where a facility may end up, influence the study area selection process. Otherwise, additional data gathering and expense is likely to occur, since you would have to add more area to the study at a late date.

The rationale for the study area selection should be documented, and included in the final report.

## **Substation Site Selection**

Although the majority of this discussion concerns how to perform a siting study for a new transmission line, it is important to note that with new transmission lines, new substation sites are often needed. The decision on where to locate a new substation greatly influences the transmission line route. Therefore, the substation site selection can have a large bearing on the ability to get the transmission line approved. Therefore, a siting study to determine the location of the substation should be conducted prior to the final site selection and before any land purchase. The factors discussed above for line siting have similar importance in a substation siting study.

It should be noted that in addition to environmental factors, engineering factors frequently play an even more important role in the substation site selection process. The substation location is a factor that can ensure the facility can operate as was planned in the facilities planning studies.

## **Routing Criteria & Technical Guidelines**

In Chapter 4, the need for a design criterion was mentioned. Before a siting study is undertaken, a philosophy or transmission line siting criteria should be established and documented. This sets a goal for the siting team to strive for to help ensure a successful project. Each regional area of the country or even departments within a utility may have different factors that are deemed more important than others. For this reason all studies do not necessarily use the same steps to completion. A discussion and agreement on the criteria must be made at the outset.

This can begin with a list of general Siting Guiding Principles that all can agree upon.

For example: In identifying, evaluating, and selecting routes, the Routing Team should attempt to minimize:

- Route length, cost, and special design requirements.
- The removal or substantial interference with the use of existing residences.
- The removal of existing barns, garages, commercial buildings, and other Non-residential structures.
- Substantial interference with the use and operation of existing schools, existing and recognized places of worship, existing cemeteries, and existing facilities used for cultural and historical, and recreational purposes.
- Substantial interference with economic activities.
- Crossing of designated public resource lands such as national and state forests and parks, large camps and other recreation lands, designated battlefields or other designated historic resources and sites, and wildlife management areas.
- Crossings of large lakes and large wetland complexes, critical habitat, and other scarce, distinct natural resources.
- Substantial visual impact on residential areas and public resources.

The Routing Criteria/ Siting Guiding Principles above are general "mom and apple pie" type statements that few could argue against. These principles work as constraints that must be reviewed in the early stages of a large siting study.

On smaller projects, or during later stages of a large siting study, it will be beneficial to prioritize the most important constraints, and to identify the opportunities that need to be evaluated as a part of the siting study. Working through this process will establish a more specific criteria list.

An example of a more specific avoidance criteria list is as follows:

In identifying, evaluating, and selecting routes, the Routing Team should attempt to minimize impacts with:

- Urban areas, cities, towns, small villages, and other built up areas.
- Federal forest and wildlife management lands.
- State forest and wildlife management lands.
- Areas near airports and airstrips.
- National Register Historic Districts and adjacent areas.
- Large recreational sites.
- Large lakes and reservoirs that could not be spanned with the structures set well back from the shores.
- Large wetlands or wetland complexes.
- Individual residences (including houses, permanently established mobile homes, and multi-family buildings); barns, garages, and other outbuildings.
- Commercial and industrial buildings.
- Recorded sites of designated historic buildings and sites, including any specified buffer zone around each site.



- Recorded sites of designated threatened, endangered, and other rare species or unique natural areas and the specified buffer zone around each site.
- Small wetlands.
- Developed recreational sites or facilities.
- Communications towers.
- Windmills.
- Designated scenic vista points.

Obviously, this list can be project specific, and if the constraints or opportunities do not exist in the study area, they need not be listed.

In addition to the routing criteria that deal with environmental issues, there may be a need to have technical criteria from the design engineers. We had previously discussed the fact that engineering issues may not be documented in a siting study. However, it is still advisable to list the most important issues if they play a part in influencing the siting decision outcome.

An example of this technical criteria list is:

- Avoid double-circuiting EHV lines.
- Do not parallel existing EHV lines for more than 1 mile in any particular location.
- Minimize the crossing of EHV transmission lines.
- Minimize paralleling corridors with more than one existing transmission circuit.
- Maintain 200 feet of centerline-to-centerline separation when paralleling existing transmission lines.
- Minimize angles greater than 65 degrees and sloping soils more than 30 degrees.

## **Data Collection**

Data collection for the siting study is all about gathering the correct information needed to make an informed decision. It means collecting data from every possible source that is reasonably available. Previous sections have provided considerable guidelines on the types of information that is needed for the study. Much information is now available from government agencies for download over the internet. For example, aerial photography is routinely used as a part of the data gathering today. That data is readily accessible from various internet sites that cover most of the United States today. Field reviews from public roadways can supplement the aerial photography.

In addition to data searches, meetings and correspondence with federal state and local government agencies should be held to collect their information, opinions, and concerns. This cooperation helps ensure that the siting study ultimately results in a decision that can later be permitted and approved.

This information must be well-organized to be useful. Modern siting studies today always use a project Geographic Information System (GIS) to catalogue and organize this process. Mapping will be prepared using this GIS system to help with decision making throughout the siting study.

The GIS and mapping from this system will also be used to help document the decisions made during the analysis and will be included in the final documentation of the study.

## **Development of Potential Routes**

This simply means starting the process of determining the location of the future transmission line project.

Routing constraints are the areas to be avoided, if possible. They are developed from the routing criteria discussed above. Most siting studies have so many constraints that it is impossible to avoid them all; this complexity is what makes siting transmission lines so difficult. These constraints can be a large area such National Forests or Historic Districts which covers many square miles, or can include a small area such as a family cemetery plot that you can't see on an aerial photo but should be avoided if at all possible.

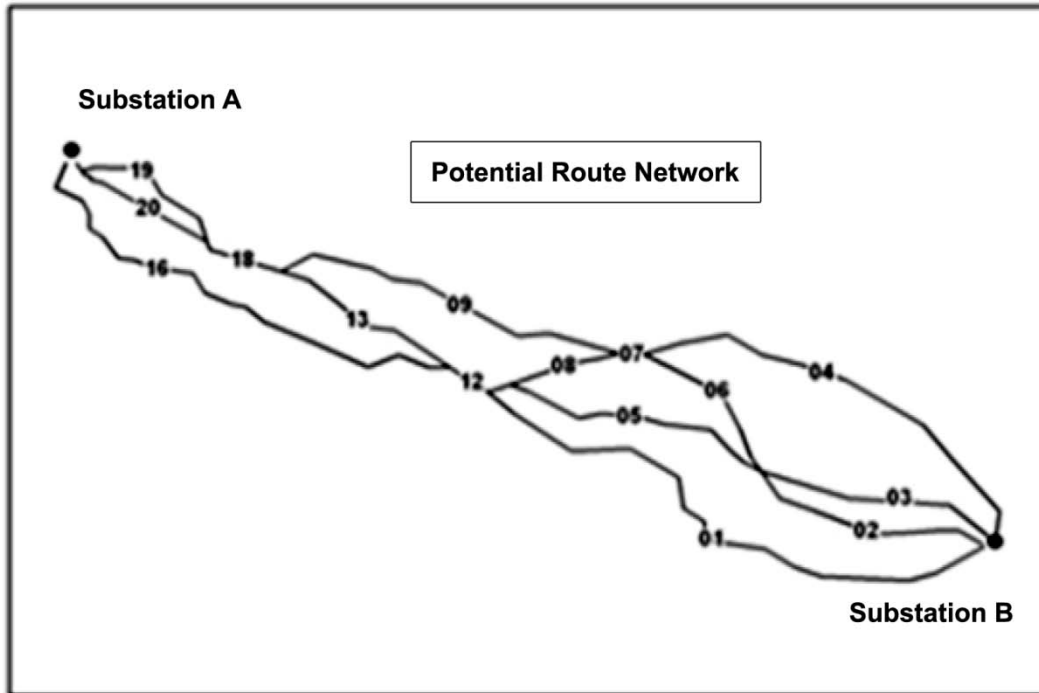
Routing opportunities are areas or infrastructures that may reasonably minimize adverse impacts if a new transmission line is placed there. An existing transmission line is an example of a routing opportunity.

The routing opportunities and constraints identified by the Siting Team during the data collection phase are then analyzed. At this point, with knowledge of the constraints and opportunities, the location options for the proposed transmission line can be developed. These routing options can be identified by examining the information that has been gathered in the GIS system, as well as using any added knowledge obtained through the following: field studies, aerial photography and maps, meetings with members of the general public, stakeholders, and with federal, state and local agencies; discussions with the project engineers and ROW personnel; and from the Routing Team's past experience with similar projects. At this early stage of the siting process, many different potential alternatives or corridors should be in the study mix.

In recent routing studies performed in the eastern United States, the biggest opportunities appear to be in utilizing the existing transmission line corridors. The general public, currently seems to have a high degree of preference in following existing transmission corridors and this is supported by many state utility commissions, state and federal regulatory agencies, and the Federal Energy Regulatory Commission (FERC, 1970).

Ultimately a series of line segments can be networked together into a potential route network.

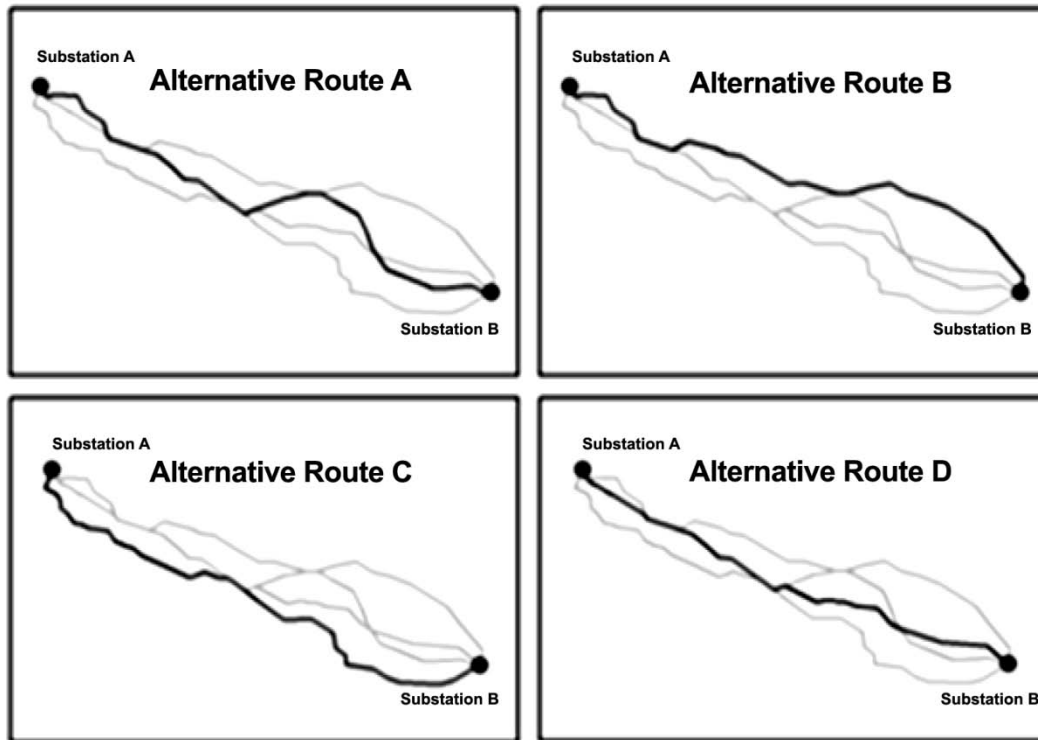




As the route development process progresses, the Routing Team continues to evaluate any new data and modifies, if necessary, the links of the Potential Route Network.

### **Refinement of Alternative Routes**

Depending on the size of the study area, and the length of the proposed transmission line, refinement of the potential route network may come in stages. A first level refinement may be followed by public input, and then further refinement is made. The network of potential alternatives must eventually be reduced, into formal Alternative Routes. These Alternative Routes are developed by assembling those that best meet the routing guidelines into a handful of individual alternative routes to be further analyzed in great detail.



## Public Involvement

In siting studies performed during the 1970's and 80's the Public Involvement phase of the study was not deemed important and was frequently skipped. In today's culture, it is very important to engage the public, and this step must never be skipped. When any type of siting approval is needed it is almost always held that some form of public involvement must be conducted. Without this step, there is little chance of getting acceptance of the project from the general public.

The point at which Public Involvement begins and ends can vary greatly. Depending on the jurisdiction, public involvement may even be mandated by law in some approval processes.

The bottom line is that you must demonstrate an honest effort to obtain the thoughts and opinions of the public before a decision is made on the final route. These public concerns need to be addressed in the siting document. This subject will be discussed in more detail in Chapter 8.

## Route Selection

After the refinement of the alternative routes into a manageable number, (usually 5 or less) a detailed quantitative analysis of these routes should be made. This should be accomplished using the modern GIS system to help complete this task. An example of an Environmental Comparison Table 7-1 is shown below:

**Table 7-1**  
**Example Environmental Comparisons**

Alternative Routes	A	B	C	D
Length Total (Miles)	6.4	6.3	6.5	7.8
<b>Hydrology</b>				
Stream Crossings	5	5	7	8
Waterbody Crossings (count)	1	1	2	1
Waterbody Crossings (feet)	200	200	500	200
<b>NWI Wetlands (acres within 200 feet of the ROW)</b>				
Freshwater Emergent Wetland	0.41	0.41	0	0
Freshwater Forested Wetland	11.52	7.77	2.12	1.77
Freshwater Scrub Shrub/Emergent Wetland	0	0.21	0.21	0
Freshwater Pond	0	2	1	0
<b>Cultural Resources</b>				
Archaeology -Potentially Eligible	1	1	1	2
Archaeology -Potentially Eligible within ROW	2	0	0	0
Historic Structures -Potentially Eligible	3	3	3	3
Historic Structures -Potentially Eligible within ROW	1	0	0	0
<b>Topography</b>				
Steep Slopes > 20% (length crossed in feet)	1000	1525	1275	550
<b>Land Use</b>				
Residences within the ROW	0	0	0	0
Residences within 250 feet/ 500 foot corridor	1	1	0	2
Residences within 500 feet/1000 foot corridor	1	1	0	17
Cemeteries within 500 feet/1000 foot corridor	0	0	0	1
Churches within 500 feet/1000 foot corridor	0	0	0	0
Commercial buildings within 500 feet/1000 foot corridor	0	0	0	0
Outbuildings within ROW(100 feet /200 foot Corridor)	1	1	0	0
Communication Towers within ROW	0	0	0	0
Schools within 500 feet/1000 foot corridor	0	0	0	0
<b>Rights-Of-Way Parallel</b>				
138 kV (miles)	0	0.2	3.2	0.4
345 kV (miles)	0	0	0	3.7
Transmission parallel percentage	0	3%	50%	52%
Highway	0	0	0	0
Railroad	0	1.1	1.1	0
Total parallel percentage	0%	21%	67%	52%
<b>Infrastructure Crossed</b>				
<= 69 kV Transmission Lines	0	0	0	0
138 kV Transmission Lines	1	1	1	0
345 kV Transmission Lines	2	2	2	2
Interstates crossed	0	0	0	1
US Highways	1	1	1	1
State Highway	2	2	1	3
Railroads Crossed	2	2	2	1
Private Airfields within 10,000 feet	1	1	1	0
Public Airfields within 10,000 feet	1	1	1	1
<b>Land Cover</b>				
Forest Clearing (acres)	17.3	13.5	10.5	27.6
Open Water	0%	0%	0%	0%
Developed (Low)	0%	0%	0%	1%
Developed (Medium, High)	0%	0%	0%	0%
Forest	9%	8%	6%	8%
Shrub/Scrub	0%	0%	0%	0%
Grassland/Herbaceous	1%	1%	1%	1%
Pasture/Hay	2%	2%	1%	14%
Cultivated Crops	84%	86%	90%	77%
Wetlands	4%	3%	1%	0%

This table illustrates the types of data that can be compared between alternative routes but it does not attempt to place a relative value on the various items. This is the fundamental difference between a qualitative route analysis approach and an analysis done quantitatively by setting relative values on measurable items.

To illustrate this, the challenge with comparing alternate routes is that the same constraints are rarely being evaluated. Route 1 may contain high quality wetlands of great concern to the federal agencies but of little perceived value to the general public. Route 2 may contain high residence counts but no wetlands. So the issue becomes which is more important to the decision process. The public will always list residences as the most important, but will differ beyond that. This has widely been described as the “Not in My Back Yard” (NIMBY) issue which still holds very true today.

There is no magic answer and it depends on the project details, the study area, and the jurisdiction from which approval is being sought.

Using the qualitative approach and the expertise of the entire routing team, a comparison of the alternatives is made reviewing the pros and cons of each alternative. Then a recommendation is presented and thoroughly documented in the Line Route Report. The answer documents the recommendation of the siting team experts involved and there are little details to argue over when challenged. This approach is more able to address concerns identified during the public input phase of the project, then again when using a potentially more ridged mathematical model.

The quantitative approach assigns a relative value to each criterion. Higher values are used for more sensitive/important items. Next, a mathematical summary of the quantitative values is multiplied by the relative value placed on each item, and then all values for each alternative route are summed. The alternative with the lowest score (having the lowest impact) is the preferred alternative. A simplified example of this process is shown below.

**Table 7-2**  
**Example Environmental Comparison and Quantitative Analysis**

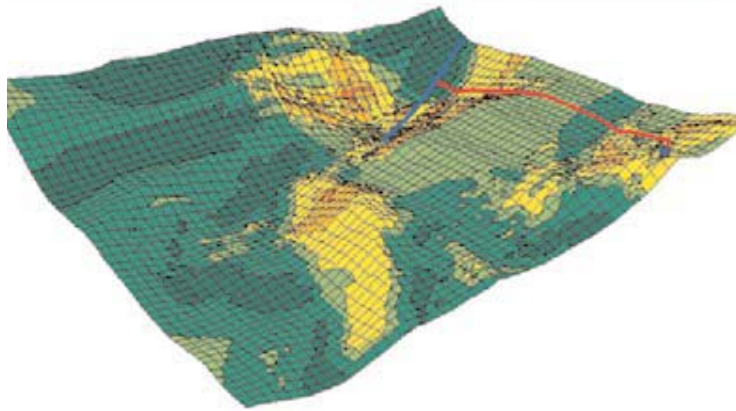
Example Environmental Comparison Table						Quantitative Analysis			
Alternative Routes	Value	A	B	C	D	A	B	C	D
Length Total (Miles)	2	6.4	6.3	6.5	7.8	12.8	12.6	13	15.6
NWI Wetlands (acres within 200 feet of the ROW)									
Freshwater Emergent Wetland	8	0.41	0.41	0	0	3.28	3.28	0	0
Freshwater Forested Wetland	10	11.52	7.77	2.12	1.77	115.2	77.7	21.2	17.7
Freshwater Scrub Shrub/Emergent Wetland	9	0	0.21	0.21	0	0	1.89	1.89	0
Freshwater Pond	2	0	2	1	0	0	4	2	0
Cultural Resources									
Archaeology -Potentially Eligible	2	1	1	1	2	2	2	2	4
Archaeology -Potentially Eligible within ROW	4	2	0	0	0	8	0	0	0
Historic Structures -Potentially Eligible	6	3	3	3	3	18	18	18	18
Historic Structures -Potentially Eligible within ROW	15	1	0	0	0	15	0	0	0
Land Use									
Residences within the ROW	6	0	0	0	0	0	0	0	0
Residences within 250 feet/ 500 foot corridor	4	1	1	0	2	4	4	0	8
Residences within 500 feet/1000 foot corridor	2	1	1	0	17	2	2	0	34
Cemeteries within 500 feet/1000 foot corridor	3	0	0	0	1	0	0	0	3
Route Summary						180.28	125.47	58.09	100.3

In this simple example, the chart clearly shows a preference for Route C (has the lowest impact). This may seem to be an improved approach to a rather subjective analysis shown in the

qualitative approach. The concern with this approach is that the numbers set in the value column can be subject to ridicule and debate. As most transmission projects are highly contested, this becomes a lightning rod for controversy. If the values are manipulated, any alternative route can be shown to become the preferred route. To set these important values, various methods have been tried, some quite extensive and complex. However, if the answer does not support a particular opposition's point of view, sometimes it doesn't really matter how "scientific" the approach. In the end, even with the use of this mathematical approach, it always comes down to the expert opinion of the siting team.

### **Computer Models to Aid in Siting**

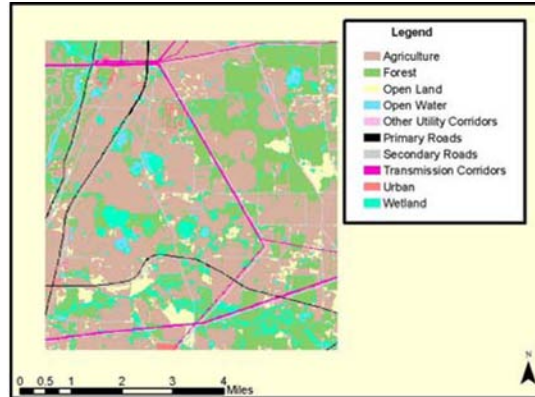
Computer models to aid in Siting transmission lines have been around for many years. These models help evaluate the GIS data and the constraint criteria that have been developed, and they automate the siting process. Forty years ago the main issues revolved around trying to place the data, and particularly the constraints, into a digital model. With the advent of the modern GIS system and the currently available digital data sources, this is no longer an issue.



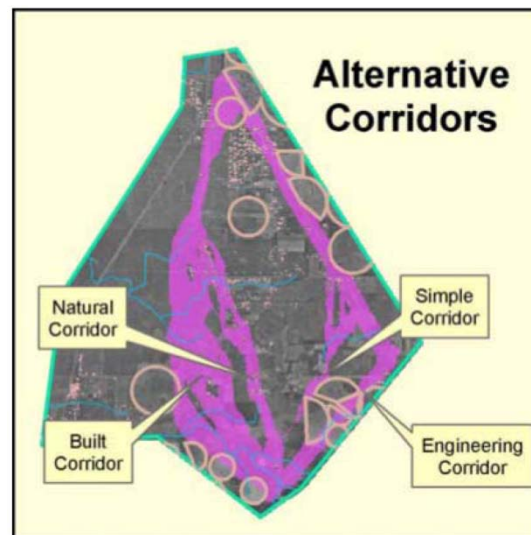
Today computer programs use modifications of the quantitative approach, discussed above, to move the siting process through study area selection, to refining corridors, to the ultimate selection of a preferred route. These programs all have similar limitations as those described above, however, they have been used very successfully in many jurisdictions. However, the use of computers tends to be impersonal in nature, and the inputs received from public meetings are difficult to quantify and may be perceived as more difficult to address in these models.

EPRI has done research in computer modeling and has developed its own model for Siting. The EPRI model uses the same philosophy to come up with potential corridors and alternate routes, and uses the following 3 phases:

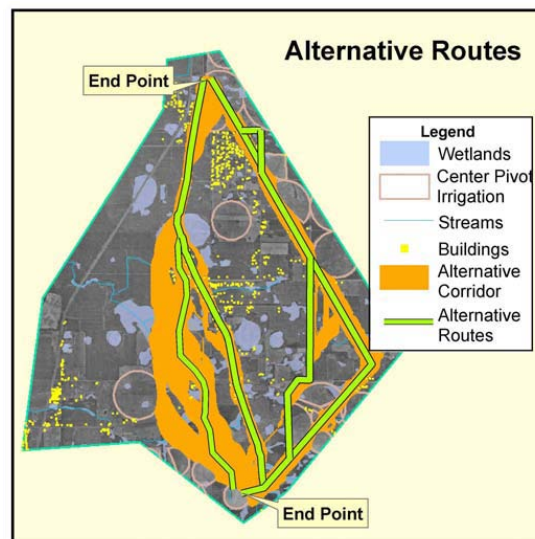
- Phase 1 – Macro Corridor Generation



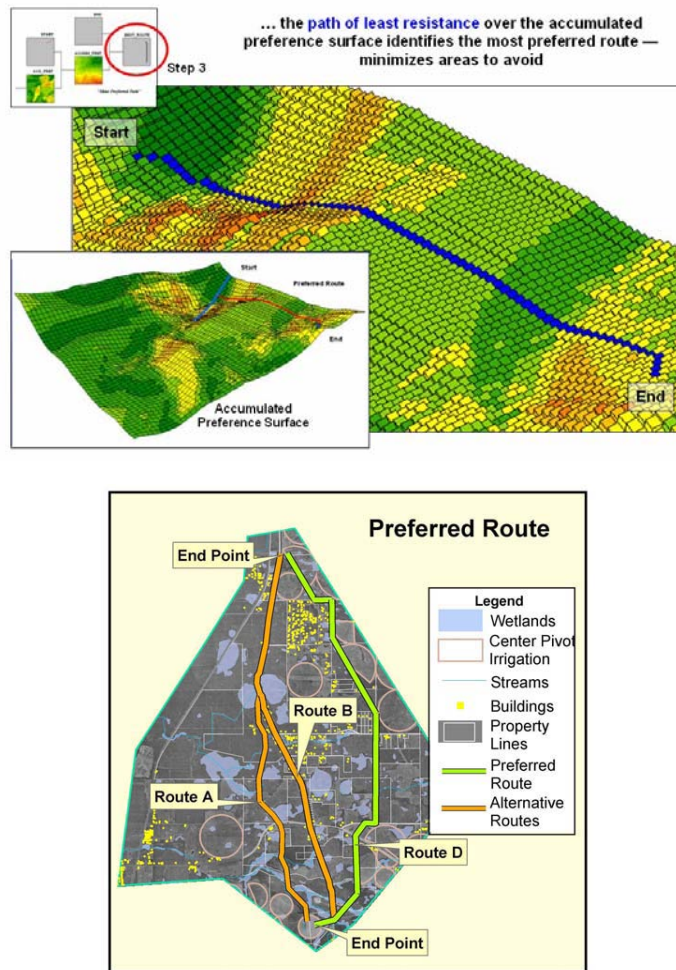
- Phase 2 – Alternative Corridor Generation



- Phase 3 – Alternative Route Analysis and Evaluation



- The Preferred Route is selected



Even when using a computer model such as the EPRI Model, judgments must be made on the accuracy and data values to ensure a proper outcome.

The EPRI model automates the decision process by using the results of numerous public input polls to select the values. This has had some success in a few jurisdictions, but is not yet widely accepted across the United States.

More information can be found on this subject by reviewing the EPRI technical reports *EPRI-GTC Overhead Electric Transmission Line Siting Methodology* (PID 1013080) and the *Kentucky Transmission Line Siting Methodology* (PID 1016198) found on the EPRI web site. In the end, even with the use of the computer models, it always comes down to the expert opinion of the siting team.

## Environmental Justice Issues

The term Environmental Justice has been a more recent addition to the list of concerns for siting teams. On federal projects where a formal NEPA process must be conducted, consideration of environmental justice (EJ) was mandated by Executive Order 12898 in 1994, which states that “each Federal agency shall make achieving environmental justice part of its mission by

identifying and addressing, as appropriate, disproportionately high and adverse health and environmental effects of its programs, policies and activities on minority and low-income populations in the United States and its territories and possessions.”

However, even if a federal action is not undertaken EJ can be a rallying point for opponents of a transmission project. The goal is to ensure minority or low-income populations do not have a disproportionately high impact. If this issue can or will be a problem, an environmental justice review should be done so that it may be addressed in the Line Route Documentation (see below).

### **Line Route Selection Process Documentation**

The final step in the siting process is to document the entire process described herein. A formal report of the process should be prepared. It should describe all steps taken to select the preferred route of the transmission line. Detailed maps must be prepared from the GIS system to supplement the written text. Aerial photography can also be utilized to help tell the story.

The final report should be a stand-alone document that tells the story of the siting efforts, and explains why the final decision was made. As was described previously, each study is somewhat unique and the items included in the final report will vary by project. An example Table of Contents is shown below:



## EXAMPLE TABLE OF CONTENTS

EXECUTIVE SUMMARY	
INTRODUCTION	
Purpose and Need	
PROJECT DESCRIPTION	
Location	
Structures	
Right-of-Way (ROW)	
Substations	
ALTERNATIVES DEVELOPMENT	
Goal of the Route Selection Study	
Study Area Definition	
Data Collection	
Public Involvement Activities	
ROUTE DEVELOPMENT CRITERIA, GUIDELINES, PROCESS	
Routing Criteria	
Technical Guidelines	
Routing Constraints	
Routing Opportunities	
DEVELOPMENT OF POTENTIAL ROUTES	
DESCRIPTION OF ALTERNATIVE ROUTES	
PROJECT AREA RESOURCES AND ENVIRONMENTAL IMPACTS	
ANALYSIS AND COMPARISON OF ALTERNATIVE ROUTES	
NATURAL RESOURCES	
Study Area Geology and Terrain	
Study Area Water Resources	
Wetland Resources	
Vegetation	
Study Area Land Use	
Study Area Recreation Resources	
CULTURAL RESOURCES	
Historic Context	
Architectural Resources	
Archaeological Sites	
AESTHETICS	
IDENTIFICATION OF THE PROPOSED ROUTE	
PROPOSED ROUTE SUMMARY	
ALTERNATIVE ROUTE ADVANTAGES AND DISADVANTAGES	
MITIGATION MEASURES	
CONCLUSION	
REFERENCES	
APPENDIX A-AGENCY CONSULTATION	
APPENDIX B- SENSITIVE SPECIES	
APPENDIX C -DETAILED HISTORIC CONTEXT	
APPENDIX D-PHOTO SIMULATIONS	



# 8

## PUBLIC INVOLVEMENT AND PUBLIC OUTREACH

In the introduction to Chapter 7 we discussed how the world view has evolved over the last half century in the USA ultimately making siting of transmission facilities much more difficult. One of the most prominent changes has been the necessity of engaging the public in the siting and approval process. This is done through two approaches: public involvement and public outreach. In this chapter, we will discuss these approaches, their importance and usefulness.

### Public Involvement

Throughout the 1970's and 80's the Public Involvement phase of siting studies was not deemed important and was frequently skipped. In today's culture, however, it is very important to engage the public, and this step must never be skipped. When any type of siting approval is needed, some form of public involvement must be conducted. Without this step, there is little chance of general public acceptance and/or government approval.

The point at which Public Involvement begins and ends, and the forums used vary. Depending on the jurisdiction, Public Involvement may be mandated by law or may be voluntary. While individual utilities must weigh the level of effort, and length of time needed to engage public involvement on each project, it is imperative to keep in mind that, if any type of approval is required, the utility must demonstrate due diligence in obtaining the thoughts and opinions of the general public before a decision can be made on the final route. Any concerns that arise must be well-documented and addressed in the siting document.

Projects that require federal National Environmental Policy Act (NEPA) approval, as an example, are mandated to include public involvement. In fact, the federal government will require a series of as many as four sets of public meetings in stages over several years, in order to gain public comment on each step of the process. As a result, NEPA reviews are measured in years to completion rather than weeks or months. A two-year NEPA review period is considered speedy. Typical review periods can last four to five years.

There are different forms of public involvement. The most well-known is the public information gathering meeting. However, this is not the only way to gather information and to solicit public involvement. We will discuss the following examples of public involvement:

- Agency Meetings
- Key Community Leader Meetings
- Community Group Meetings
- Key Stakeholder Committees
- Public Information Gathering Meetings
- Web Sites

### ***Agency Meetings***

Agency meetings are usually held during the data gathering process when siting a new transmission facility. These meetings can be with federal, state, and local agencies and are

usually fairly factual in nature. Information on laws, permitting requirements and data sources are frequently discussed. However, opinions and concerns that are not necessarily regulatory in nature may arise. For example, discussions with individuals that are a part of the effected community can bring out individual and local concerns. Use of this information must be taken with care when documenting these findings.

### ***Key Community Leader Meetings***

Key community leaders often have strong opinions and influence over the community. Elected officials at all levels of government are the most notable members of this constituent. However, there may be other key individuals such as business leaders, members of the local Kiwanis Club or other such organizations. Identifying these folks can be difficult and require local expertise. The help of the local utility is needed here.

Discussions with these individuals can clarify the issues important to the public within the study area of the project. Again, care on use of this information must be given when documenting these findings.

### ***Community Group***

The term community group is a generic term for any group that regularly meets together for a common interest. Many utilities have had such groups join forces to oppose a transmission line project. If a common interest group is known to exist in the study area, and it is possible that they may have an interest in the project, consultation with this group during the study phase is helpful. It may turn a potential project opponent into a supporter.

For example, if a study area contains many historical resources, and there is a local, active civil war re-enactment group, meeting with them to discuss their interests may go a long way to appeasing any concerns over the project.

### ***Key Stakeholder Committees***

A key stakeholder committee format is used when there are a large number of constituent groups and key leaders interested in the transmission project and the route selection process. Some utilities have agreed to hold a number of detailed siting meetings with these interested parties. However, a smaller committee is usually formed and a representative from each group or area of interest is selected. This process reduces the number of individuals on the committee, but still representing the key interest groups. In this way, the facilitator can work with a manageable size committee toward a consensus, and the risk of a mob mentality is minimized.

This stakeholder committee can be made up of widely diverse interests. Members can include, those from government agencies, key community leaders, landowners, etc. This committee works hand in hand with the siting team to help evaluate the data that is gathered, help in the selection of alternate routes, or may even help to select the final. The utility should determine the extent of involvement and role of this committee early in the process. The role of the key stakeholders committee should be clearly communicated during formation of the group and agreed upon with the final committee members in order to avoid misunderstandings.

Key Stakeholder Committees are the most inclusionary form of public involvement, and has its proponents; however, it has not been widely used.

## ***Web Sites***

Web sites and other social media sites, such as Facebook, are gaining significant popularity. A utility starting a significant transmission project may be well-served to create a project web site, with a public input page. The web site enables the utility to:

- Communicate accurate and up-to-date information,
- Provide a method to collect public opinion and meaningful input on issues that may be important to the siting project;
- Help to eliminate concerns that there are not enough public meetings or not enough locations for public comment.

In addition, for those not able to attend meetings, or who may have missed the public meetings, web sites can enable access to any information presented at those meetings, and provide them the opportunity to give their input.

Web sites will be discussed in more detail in the Public Outreach section.

## ***Public Information Gathering Meetings***

The term “public meeting” can have different meanings. In this context we are referring to the siting team meetings where the public is invited to attend and provide input into the siting of a new transmission facility. These meetings can follow different formats. We will discuss the most common types of public information gathering meetings and their advantages.

In the past, public meetings were informational only, and might consist of one or two utility employees presenting a map and describing what the utility planned to build; no real public input was sought. Questions were not really welcome, and if addressed, the answers were often not well-received. This sometimes resulted in an aggressive mob scene where an individual opposing the project could rally the crowd in attendance and nothing positive was accomplished.

The disadvantages of this format include:

- There was no process to gather meaningful public input
- Utility staff member did not have the expertise to deal with the many questions raised by the public
- Allowed for grandstanding by those opposing the project

Recent studies have shown that a more inclusive format for public meetings is more effective. To hold a successful public meeting the entire siting team must be fully engaged, and the utility must commit significant resources, time and effort to implement a successful meeting. As described above, a poorly planned public meeting can do more harm than good.

To ensure meaningful input from the public, information must be clearly communicated. The public must have an understanding of the why, what, where, and how of the project. While these points are usually obvious to the utility members they are not necessarily clear to the public. A successful public meeting includes a cycle of giving and receiving information.

Items that should be presented at a public meeting include:

- Why- Project need story
- What- Project description, i.e. double-circuit steel pole line
- Where- Project study area
- How- Siting discussions, approvals, permitting, and construction

The meeting should be set up in clearly marked informational stations to facilitate the flow of the public from one station to the next providing information on each area of interest. The stations should be “manned” by experts in each area or field so that questions are able to be answered before an individual leaves the meeting.

A number of overview decisions must be made by the siting team before planning the details of the public meeting. These decisions include:

- Timing - At what point in the siting process do you feel it is important to get public input?
- Number - How many public meetings should be held?
- Location- Where should they be held?
- Handouts- What information that will summarize the project and what can be taken as reference material?
- Public Input- What method will be used to gather public input?

Suggestions on these items are listed below.

## **Timing**

The timing of the public meeting is important. If you start too soon many answers to the public’s questions are not yet available, which may cause a feeling of distrust and withholding information. Conversely, if you wait too late in the project, you may miss the opportunity for the public to buy-in, as they may feel everything is already “cast in stone”, their views are not important and will be ignored.

The perfect time for a public meeting varies for different projects. In a study area with residents that are familiar with the process of siting new transmission lines, you may need to start earlier as you will be dealing with interested, well-informed individuals that understand the issues and want information as soon as possible. In areas with little infrastructure, lower levels of interest and concerns, you may wait till later in the process as these folks “just want answers”. Experienced siting team members will have to use their judgment to make the call on timing.

In reference to the siting process steps reviewed in Chapter 7, the public meeting timing falls somewhere after the initial data gathering within the study area and obviously before final route selection. The public meetings can begin before any of the steps of the process, depending on the size of the project and the number of iterations the siting team uses to refine their route decisions and selections. Public meetings can begin at any time before the following steps:

- Corridors are selected
- Potential routes are selected
- Refined routes are selected

- Final alternate routes are selected
- The preferred route is selected.

As such, there are numerous opportunities to begin this input. In some cases multiple rounds of public meetings should be held. For many projects public meetings should begin after the potential routes are refined and the more obviously poor choices are eliminated but before the final alternatives are selected.

## **Number**

As discussed under “Timing”, the number of public meets can vary. If you are going to solicit input from the public numerous times throughout the siting process, the number of meetings at any one time becomes less important. The number of meetings held is also dictated by the number of jurisdictions crossed by the project and the length of the project. In some areas, one (1) public meeting is sufficient. On larger projects crossing several jurisdictions many separate meetings will be necessary. As a rule of thumb, the public will normally not want to drive more than 30 minutes from their home to attend these meetings. This rule can be used to estimate the number of locations for public input that may be needed to get good participation.

## **Location**

The public meeting locations can be any meeting place that is large enough to hold the number of people you expect to attend comfortably. A neutral site such as a school or large community room is usually ideal if one can be found centrally located to the study area. But you want the location to be close to those potentially affected by the transmission line project. As was stated above no more than a 30 minute drive is ideal.

## **Invitations**

The simplest form of invitation is to place advertisements in the local newspapers in advance of the scheduled meetings. With less of the public regularly reading newspapers, little participation can be expected from just this form of invitation. Today many folks also use the internet to gather information. An informational web page detailing the proposed public meetings should be available on the utility company web page. Radio and TV ads may also be incorporated. Perhaps the best method is to use the local utility customer database to send individual written invitations to those located in the study area. Basically all methods of getting the general public the knowledge of their ability to provide input at these meetings are needed.

If a poor effort is made to gain public input, this process will offer little protection to the utility as the project moves forward.

## **Method of Public Input**

A method of systematically recording and organizing the comments and issues from the public must be determined and prepared prior to the meeting. Usually a questionnaire is prepared in advance of the meeting, is distributed as the public enters the meeting room, and is collected as they leave. Some utilities prefer anonymous questionnaires while others prefer documenting the concerns by name and location. Some utilities display paper maps/aerials of the study area, showing the various routes on these maps and have the people attending write their comments directly on them. Any of these methods can be effective. No matter the method, in the end, all comments must be reviewed, catalogued, and put into a usable format where trends can be

identified; specific concerns can be reviewed and then incorporated into the selection process of the final route.

## **Public Meeting Stations**

A list of suggested stations to be included in a public meeting is as follows:

- **Greeting Station** – hosted by local representatives to welcome the people, distribute informational brochures, maintain a sign-in sheet and provide an overview of the meeting set up and methods to be used to provide input to the project.
- **Project Need** – to be manned by the System Planners who will explain the problems with the current transmission system and will describe how this project will relieve those issues.
- **Engineering** – depending on the project, this group may include a line design engineer as well as a substation design engineer that can answer questions on the specifics of the planned designs and what the project will look entail. Photos and drawings of the proposed structures and substations can be helpful.
- **Siting** – to be manned by the siting specialists, environmental specialists, and engineers. This is the most important station as it is the one area where the information flow needs to be reciprocal. If the goal is to get public input into the selection of a line route it must be done at this station. Methods of accomplishing this will be discussed later.
- **Real Estate** – usually the purchasing of land rights from the public in some form will be needed. This issue concerns many attendees. It is beneficial to have the real estate land agents that will be dealing with the landowners working this booth. The land agents will be able to build relationships and good will by being able to explain the methods that will be used for land acquisition. In this way, the public may gain a level of confidence that each owner will be treated fairly and respectfully.
- **Health and Safety** – this station should be manned by someone familiar with the EMF health issues surrounding transmission lines. Since this issue is no longer a front page issue many utilities no longer have this individual station, but in every major transmission project, opponents will raise this issue as a concern. Therefore, it is imperative that someone be available to openly discuss this issue with concerned individuals even if a station is not devoted solely to this subject.
- **Regulatory** – (if it applies in this jurisdiction) to be manned by a representative of the legal team to discuss the legal process the utility will follow to get formal siting approval and to discuss the avenues for public involvement in that process.
- **Permitting** – to be manned by an environmental specialist to explain all the environmental field studies needed for the permit process and why access to the land is needed at a future date.
- **Forestry** – (may be a part of construction) to be manned by a forester familiar with the clearing practices that will be used immediately prior to the start of construction activities.
- **Construction** - to be manned by a representative of the construction team to explain how the line and/or substation will be built in stages and the activities that involve individual landowners.



## ***Public Meeting Ancillary Issues***

### **Handouts**

In addition to the questionnaire discussed above, it is advisable to prepare a summary handout explaining the important points that the siting teams want to convey to the general public. These points will vary by project but a good starting point for items to be included in the handout can be found by reviewing the Public Meeting Stations reviewed above.

### **Clothing**

In the past it was felt that all utility representatives should be dressed formally to meet and address the public, so business attire was always worn. Since the goal is to engage the public to get and give information, recent experience has shown that “business casual” attire seems to allow for easier conversations.

To insure that the public easily understands who is available to talk with them, some “uniform of the day” should be established that makes the people manning the stations easily identifiable. This can be achieved by wearing a siting team hat, or golf shirt or simply having everyone wear a name tag, dark pants and white open collar shirts.

### **Security**

Unfortunately, since transmission line projects tend to be very controversial, the need for security should be reviewed and addressed. Frequently private security folks are brought in if the meeting is expected to bring in large crowds that may be unruly. By getting a good understanding of the room’s maximum capacity and the number of people that can be handled effectively by the Station staff in advance of the meeting, a security person can be used to monitor and limit the number of people entering to a manageable number, preventing the Station staff from being overwhelmed and creating a mob scene.

### **What To Do with Public Input**

As stated earlier, public input into the selection process is a generally accepted practice. Whether this information comes from various shareholder meetings, public input meetings or information files on a project web site, all information must be reviewed, organized and catalogued in some fashion. On larger projects this information is sometimes placed into a data base system for easy sorting and inquiry. On smaller projects this same process can be accomplished by a simple spreadsheet. In either case a review of the data, a summary and trending should be performed, and this information should be documented on the final siting report to demonstrate to the public that their concerns and issues were considered.

### **Public Outreach**

The term Public Outreach is becoming more prevalent in relation to siting transmission line projects. In the past, Utilities did not do a significant amount of outreach efforts. They felt they had the right and ability to tell governing bodies that a new line was needed, and after some review and perhaps a simple hearing their approvals were granted. However, after some well documented siting failures around the country, this concept of public outreach is now becoming much more accepted. In fact, frequently specific public relations plans are created to educate and convince the public within a study area that the project is important and needed for the betterment of the affected communities.

Public Outreach in its simplest form is the public meeting format discussed above. This is a good example of what is needed to help educate and gain public acceptance. The project web site is another example of outreach. However, on larger more significant projects, or projects that have the potential to develop a significant amount of opponents, a much more aggressive outreach program should be developed. These needs will go well beyond the expertise of a standard siting team; experts in this field will be needed.

On complex projects, public outreach becomes a campaign with effort analogous to a political campaign and should be run by expert public relations people. Focus groups can be formed and used to develop and prepare the proper utility message on why this project is important. Television, radio, print media, and political action groups are all given this message in order to unify efforts. This outreach effort can be very expensive but is important since opponents to a project will use the internet and all media to get their message across. The utility must be prepared to address their opponents' concerns with appropriate, consistent, and coordinated responses and messages.

Key steps to this aggressive approach are to:

- Start your campaign early! Do not wait for the opponents to get the first word out to the community.
- Meet with potential supporters early and build coalitions outside the utility to help spread the project message. A 3rd party message is sometimes better received than from the utility.
- Use all forms of media for the widest possible connection to the community.
- Don't forget the politicians, they rarely want to get involved on the side of the utility, (utilities don't get them voted into office) but they can sometimes be convinced of the benefits of a project and therefore to remain neutral.

**A word of caution** should be made on the use of web sites, and particularly Facebook, as a way of getting the utility's messages out to the public. While the goal is to provide a forum to support the proper message by educating interested parties, care must be taken to prevent opposition groups from hijacking the utility's message board, and turning a well-meaning attempt to educate into a forum for opposing parties to twist the message and publish "misinformation".

Some Facebook settings allow all comments to be published without "approval" from an administrator. As a consequence, opinions can be immediately available to all those who have joined the group. So the utility must be sure to understand which security settings are needed. This will prevent Facebook from creating problems for the project. In this digital age, an opposing group can easily create its own website, and can publish misinformation. The utility just must be prepared to address these issues.

# 9

## APPROVALS

Every transmission line built today in the United States is subject to some if not many environmental approvals. But who is in charge of transmission lines and siting? There are several groups:

- United States Department of Energy (DOE)
- Federal Energy Regulatory Commission (FERC)
- The various 50 states

To some degree they all could have an interest, depending on the type, size and location of the transmission line project, but primarily it seems to fall on the states. In most states, depending on voltage requirements, they require a Certificate of Public Conveyance and Necessity (CPCN). It is not the purpose of this discussion to review the various issues involved in all of the state CPCN processes, although these are probably the most important in getting an approval of a new transmission line. Most projects only require state approval and the federal regulations never come into play.

The need for detailed siting studies is the result of the fact that many states today have transmission siting legislation which requires an extensive review and hearing process before approvals can be obtained. In states where there are little environmental siting requirements, the new transmission lines are still subject to federal permitting laws and reviews which may require public hearings.

### State Siting Approvals

Every state has differing rules on siting of transmission lines. Many have specific rules or laws that were written specifically for a review of all new transmission lines and fall under the preview of the state utility commission. Some states have a state level office whose only purpose is for this review. For example, the Ohio Power Siting Board's primary function is the siting review. In Indiana there is no specific law but review is handled by the State Department of Natural Resources. In some states it can be somewhere in the middle, such as West Virginia where the siting law for the most part only deals with transmission lines above 200 kV with no review at 138 or 115 kV.

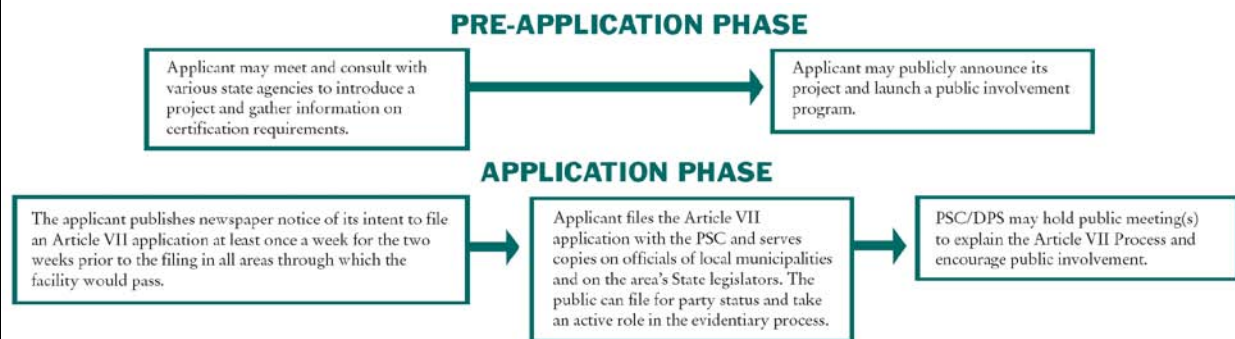
The material that must be presented also differs per state. Most all require two primary areas to be covered when applying for approval. The need for the line must be demonstrated and the reason for the location must be documented. The siting selection study document discussed in Chapter 7 is used for this purpose. Some states required other information, such as expected EMF values or noise level values, be included as well.

In this section, we will review an example of what is done the State of New York to give the reader a sense of the state processes that they may encounter. In New York they have a very well-defined process that is followed. Many other states, however, are not so structured.

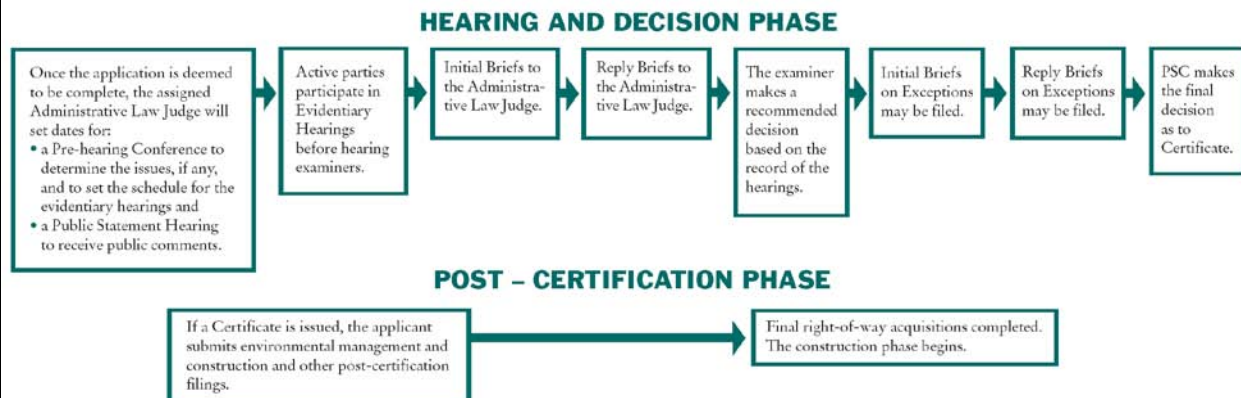
It is imperative that the laws of the state in which the line is being planned are reviewed in detail to determine the requirements.



## Pre-Application and Application Phases



# Hearing and Decision and Post-Certification Phases



## Article VII

- Transmission lines 100 kV or more, extending for at least 10 miles or
- Transmission lines 125 kV or more, extending for at least 1 mile but
- Excludes Hydroelectric.
- The New York State Public Service Commission makes the final decision.
- Article VII establishes the forum in which communities can participate with state and local agencies.
- A public information process is strongly encouraged throughout the review process.

## Public Involvement

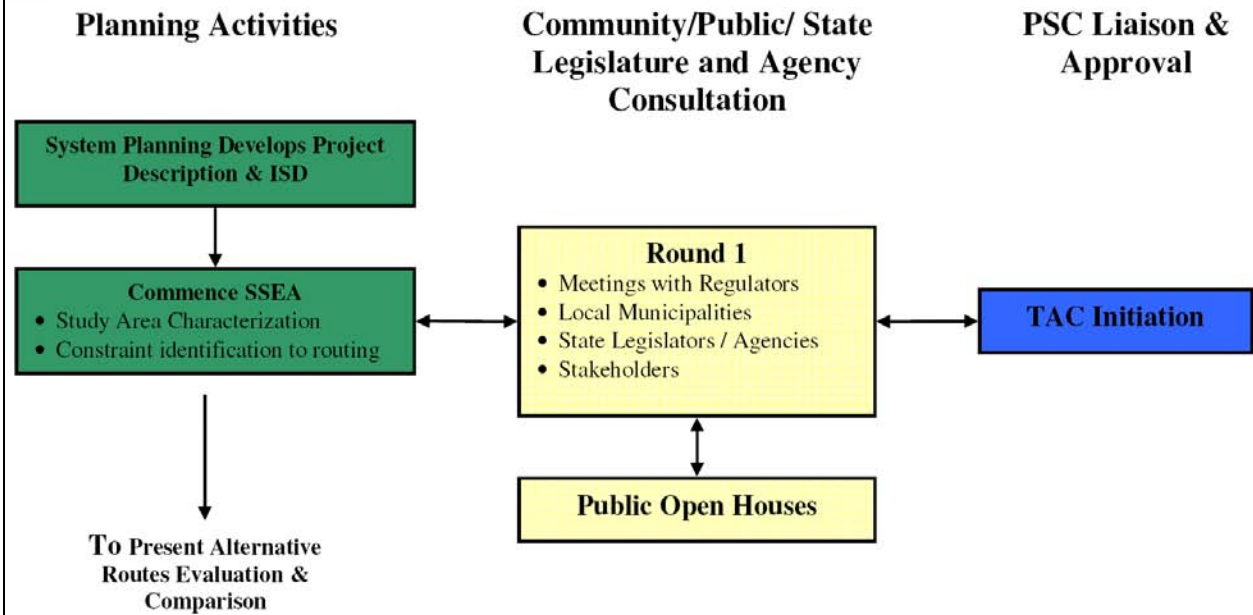
- To first alert the public.
- To explain the proposal to the public.
- To get input and provide feedback.
- To establish a presence in the community.
- To keep the public informed and provide updates.

## Commission Decision Based on...

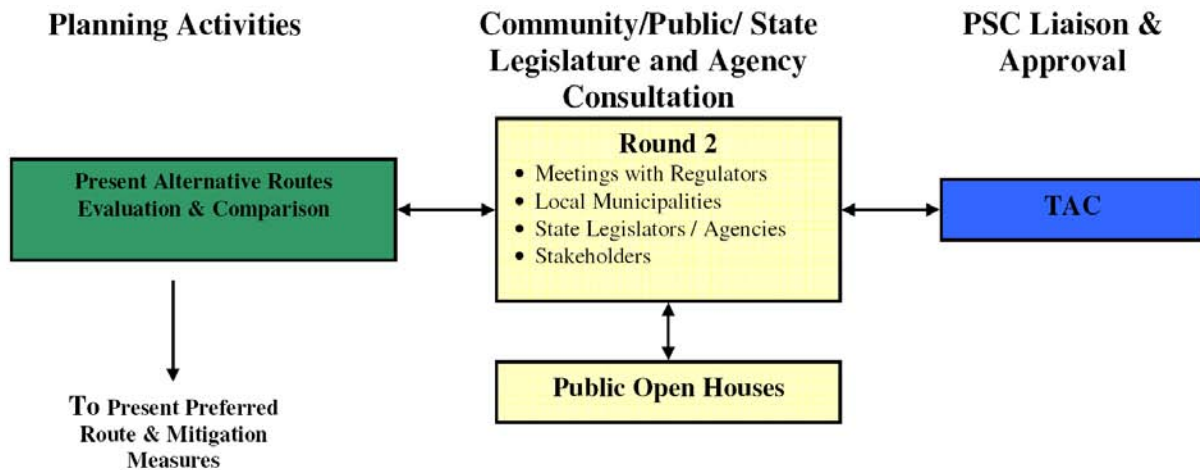
- The need for the facility.
- The environmental impact.
- Does it minimize adverse environmental impact?
- Is part of the line underground?
- Does it conform to the long-term plan for interconnections, economics and reliability?
- Does the location conform to applicable laws (both state and local)?
- Is it in the public's interest?

## Project Planning and Regulatory Process

## Flowchart – Part 1

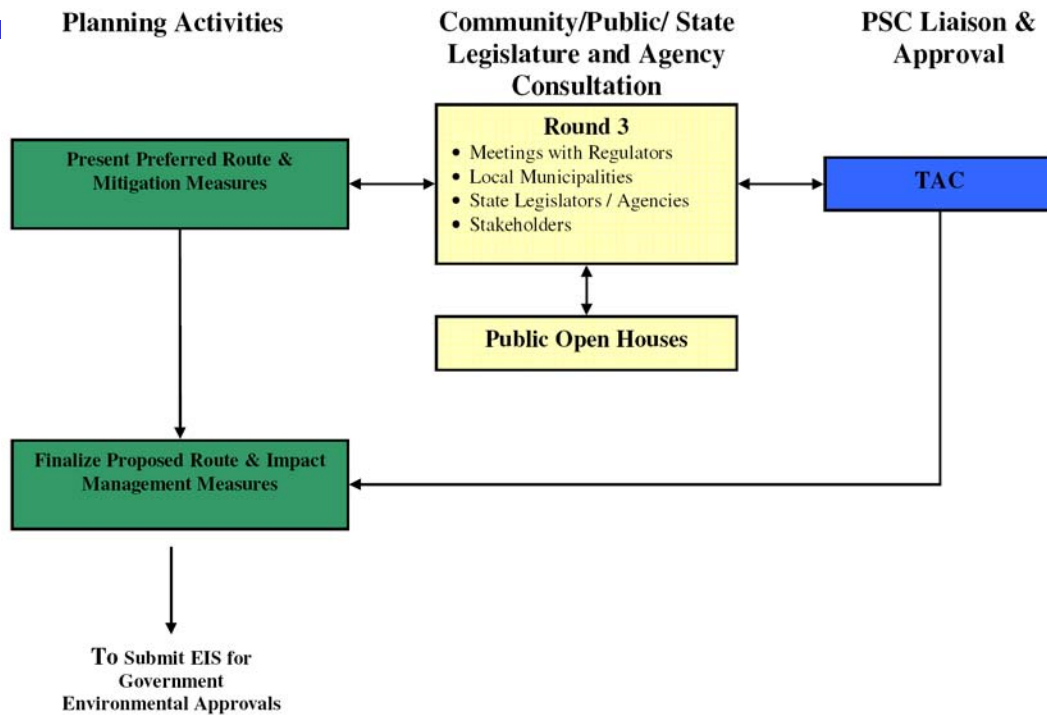


## Flowchart – Part 2





## Flowchart – Part 3

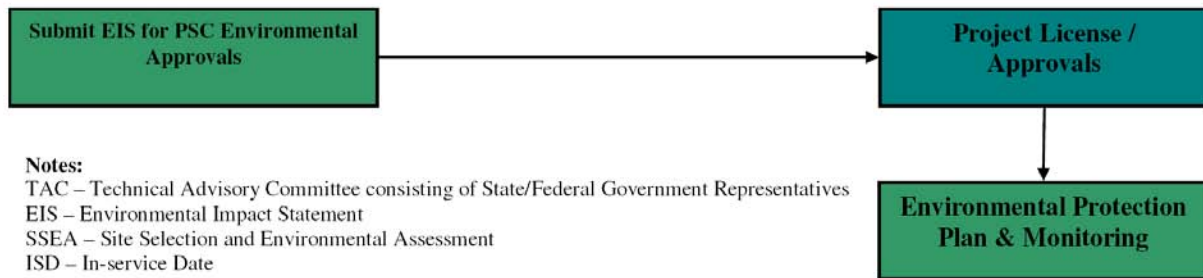


## Flowchart – Part 4

### Planning Activities

### Community/Public/ State Legislature and Agency Consultation

### PSC Liaison & Approval



## Development of an Environmental Impact Statement

### Conduct Environmental Assessment

### Evaluate Effects on Animals (Fauna), Human, Plants (Flora), Fish (Aquatics), Water, Air

### Develop Methods to Mitigate, Protect, Monitor and Restore

### Prepare an Environmental Impact Statement

(Also include justification of project, engineering design, schedule and construction method)

## Federal Siting Approvals

In this section, some of the federal regulations that had a significant impact on the siting of transmission lines in the United States are reviewed. It contains a history of Federal actions that became more proactive in getting transmission built in the United States. However, the bottom line under current rules, is that siting from a practical point of view, is **not handled by the federal government , but rather falls to the states for all siting approvals.**

With that in mind, let's begin by reviewing the two (2) federal agencies that oversee Transmission. They are: the Department of Energy (DOE) and the Federal Energy Regulatory Commission (FERC). DOE and FERC are very different organizations with different missions.

### The United States Department of Energy (DOE)

The DOE is a Cabinet-level department of the United States government concerned with the United States' policies regarding energy and safety in handling nuclear material.

- Its responsibilities include the nation's nuclear weapons program, **nuclear reactor** production for the United States Navy, **energy conservation**, **energy-related research**, radioactive waste disposal, and domestic energy production.
- DOE also sponsors more basic and **applied scientific research** than any other US federal agency; most of this is funded through its system of United States Department of Energy National Laboratories.
- The agency is administered by the United States Secretary of Energy who reports to the President.

This list would lead one to believe that DOE has no part in siting. However, one provision of the law known as EPact 2005 brought them into the siting area. This is explained below.

### The Federal Energy Regulatory Commission (FERC)

The Federal Energy Regulatory Commission is an independent regulatory agency within the United States Department of Energy. Neither the President nor Congress reviews FERC decisions. All FERC decisions are reviewable by the federal courts. FERC is also self-funding. The Commission pays for itself by recovering costs directly from the industries it regulates through annual charges and fees. FERC is composed of five commissioners who are appointed by the President of the United States with the advice and consent of the Senate. Commissioners serve five-year terms, and have an equal vote on regulatory matters. To avoid any undue political influence or pressure, no more than three commissioners may belong to the same political party.

Please see below for a list of FERC's responsibilities. You will note that while it does not say anything directly about siting of electric transmission lines, the line highlighted below shows that they control the economics of the transmission grid and hence their influence is an important factor.

- Economic Regulation
  - Transmission and sale of natural gas for resale in interstate commerce;
  - Transmission of oil by pipeline in interstate commerce;

- **Transmission and wholesale sales of electricity in interstate commerce;**
- Administers accounting and financial reporting regulations and conduct of regulated companies
- Infrastructure Regulation
  - Licenses and inspects private, municipal, and state hydropower projects;
  - Approves the siting of and abandonment of interstate natural gas facilities, including pipelines, storage and liquefied natural gas; and
  - Oversees environmental matters related to natural gas and hydropower projects and major electricity policy initiatives.

The next list it shows items that FERC is **NOT** responsible for handling.

- Economic Regulation
  - Retail electricity and natural gas sales to consumers;
  - Oil company mergers and acquisitions;
  - Regulation of municipal power systems, federal power marketing agencies like the Tennessee Valley Authority, and most rural electric cooperatives; and
- Infrastructure Regulation
  - **Approval to construct electric generation, transmission, or distribution facilities,** except hydropower;
  - Nuclear power plant regulation;
  - Oversight of oil pipeline construction;
  - Abandonment of service related to oil facilities;
  - Pipeline safety or pipeline transportation on or across the Outer Continental Shelf;
  - Regulation of local distribution pipelines of natural gas; and
  - Development and operation of natural gas vehicles

So a review of these lists shows a huge divergence between the gas industry and the electric industry. FERC controls the siting and construction of interstate gas lines but does not control the same thing in the electric industry. FERC also does not approve construction of electric transmission lines. Although, we will explain how and why they have had great influence.

### **Important Federal Legislation Changes**

There are two (2) key federal actions that changed the transmission industry, and had a huge impact on transmission construction, operation and maintenance. These actions also affected transmission line siting and its approval process.

First, the **Open Access Rule of Order 888** was not technically legislation but rather an order by the FERC that applied to the national electric grid. This has had the same effect as a law, in that it required compliance by the utility industry. This was a major development in a growing number of independent power producers. The existing large utility monopolies began moving

from the typical silo industry of making, transporting, and selling electricity to splitting off certain function of the process such as generation, into Genco operations in the hopes that they could be more profitable.

The second action was the **Energy Policy Act of 2005**. This far reaching overall legislation was passed by congress and tried to organize a national direction for all energy needs, including electric. It included special provisions directed at transmission lines. The bill (aka EPAct 2005) was passed by the United States Congress on July 29, 2005, and signed into law by President George W. Bush on August 8, 2005. It was directed at all types of energy and all levels.

### **Energy Policy Act of 2005**

- Established a number of energy management goals for Federal facilities and fleets.
- Amended portions of the National Energy Conservation Policy Act (NECPA).
- EPAct 2005 sets Federal energy management requirements in several areas, including:
  - Metering and Reporting
  - Energy-Efficient Product Procurement
  - Energy Savings Performance Contracts
  - Building Performance Standards
  - Renewables Energy Requirement
  - Alternative Fuel Use

Of particular interest to the electric industry and in particular the transmission sector, is the addition of Section 219 to the Federal Power Act. This directed the FERC Commission to develop incentive-based, rate treatments for transmission of electric energy in interstate commerce, adding a new Section 219 to the Federal Power Act.

The Rate treatments rules included:

- Incentive rates of return on equity for new investment by public utilities (both traditional utilities and stand-alone transmission companies, or Transcos)
- Full recovery of prudently incurred construction work in progress; (CWIP)
- Full recovery of prudently incurred costs of abandoned facilities
- A higher rate of return on equity for utilities that join and/or continue to be members of transmission organizations, such as (but not limited to) regional transmission organizations and independent system operators

All rates approved under the rules are subject to Federal Power Act rate filing standards. The rule allows utilities, on a case-by-case basis, to select and justify the package of incentives needed to support new investment. Additionally, the rule provides expedited procedures for the approval of incentives to provide utilities greater regulatory certainty and facilitate the financing of projects. The rule became effective on September 29, 2006.

For the last several decades “everyone” said the backbone bulk transmission (EHV) grid was being ignored, because the risk was too great to take on the large projects. Up until this point no

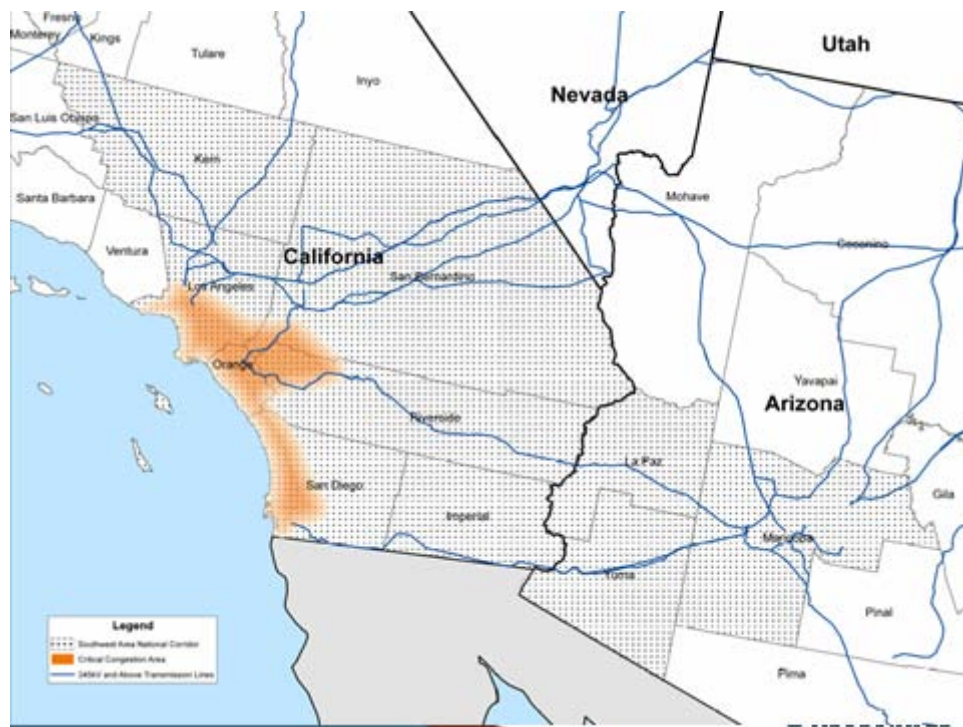
company could get paid back for its investment until it was in service. If special interest groups would force construction to stop, the utility was stuck with the costs. The financial risk was too great and the rewards too small (since open access means anyone can use it anyway). So this shows why there was a sudden change in attitude for large interstate transmission projects.

- Companies can build large interstate Bulk Power Transmission lines and be guaranteed to get paid even if they are stopped before they are completed.
- And they could make good money because of these rate incentives!

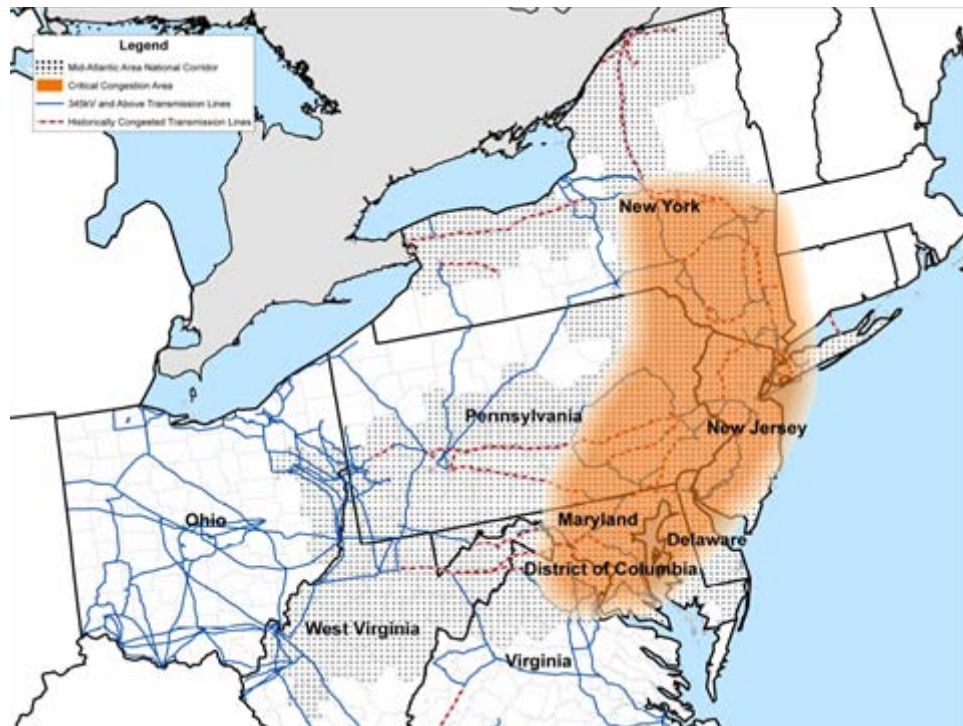
## NIETC

Another significant change brought about by EPAct 2005 was Section 216(a) of the Federal Power Act which required the Department of Energy to issue a national transmission congestion study (Congestion Study) for comment by August 2006 and every three years thereafter.

The first Congestion Study was issued on August 8, 2006, and examined transmission congestion and identified constrained transmission paths in many areas of the Nation. The study was based on examination of historical studies of transmission conditions, existing studies of transmission expansion needs, and region-wide modeling of both the Eastern and Western Interconnections. For sections of the US, a special designation was set up to try and deal with specific known problem areas. A National Interest Electric Transmission Corridor (NIETC) defined as a geographic region, as designated by the United States Department of Energy, where electricity transmission limitations are adversely affecting American citizens. These were very important for utilities operating in these select areas. There were more than 2 of these set up but 2 were designated as critical areas and most of the work and discussions were around these two areas.



Western NEITC Critical Area



Eastern NEITC Critical Area

A special rule was adopted in EPact 2005 that would allow utilities within this zone to get Federal backstop approval. The rule stated that in a state that didn't "approve within 1 year"; a utility could go to the Federal Government for the approval of that project. This would now make approval more similar to that for gas transmission lines. Utilities now have the option that if state CPCN approval got bogged down, they could change direction and head to the feds for approvals.

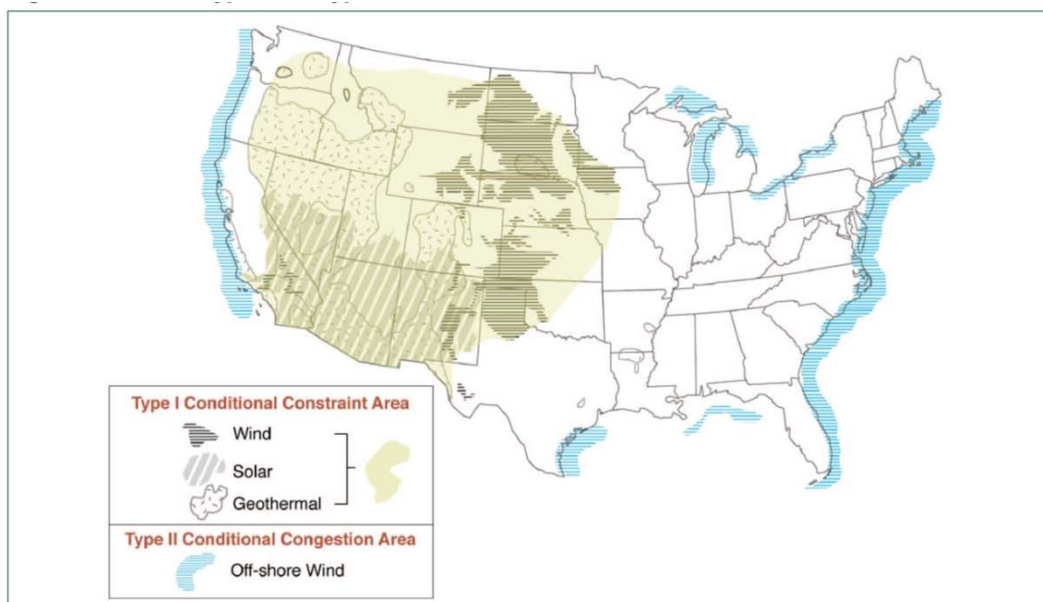
This rule was found to be controversial and the states, particularly in the Mid-Atlantic region, got together to oppose it. Appeals of this rule began immediately. The governors of Virginia, Pennsylvania, Maryland, New Jersey and New York had their states file appeals. Many special interests groups such as the Sierra Club also filed protests as well. The first method of appeal was over the vague language of EPact 2005.

In practice, the utilities believed they had 2 shots at obtaining line approvals. If the states said no they would go to the feds and get FERC approval just as is done with a gas line. Many believed that this was the intent of EPact 2005. However, EPact 2005 was overturned in a ruling, made on an appeal by an environmental group opposing the TrAIL transmission project in VA. The federal court ruled that "if a state says no" then there is no federal backstop authority. It only applies if the state failed to finish and did not respond within 1 year.

This ruling took much of the teeth out of NIETC and was a big win for those opposing the legislation. Because of the appeals in progress and the concerns that any transmission line trying for federal approval would be tied up in litigation for years, no utility has ever filed for federal back-stop approval. So NIETC has been completely untested.



Meanwhile, with all of the appeals going on over NIETC, the “every 3 year timeframe” was up. Also, the American Recover Act came into law before the next 3 year report was due. It changed the direction of the next congestion study. It directed the study to look at renewable energy and getting these to market. Reviewing Figure 8-1 you can see that this map is distinctly different than the NIETC maps. The 2009 report took the Epect in a completely new direction and away from NIETC.



**Figure 9-1**  
**2009 Congestion Study Showing Renewables**

- The 2009 study says, “The present document identifies areas that are transmission-constrained, but it does not make recommendations concerning existing or new National Corridor designations. The Department may or may not take additional steps concerning National Corridors at some future time.” It seems they did not make any comment on NEITC, in order to prevent any controversy for the report.
- Finally, NIETC died on February 1, 2011, the United States Court of Appeals for the Ninth Circuit decided that the DOE 2006 congestion study and the national interest electric transmission corridor (“NIETC”) designations were vacated and remanded back to DOE. This means they have to start all over again! This was thought by many to be the final death blow to NIETC. Currently, it is unlikely that it will ever get back to a point that it would help with any approval of transmission lines.

FERC order 1000 issued on July 26, 2011 is another game changer for the transmission industry as follows:

- It required public utility transmission providers to improve transmission planning processes.
- Allocated costs for new transmission facilities to beneficiaries of those facilities.
- Removed barriers (First Right of Refusal) to development of transmission facilities which builds on FERC’s open access reforms of Order No. 888.



The big news here is that a utility's "first right of refusal" to anyone building a transmission line in their zone is potentially removed. Time will tell, but this could be an opportunity for 3rd party, non-incumbent utility developers to take a more active role in the future development of the nation's transmission grid.

The Federal Energy Regulatory Commission issued two clarifying orders in 2012, Order No. 1000-A and Order No. 1000-B in which they affirmed and clarified the basic determinations in Order No. 1000 issued in 2011.

Another issue was the lack of a 2012 National Electric Transmission Congestion Study. As previously stated the EAct 2005 requires an updated congestion report every 3 years. This means that the DOE should have published a new report in 2012. This did not happen. The DOE hosted three webinars in August 2012 to receive input and suggestions concerning the preliminary findings of the 2012 study. Comments were received from numerous special interest groups and utilities but the 2012 report was not published. A review of the information provided at the webinars indicated no movement to re-establish NEITC corridors and therefore this study is not expected to have any significant impact on transmission line siting.

On a side note, an additional item of significance concerning NIETC occurred in 2012. FERC issued a draft statement to the DOE suggesting that FERC take over the national corridor designation process since there was no movement on any Federal backstop authority that was set to occur in EAct 2005. If this takes place this could have an impact on federal involvement in the siting process. The DOE released the idea of the FERC takeover for public input, but there has been no further movement to make that happen.

Another federal action in 2012 included an Executive Order 13604 issued by President Obama for "Improving Performance of Federal Permitting and Review of Infrastructure Projects". This Order requires federal agencies to collaborate and create a plan to improve or streamline the NEPA review process for critical infrastructure projects such as Electric Transmission Lines. Ultimately, this could improve the Transmission Line Siting Process where federal properties are involved, however, it does not change the fact that the siting approval process remains primarily in the hands of the State PUC's. Nothing of substance has been resolved to date from this order.

In 2013, a Presidential Memorandum was issued on "Transforming our Nation's Electric Grid through Improved Siting, Permitting, and Review". This memorandum supports the intention of Executive Order 13604 by suggesting actions for federal agencies.

In response to the Presidential Memorandum, the Administration has created a Rapid Response Team for Transmission (RRTT). The RRTT aims to improve the overall quality and timeliness of electric transmission infrastructure permitting, review, and consultation by the Federal government on both Federal and non-Federal lands through:

- Coordinating statutory permitting, review, and consultation schedules and processes among involved Federal and state agencies, as appropriate, through Integrated Federal Planning
- Applying a uniform and consistent approach to consultations with Tribal governments
- Resolving interagency conflicts and ensuring that all involved agencies are fully engaged and meeting timelines

Participating Agencies include: the Department of Agriculture, the Department of Commerce, the Department of Defense, the Department of Energy, the Department of Interior, the Environmental Protection Agency, the Federal Electric Regulatory Commission, the Advisory Council on Historic Preservation, and the White House Council on Environmental Quality.

However, nothing has officially changed with regard to the specific siting and federal permitting process. Therefore, while there has been little to no impact on siting so far, this will need to be monitored as it moves forward to see if improvements take place.

## **Permits**

In the beginning of Chapter 8, it is pointed out that every transmission line built today is subject to many environmental reviews and approvals. In the sections that follow, only the siting approval was dealt with, where the exact location of the line is reviewed to determine if it is located appropriately. However, there are numerous environmental permits that deal with a very specific review of potential impacts to a certain specific natural resource. These permits can become a major activity and greatly impacts the timeline for construction of the project.

As with other discussions, the permits can be federal, state and local permits. Each permit will have its own requirements. An early task when planning for a new line must be a preliminary review of the potential permit impact on the project. For example, if a National Park must be crossed to build a new line, several years need to be built into the project schedule to allow for the federal hearing process needed to get NEPA approvals.

It is beyond the scope of this document to review all the permit needs in great detail. Also the permit list will vary greatly depending on the location of the project and the project impacts. However a representative list of what may be needed is included below.

<b>Representative Permit List</b>	
<b>Federal</b>	
U.S. Army Corps of Engineers (USACE)	Regulated waters/wetlands encroachment permitting (Section 404/401 permits).
Federal Aviation Administration (FAA) FAA	FAA Form 7460 -1
U.S. Fish & Wildlife Service (USFWS)	Federal threatened & endangered species (T&E) reporting and compliance with Section 7 of Endangered Species Act
U.S. Forest Service	Special Use Permit and consultation for surveys necessary to prepare NEPA.
U.S. Park Service	Special Use Permit and consultation for surveys necessary to prepare NEPA.
US Bureau of Land Management	Special Use Permit and consultation for surveys necessary to prepare NEPA.
<b>State</b>	
Department of Natural Resources (DNR)	NPDES, Section 401 water quality, stream crossings
Department of Historic Resources (State Historic Preservation Office)	Cultural resources data, consultation (including Section 106 process), and approvals
Department of Transportation	Various state road crossing permits and approvals.
Department of Conservation	State Rare Species
State Public Utility Commission	CPCN siting approval
State Parks and Recreation	Land Encroachment Permit
<b>Local</b>	
County Road Department	Various local road crossing permits and entrance road approvals.



# 10

## TRANSMISSION LINE IMPACT MITIGATION MEASURES

The construction of a new transmission line inherently brings with it some impacts on the environment. Even when all due diligence has been applied to the siting process in order to select a transmission line route that minimizes impact, the construction will still have some impact. There are engineering and construction techniques that can be employed to minimize these impacts. In this Chapter we will review some of these techniques.

### Minimizing Environmental Impact of New Lines

- Reduce visibility by lowering structures, moving conductors closer, deleting shield wires, darkening conductors.
- Choose routing to minimize visibility.
- Where highly visible, use of industrial & esthetic structure designs.
- Select conductors & phase spacing to minimize corona and thus electrical/audible interference.
- Make lines bird friendly by marking critical areas to avoid impacts and by making structures nest-friendly
- Minimize conductor spacing to keep E and B fields low.

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### Structure Design

#### ***Compact Construction of Transmission Lines***

Why can't transmission lines look more like distribution lines? Many technical studies have been performed in order to minimize the spacing of phase conductors to reduce the visual impact of overhead lines. The following discusses the various methods of compaction and why certain natural phenomena, such as ice galloping, limit our ability to compact lines.

## Line Siting Question

- A standard 230 kV transmission line (wood pole H-Frame, 20 ft phase spacing) is to be built in a heavily populated area. In order to reduce the visual impact and right-of-way width needed, it is proposed that the line be built on a single steel pole with reduced phase spacing. What are the advantages and disadvantages of compact versus conventionally spaced lines?

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## Possible Line Siting Answers

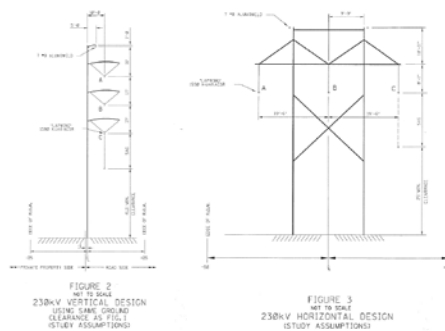
- Conventional overhead lines are usually easier to maintain than compact lines.
- There is little difference in construction time.
- Compact lines are less intrusive visually, they look more like distribution lines.
- Compact lines can usually be built on narrower rights-of-way than conventional lines.
- The electrical stress for conductors in compact lines is higher so there is an increased possibility of corona-induced noise.

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## 230 kV Typical Structures

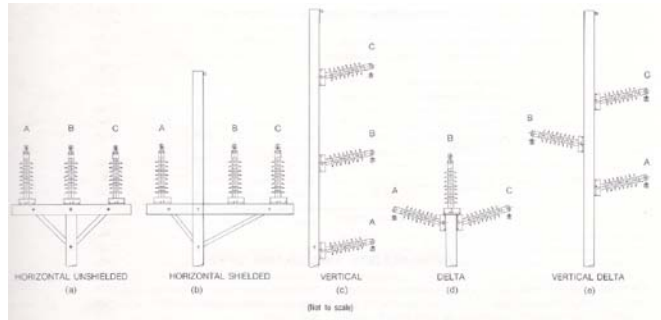


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## EPRI Compact Configurations

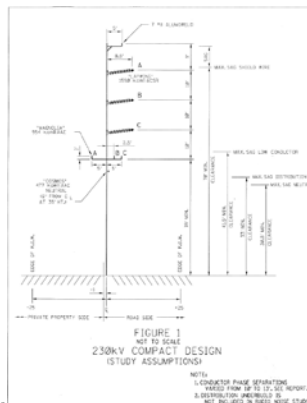


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## 230 kV Compact Conceptual Structure



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## Conflicting Compaction Goals

- Short structures
- Few and small conductors (avoid shield wires)
- Minimize footprint
- Small sag/high tension to minimize blowout & ice galloping
- Fewer structures
- Bundles, large conductors for low noise/interference
- Simplify & speed maintenance
- Low tension loads (cost of angles)
- Avoid hardware in span

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## Conductor Needs & Answers

- |  |   |
|--|---|
| 1. Short lines, low react, high electrical loads, minimum OD | 1. HTLS conductors, TW alum             |
| 2. Short structures, low sag, no hrdwr in span               | 2. SDC, T2, High Mod for ice, High SD   |
| 3. Minimum tension   | 3. Annealed aluminum, light weight core |

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## Benefits of Compaction

- REDUCED STRUCTURE HEIGHT
- FIT MORE LINES ON A RIGHT-OF-WAY
  - OR UTILIZE NARROWER RIGHT-OF-WAY
- REDUCE VISUAL IMPACT
- REDUCE EMF EFFECTS

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## Issues With Compact Lines

- CLEARANCES FOR MAINTENANCE
- WIRE SEPARATIONS FOR GALLOPING OR ICE UNLOADING
- LIGHTNING PERFORMANCE
- AUDIBLE NOISE

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## Characteristics of Compact Lines

- Usually have restrained insulators
- Often use reduced insulation levels
- Usually have reduced clearances
- Usually use pole structures
- Often have shorter spans

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## Advantages of Reduced Sag

- Reduce everyday final unloaded sag (D1), then high temperature sag (D2) and maximum mid-span blowout (H3) are also reduced.
- Reduce conductor thermal elongation without reducing the elastic modulus or increasing plastic elongation, then reduced max sag (D2) allows shorter/fewer structures.
- Reduce sag under high wind (D3), then smaller mid-span blowout (H3) & reduced ice galloping ellipse allow reduced phase spacing & smaller ROW width.

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## Perhaps Reduced Sag Also Reduces Visual Impact



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## Management Issues

- Potential challenges associated with compaction
  - Increased difficulty/risk associated with energized maintenance
  - Increased risk of animal-caused outages

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## Impact on Maintenance Work Practices

- Reduced clearances will complicate use of LW techniques
  - May require spreading of phases
  - May limit use of LW techniques to those performed from insulated aerial devices



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As stated previously one of the goals of compact construction is to reduce the visual impact. One possible detriment to doing this is that the reduction of phase spacing increases the risk of avian electrocutions. Larger birds, when stretching out their wings, can now span the distance between the phases, cause a short circuit, and hence their demise.



## Avian Wildlife Issues

- **Compact configurations may lead to bird electrocutions**
- **Electrocutions may be prosecuted under the:**
  - Migratory Bird Treaty Act: \$15,000 Fine
  - Bald and Golden Eagle Act: \$200,000 Fine
  - Endangered Species Act: \$200,000 Fine




Source: Avian Power Line Interaction Committee (APLIC). 2006.

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## Avian Wildlife Issues

- **Compact configurations may lead to increased occurrences of streamer caused outages**





Photo Credit: Shawn Carey

Source: EPRI Technical Update 101361.

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## Avian Wildlife Issues

- Compact configurations may lead to reduced clearances for nesting birds.
- Outages could result due to:
  - Nest material contacts (e.g., sticks, wire, etc.)
  - Prey contacts (e.g., snakes)
  - Bird contacts



## Example Compact Line Design\*

- Study to Replace Existing 69 kV Line with a 230 kV Line
  - Urban Area Along Road
  - Short Spans to Match 69 kV Alignment
  - Compare Electrical Effects w/ Typical 230 kV Configurations
- \* - Courtesy Rich Collins, Commonwealth Assoc.

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## Existing 69 kV Line Tangent



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## Existing 69 kV Line Angle

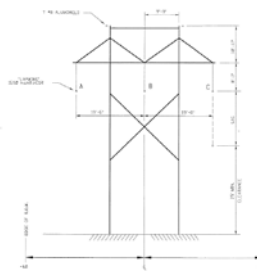
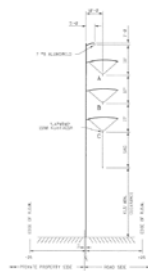


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## 230 kV Typical Conventional Structures

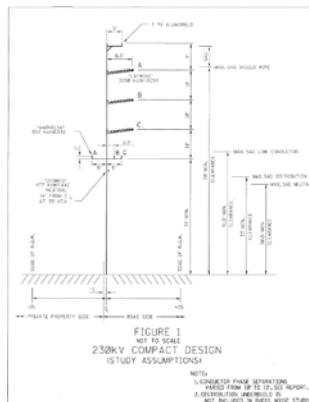


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## 230 kV Compact Conceptual Structure



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## Structure Configuration Study

- Studied Vertical Phase Spacing of 10', 11', 12', & 13' w/ Underbuild
- Clearance to Narrow ROW Evaluation
- Galloping Check for Phase Spacings
- Maintain Shield Angle Present on 69 kV

## Structure Configuration Study Results

- Due to Short Spans the 10' Vertical Phase Spacing was deemed adequate:
  - Vertical Configuration Met NESC Bldg. Clearance to Narrow ROW at 6 PSF Wind
  - Short Spans Kept Galloping Within Tolerance at 10' Phase Spacing

## Electrical Effects Study Synopsis

- Electrical fields less than 2 kV/m Criteria at ROW Edge
- Magnetic fields less than 200 mG Criteria at ROW Edge
- Audible Noise less than 52 dB (A) Criteria
- Radio Noise higher than 230 Configurations but less than 345 or 500 kV, therefore it was deemed adequate

## Results

- Line Constructed at 230 kV With 10' Vertical Phase Spacing
- Performance = Excellent
- No Complaints From Area Residents

## Main Points – System Planning

- Compact lines Planning involves both short term (relieving a specific transmission constraint) and long term goals (determining the need for a new voltage class or use of DC).
- It also involves both economic decisions (choosing to build a new line to gain access to low cost generation) and non-economic decisions (replacing old equipment to improve reliability).
- Planning decisions are often complex involving long term goals and sequential actions intended to achieve them.
- The impact of decisions taken concerning one circuit may influence other circuits and future actions.

## Conclusions

- At 69 kV to 230 kV it may be possible to reduce the spacing of phases in an overhead line, a process called “compaction”.
- Compact lines are usually no more expensive to build than conventionally spaced lines but may be more difficult to maintain, especially “live”.
- Compact lines are less intrusive visually, they look more like distribution lines.
- Compact lines can usually be built on narrower rights-of-way than conventional lines.
- The electrical stress for conductors in compact lines is higher so there is an increased possibility of corona-induced noise.

## Structure Modifications

Structure design can have a significant effect on the perceived, environmental impact of a transmission line. We have discussed compact construction to reduce the R/W requirements and the structure heights. However, it is possible to do other things to reduce the impacts once identified.

If agricultural crop reduction is a major concern, structures with a smaller footprint can be used. For example, a single pole design would be selected, rather than a 4-legged tower design.

If visual impact is a concern, a structure that blends into the existing environment should be selected. There are different ways to accomplish this goal. Probably the most famous single, non-standard example is the transmission structure in Disney World, where a specially designed pole was manufactured.



Other more attractive designs have been tried.







When dealing with visual impact issues, the facts that support your case are not always believed or supported by the general public. For example, studies have shown that when a tower is viewed from middle-ground or background distances the tower design is less visible than a pole design. However, when the general public is questioned, their preference is most often poles.

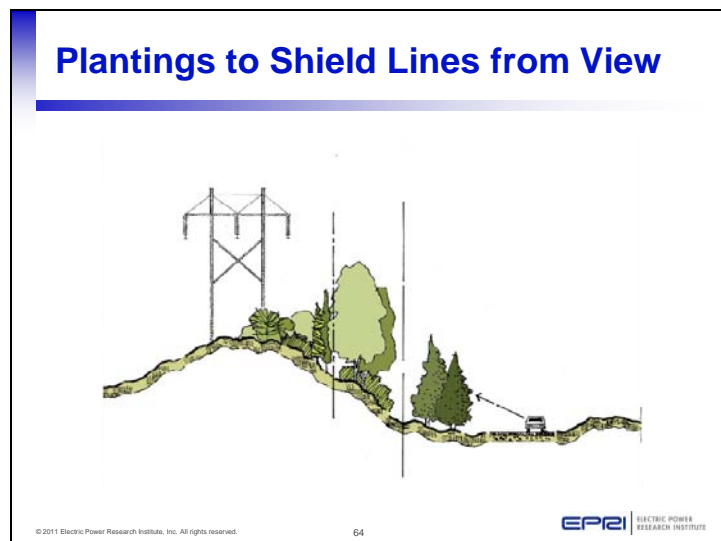
Another way to mitigate the visual impact is by using an extra acid dip process on the steel structures. After the galvanizing process is completed on a steel structure, an extra acid dip process is used to dull the structure to make it less visible. This will be discussed later in more detail in a case study found in Chapter 12.



Structures can be selected that blend in to their surroundings.

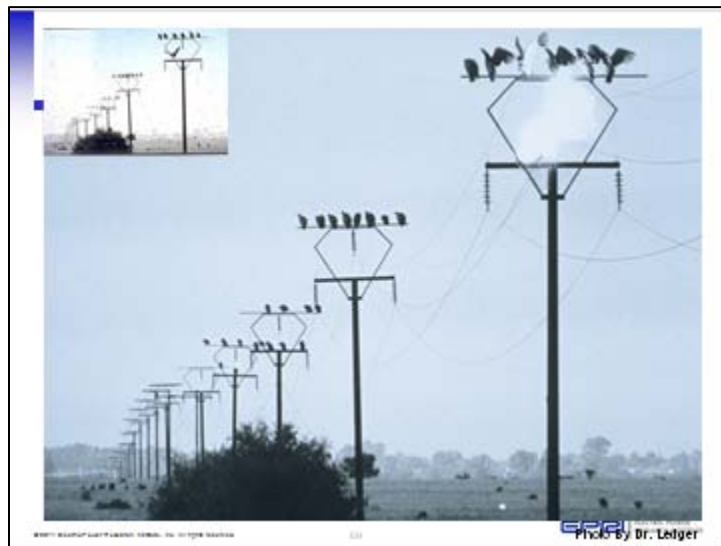


In addition to structure designs, changes to the surrounding environment can be designed such as planting vegetation to improve the visual impact.





Finally, a special design can be developed in order to address a particular environmental concern. Please see the avian electrocution shown in the example below.



### **Wire Design**

The wire, conductor and shield engineering issues were discussed in detail in Chapter 4; however, they also present environmental issues that can result in complaints from the general public. Different wire configurations can result in different noise characteristics or levels on EHV lines. Light reflecting off of a new aluminum wire may make the transmission line very noticeable.

When visual impact is an issue, a special wire can be produced and purchased known as non-specular conductor. This type of wire is manufactured exactly the same as any standard conductor but it is run through an extra process to remove the shine from the aluminum wire. So, any wire selected to meet the electrical and mechanical requirements of the project can also be specified as non-specular.

For a small project, this special added process adds to the cost of the wire. However, on large projects the economies of scale reduces this cost significantly, so that it has a minimal effect on the overall cost of the project.

Examples can be found in the case study in Chapter 12 of this document.

### ***R/W Clearing***

Frequently the impact of the tree removal from the R/W during construction is the subject of much debate. In the east, where the lines are spanning large valley floors and have significant wire separation from the trees, approving agencies recently have required a selective tree removal, where most trees remain within the R/W. This will be discussed in the case study in Chapter 12.



### ***Electrical and Magnetic Fields***

The following slides explain the basics of electrical and magnetic fields. These fields have been the basis of numerous studies over the last several decades.

## Electric and Magnetic Fields (EMF)

- ✓ Electric and magnetic fields are generated by overhead transmission lines
- ✓ Electric and magnetic fields are force fields, similar to a gravitational field.
- ✓ Electric fields are due to the capacitive electric charges that reside on the conductors and is dependent on the line voltage
- ✓ Magnetic fields are due to the currents in the conductors.

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## Magnetic Field Issues

- ✓ Magnetic field of an overhead line induces a voltage on long objects such as fences, railroad tracks, pipelines, and distribution lines

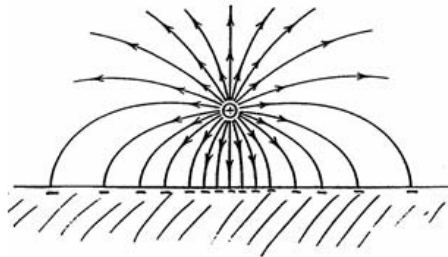
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## Electric Field

### E-Field from an energized overhead conductor



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The effects of electrical and magnetic fields on health, is widely debated in every new transmission line approval process. The cancer studies have been shown to be inconclusive and most scientists no longer support the cause/effect relationship. However without compounding proof, this is always a serious topic of discussion with opposition groups during the siting and approval processes.

Without dealing further with the health debate issue, there should be a plan in place to address the concerns of the public. Someone with knowledge of the health issues should be available to answer questions at any public event where controversy is expected and may be required to testify at approval hearings concerning the expected field levels on the new transmission line.

The results of this health debate were that of few states have set standards for these fields.

Magnetic Field Standards		
State	M-Field in ROW	M-Field @ ROW Edge
New York	No standard	200 mG
Florida	No standard	200 mG
Minnesota	No standard	No standard
Montana	No standard	No standard
New Jersey	No standard	No standard
Oregon	No standard	No standard
Manitoba	No standard	No standard

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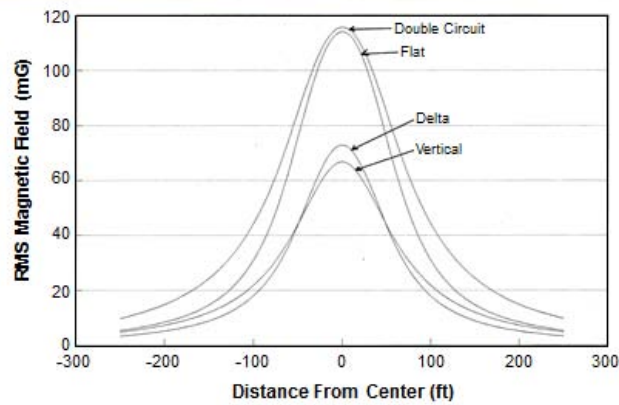
### The Issue of Magnetic Field in Transmission Line Design and Operation

- **Concerns about long-term effect of exposure to 60 Hz magnetic field**  
Important issue for certification of new and upgraded lines.
- **Magnetic field induction in parallel wires**  
Currents in shield wires. Voltage buildup.  
Induction in fences.  
Induction on railroad tracks.  
Induction on pipelines.  
Neutral-to-ground voltages on distribution lines.
- **Interference with computer monitors**

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## Magnetic Field Profiles



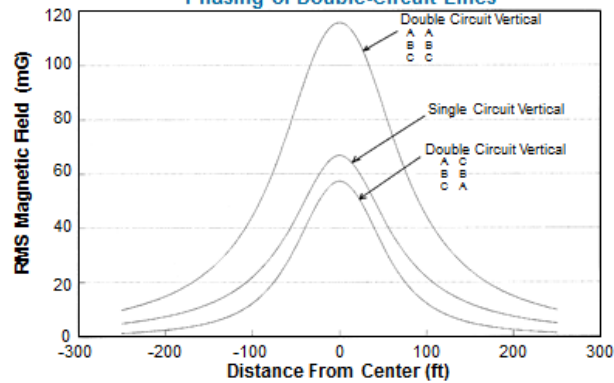
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## Effect of Line Parameters

### Phasing of Double-Circuit Lines



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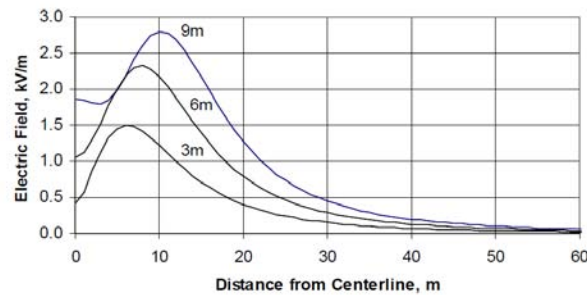
There are engineering techniques that can be used to reduce EMF values. Reversing the phasing arrangement on double circuit lines, to allow for a cancellation effect, is most effective. Reducing the phase spacing can also have a positive effect. Recently, this type of spacing reduction has not been as widely accepted due of the detrimental effect on live line maintenance activities.

Even with diminishing activities in this area, many states require the expected EMF values produced by the new line to be reported during a siting hearing process.



## Ground Level Electric Field Drops with Compaction of Phases

Horizontal configuration; 230 kV, single 2.54 cm conductor, 10 m conductor height.



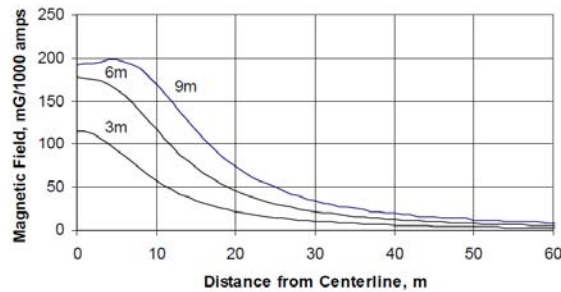
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## Reduction of Ground Level Magnetic Field with Compaction of Phases and Distance

Horizontal configuration; 230-kV, single 2.54 cm conductor, 10 m conductor height, 1000 amps flowing in each phase.



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## Noise

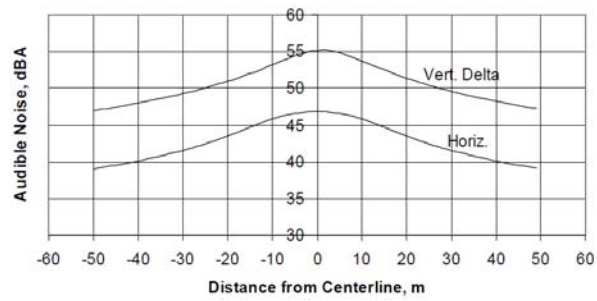
Noise is not an issue when operating transmission lines in the lower voltage range. Any discernible noise is rarely detectable by humans, on lines below the EHV range unless there are unusual circumstances. Therefore if the project is planned for levels below 345 kV, the audible noise is usually not a significant design factor.

However, for transmission lines above this level, design of the wire configuration should address noise. One possible way to address this problem is to use a smaller conductor in a bundle arrangement. This is one of the reasons American Electric Power has moved from using a 4-bundle conductor arrangement to a 6-bundle conductor arrangement. It offers a significant reduction of the noise at that high voltage.



## Comparison of Audible Noise for Compact Delta and Conventional Horizontal Phases

Single 2.54 cm conductor, 10 m conductor height.





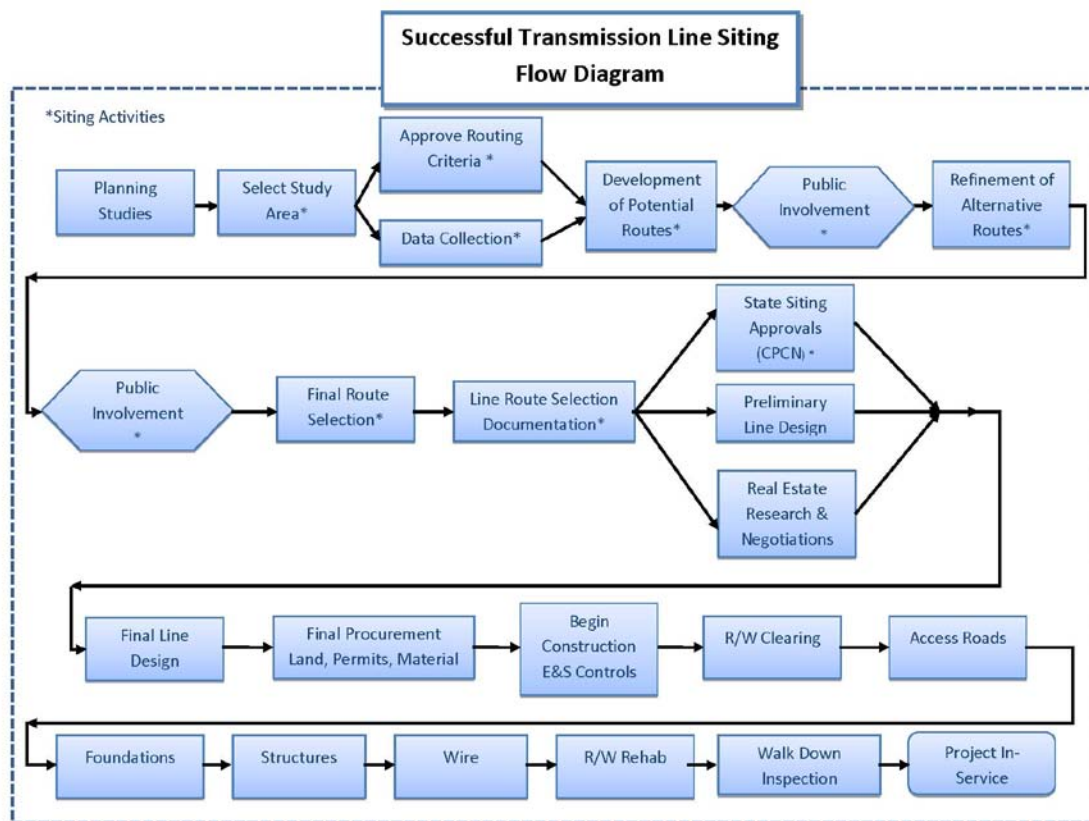
# 11

## FLOW DIAGRAM AND EXAMPLE OF SUCCESSFUL SITING OF A NEW TRANSMISSION LINE

In this chapter, we will review the items discussed in the previous chapters, and put together a representative flow diagram of the various actions and decision needed to achieve a successful new transmission line project. On an actual project, the details and the local jurisdiction of the project, will dictate many of the decisions and details of the project.

### Flow Diagram

The flow diagram shown below in Figure 11-1 illustrates a generic process for a successful siting of a new transmission line.



**Figure 11-1**  
**Successful Transmission Line Siting Flow Diagram**

## **Fictitious Example of a Successful Siting of a New Transmission Line**

In this section, we created a fictitious project to illustrate how decisions can be made to complete the project in a timely and successful manner.

First, the System Planners identify a need for a new transmission line through their electrical load flow studies and recommend a solution. For this exercise, we will assume an urban area is expanding with an influx of new housing, along with the commercial growth associated with residential growth. The existing infrastructure is served by a 46 kV sub-transmission system which has been previously up-graded and has reached capacity. The only transmission in the area is a 138 kV line about 10 miles away. Their decision seems straight forward... to build a new 138 kV substation and a new 10 mile, 138 kV line. But should it be single or a double circuit line? How much transfer does the line need to carry? In our project, the System Planners issue a plan for a double circuit line. The second circuit is needed for reliability reasons to allow for electrical feeds from two sources. This utility routinely uses a standard 954 kcmil, ACSR conductor for its 138 kV system unless unusual circumstances dictate a change from the standard. The line will originate at Substation "Existing" and will proceed to the new Substation called "New." They believe that the project will need to be in service before the summer peak in three years, at which time, the 46 kV lines will no longer be able to serve the area. This concept gets internal company approval and is passed to the Siting Team.

The Siting Team sees two projects here: First, they must find a location to build a new substation site that meets the electrical needs; then, they must find a route that can get approval quickly to meet the three years in-service date. Preliminary data collection efforts should begin immediately. After review of existing readily available mappings, a reasonable study area is defined and data collection efforts begin. The first step in data collection is to review all on-line sources and to download information into the project GIS system. Next, meeting with all affected government agencies and officials should be planned to supplement the on-line data. At this point, the general public may become aware of the project, and the utility team must decide if/when to make any public announcements.

Many line siting efforts can be done simultaneously with the substation site selection. However, on a line as short as 10 miles, a preferred site should be tied down, before too many line decisions are made. In some jurisdictions, approval hearings may be needed for the new substation as well. The siting team will be reviewing available sites that meet the electrical needs, for the new substation. In the exercise here, the existing 46 KV substation that serves the area is located in a commercial/industrial area and additional property for expansion is available. So this quickly becomes an easy decision point. The line siting team can move forward, with little risk, and buy property around the existing substation for the new substation.

With the new substation location identified, and the existing beginning point known, it seems everything is ready to move forward. However, during data collection, the team realizes that the line route will cross a desolate mountain area, and then will need to cross a federal national wildlife area, or else it will cross the expanding residential areas which caused the need for increased electricity and the project itself. This is the classic people vs. wildlife issue faced by many projects. Are there any routing opportunities available? After exiting the mountains, there is a railroad that generally travels in the needed direction, and avoids the wildlife area and most of the residential area, but the industrial and commercial buildings are far too close for the needed 100 foot wide Right of Way. In addition, it goes almost 5 miles out of the way. An existing 46kV line serving the area follows the same railroad. These are the biggest issues, and

we haven't even mentioned the wetlands, the endangered bog turtle, the elementary school, high school, the town cemetery, and the historic sites. We could go on, but the point is that the routing team has issues.

At this point, as many as 20 or 30 potential routes could be reviewed and analyzed. So how will they move forward with the decision process? The team knows that the project is going to be controversial, and this line will need, at a minimum, state CPCN approval, so it may be time to bring the general public into the decision process. It may be appropriate to develop a decision tree that helps identify what is most important in this region. In our exercise, the team feels that there are too many choices for the general public to easily understand, but they believe some help is warranted. Working with the local utility government affairs representative, and a few government officials, the team picks a panel of 6 prominent local people, with whom to discuss the data and options in detail over several meetings. This "advisory panel" is another form of public input without holding open public meetings. Using the advisory panel, input decisions are made in order to narrow down the routing choices. Using a manual or computer review, alternate routes are developed. In our example, the siting team comes up with 3 basic routes with a few variations.

- **Alternate Route A** is the shortest but it will go through the national wildlife area. This will require NEPA reviews and hearings, with a minimum 2 to 3 year process added to the state CPCN and other permitting. With real estate work and construction the time line appears to be a total of 4 to 5 years for this route.
- **Alternate Route B** will impact new housing and will be very close to the historic areas and most certainly will have some impact on the wetland and bog turtle habitat.
- **Alternate Route C** is 5 miles longer, follows the railroad and is close to the schools and there is not enough land for construction. It also has an existing 46 kV line in the way.

It may seem the project appears to be at an impasse. There are significant decisions to be made and the siting team should not make these unilaterally. Is it time to take these out for public comment? We suggest it is not yet time, because there are too many issues that need further exploration. If you go to the public without answers to some of these questions, credibility will be lost. It is time to hold a company meeting. Perhaps if the utility company reviews their transmission line design standards a solution can be found. Questions that should be discussed:

- Can the project withstand a two year delay for Route A?
- Are there ways to build through the turtle bog without impacting it on Route B?
- What about all the houses along Route B? This will surely cause public concern. Anything we can do to minimize impacts?
- Can the Rights of Way requirements be reduced to be able to build Route C?
- What will we do about the existing 46 kV line? Can it be taken out of service during construction and moved?

There are engineering and construction solutions that need to be investigated. In our example, the company meeting takes place and the System Planners stand by their need date, and as such decide that Route A will not work. The Construction Department says that winter construction through the wetlands would reduce wetlands impacts. The design engineers say that special compact single pole construction would allow for a reduced R/W along the railroad, but this will require 2 to 3 times the number of poles because of the reduced spans allowed. The 46 kV line could be built under the 138 kV line, on the same poles, and since it is a network line, the existing substation could be temporarily fed from another direction. This special design, while significantly raising the project budget estimate, makes Route C a feasible option.

With these answers in hand, the siting team moves for public input. Open house events are planned along the alternate routes. Maps and detailed exhibits are prepared to answer all questions. Handouts covering all major points are created and to be available to take home. The same information is made available on a company web site for those who cannot attend. At these open houses all the alternatives are discussed and the public is asked for any comments and concerns. Additional input is sought to ensure that nothing was overlooked during the data collection process. At the events, every major department from the utility is represented to answer their questions and concerns. This list could include:

- System Planners - to tell why the project is needed.
- Siting team - to explain the routes and how they were selected.
- Design Engineers - to explain the design and how it will look.
- Real Estate - to explain the process to acquire the needed R/W.
- Legal - to explain the upcoming CPCN state hearing process, and inform them that they will have the opportunity for direct contact with the state decision makers.
- Construction - to explain what happens to the properties during the construction of the line.
- Maintenance / Forestry - to explain the methods used to maintain a R/W such as, notification and herbicide use, if applicable.

The public input forms are collected from the open houses, and from any emails, or other online vehicles. The information is categorized and tabulated.

#### Alternative Route A

No short cuts to the NEPA process are found, so clearly Route A will not meet the need date for the project.

#### Alternative Route B

Even though no homes would need to be removed during construction, the data from the public input overwhelmingly states that Route B, traversing nearest to the homes, is the least preferred route.

Alternative Route C is the only remaining choice. This alternative would take the long route, along the railroad, and requires the use of special compact construction. However, the mountain section could still be built with standard construction. Steel towers would allow for the longest spans in the mountains and they are selected for this area.

Once these siting decisions have been made, the decisions are documented in a report that reviews and explains all the steps taken to reach the conclusions.

The next step is to file the state CPCN application and request the needed state approval. The application contains the information needed regarding the line, and is prepared by the system planners, and includes the siting report prepared by the siting team. During this time, a preliminary design with the new structure locations is created and given to the real estate department to begin negotiations. After all of the Siting Team's careful work, you would think that the CPCN hearings would go off without a hitch. The utility has agreed to spend many extra dollars in order to avoid the housing, the wildlife area, and they have done everything thoroughly and correctly, what could go wrong? Well no matter how good a job the siting team does, problems can always arise.

"The American Steam Engine Railroaders Association" files a formal protest that the galvanized steel poles used in the compact construction, along the railroad, will change the character of the railroad used by their historic Steam Engines. The "Wild Flying and Crawling Critter Society of America" members also file a protest that says compact construction will surely kill off the "Flying Critters." In addition, they claim the view from all of the scenic overlooks within the national wildlife area are going to be ruined by the steel towers, as well as by the R/W clearing in the mountains (even though they are over 3 miles away). Further, this was the only part of the line that everyone did not cause controversy during the open houses. Finally, the local PTA files a complaint and is concerned over health effects of a new line near the schools.

Most of these groups assert "You should put the line underground." The good news is the utility was prepared for this suggestion. They had already done a study to show that, it was technologically possible to build this as an underground line, but the cost of digging the trenches in this geological area, full of granite, is over 20 times more expensive. The resulting costs would have to be passed onto the ratepayers, and the resulting electric costs to the community would be staggering. Everyone except "Wild Flying and Crawling Critter Society of America" and the PTA quickly rejected this answer.

Once again the Engineering, Construction and Maintenance Departments were able to come up with solutions.

1. The engineers suggested weathering steel poles instead of galvanized poles for use along the railroad. The steel on weathering poles starts out as an orange color, but within months, turns a dark brown color. In essence, they would resemble the wood poles that have always been along the railroad, just a little taller. Hopefully, this would satisfy the concerns of "The American Steam Engine Railroaders Association".
2. The engineers also suggested that the phasing on the compact construction be arranged so that there is a canceling effect on the EMF values. They were able to show that at 600 feet, (the closest distance that a school play area is located from the proposed line), the EMF levels will be no higher than the existing conditions.
3. They also suggested that the steel towers in the mountains include a dull acid dip in order to blend into the background, and that a non-specular conductor be purchased which would also have a duller finish and would not reflect so prominently in the sunlight. Ultimately, the line at a distance of over 3 miles would not be visible from the scenic overlooks.

4. Forestry suggested that the R/Ws in a few select valleys not be cleared, since the proposed lines had high spans over top of the trees and as such, the R/W also would not be visible.
5. The engineers also looked into putting bird perches up to reduce the electrocution risk, the last outstanding concern of the "Wild Flying and Crawling Critter Society of America." But it was determined that in the compact construction area, most birds would sit on the non-electric static wires along the top of the structures. Consequently, they did not see any benefit to this added cost. Further, the maintenance department did not want these perches because of potential risks during live line maintenance procedures.

These decisions were addressed during the final phases of the CPCN hearing and agreed upon before the close of the hearing. The hearing examiner agreed with the utility amendments and the CPCN was awarded as modified.

Probably the biggest milestone has now been reached.. From here on, the project will face other issues but none that should stop the project from being built. The project moves into final design. Real estate asks for minor modifications to structure locations to satisfy property owner concerns. If they do not violate CPCN requirements, they should be considered and approved. The bill of materials are prepared and sent to purchasing for all acquisition.

Final construction permits are obtained per the design; land is acquired, and construction begins. A few properties that cannot be acquired through amicable negotiations require filing of a court eminent domain proceeding. In these cases, the court will review the issues, and hearings take place. In most jurisdictions, when a CPCN has already proven the need and the location of the line, the court may just be to decide the appropriate compensation owed to the land owner. The court will grant a right to enter the property and construction proceeds.

The line construction begins with putting all soil erosion and sedimentation control devices, and any permit requirements in place. Next, R/W clearing will take place along with access road construction. The concrete foundations are installed and the poles and towers are erected. The wires are pulled, sagged, and clipped into place. Lastly, the R/W rehabilitation is completed and all permits are satisfied. These construction activities are all usually done in sequence, where R/W is being cleared in one area and foundations are being installed back line.

Finally a "walk down" the line is completed by the engineering, construction, and the operations departments and the line is put into service 2 months ahead of the need date. This completes a successful project, with the general public pleased with their part in it, and happy to have their needed electric transmission service.

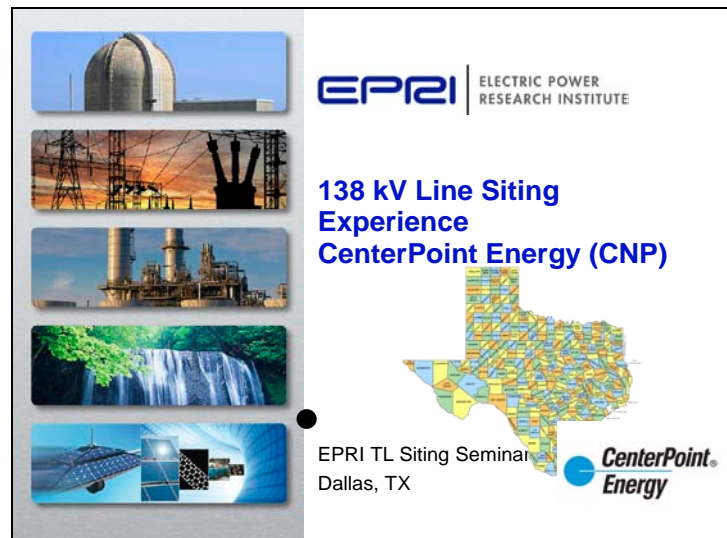


# 12

## CASE STUDIES TO ILLUSTRATE AND SUPPORT PROCESS DISCUSSIONS

Case Study 1 – 138 kV Transmission Line Siting at CNP

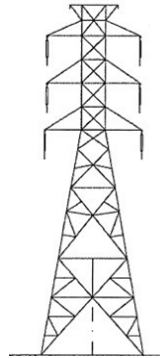
*Zenith to Gertie 138kV Line*



5 mile new 138 kV line in Harris County, TX.

## Why is this Line Needed?

Beginning in 2011 in Northwest Houston, several single contingency events and common mode contingency events (two circuits on the same tower) will cause voltage violations, and overloads on 138 kV lines and 345/138 autotransformers. These increase rapidly by 2013.



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## ERCOT's Recommendation



CNP submitted a proposal to ERCOT, and ERCOT agreed to CNP's solution:

- New 138 kV line from Zenith to Gertie Corner.
- Install a new 345/138 1000 MVA autotransformer at Zenith Sub.
- Reconductor Cy-Fair to Kluge line.
- Reconfigure a couple of 138 kV lines.

(The last 3 do not require PUC permitting)

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## The Various Requirements to get a New Line Built:

**Legal**

**Political**

**Technical**

**Clerical**

**For example...**

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If near the ocean, others permits might need to be obtained.

### The Various Requirements to get a New Line Built:

- **Justify the need of this construction.** Show how alternatives are not sufficient (bundling, voltage upgrade, adding xfrmers).
- **Submit a proposal to the ISO** obtain their recommendation. PUC gives weight to the ISO to justify the need (25.101b3; PURA 39.151).
- **Justify the proposed line route.** Study the route alternatives and why they are not preferable.
- **Identify route constraints:** dwellings, cemeteries, recreational areas, historical areas, environmentally sensitive areas.
- **Obtain approvals:** FAA, TX DOT, TX Hist comm., TX Parks & Wildlife Dept, TX Comm on Env Quality, US Fish and Wildlife Serv, US Army Corps of Eng, municipals, and maybe others.
- **Hold a public meeting(s)** as required by law.
- **Contact** nearby towns, counties, utilities, and affected landowners.

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If near the ocean, others permits might need to be obtained.

### Does the Utility Need a PUC Permit?


**Yes:**

- Changes in service area.
- New lines.
- New generators.

**No:**

- A contiguous extension of those facilities described in PURA §37.052
- A new electric high voltage switching station or substation.
- Repair or reconstruction of a transmission facility due to emergencies.
- Construction or upgrading of distribution facilities within the electric utility's service area.

(See TAC, Title 16, Part 2, 25.101)



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TAC is “Texas Administrative Code”

## The Main Permit Form:

### “Certificate of Convenience and Necessity”

#### Available from the PUC of Texas:

[http://www.puc.state.tx.us/industry/electric/forms/ccn/CREZ\\_Std\\_CCN\\_App.pdf](http://www.puc.state.tx.us/industry/electric/forms/ccn/CREZ_Std_CCN_App.pdf)

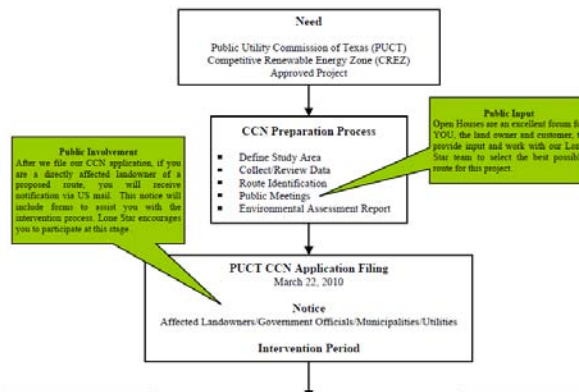
- Attach the ISO report, environ report, municipality approvals, hist & projected load, maps of route.
- Compare alternatives to the new line. Show why they are not sufficient.
- PUC will only approve if the line is deemed *necessary*. An ISO report carries weight with the PUC. (PUC and ISO work closely together.)
- Justify the project, line route, types of towers.
- State if the line is for an additional customer, or for general load growth & reliability.

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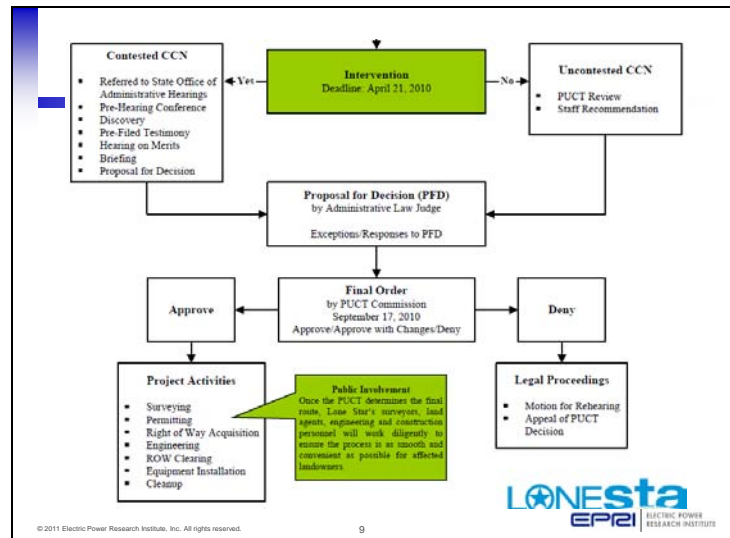
### Certificate of Convenience and Necessity (CCN) Approval Process



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## Authority Structure (for New Line Approval)

### **FERC** and the Federal Energy Policy Act of 2005:

Authorized FERC (Federal Energy Regulatory Commission) to designate NERC (North American Electric Reliability Corp) as the Electric Reliability Organization for the U.S.



### **NERC**: Ensure the bulk power system in North

NERC develops standards for power system operation, monitors and enforces compliance, & assesses power equipment adequacy.



### **ERCOT**: One of the 8 regional reliability entities that

ERCOT is also one of the 8 ISO's in North America that operates the electric grid.



### **Texas PUC**: Given authority by Texas law (PUCA, which is Title 2 of the TX Utilities Code). The PUC issues the new line application.



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ERCOT includes the system of most of Texas.

## Laws to Satisfy for Building a New Line.

The **Texas Administrative Code (TAC)** is a compilation of all state agency rules in Texas. The Public Utility Commission of Texas rules are under TAC Title 16 (Economic Regulation), Part II (PUC).

Chap 25.101 (<http://puc.state.tx.us/agency/rulesnlaws/subrules/electric/25.101/25.101.pdf>)

- PUC approves only if it is necessary for the service, convenience, or safety of the public, and complies with the Public Utility Regulatory Act (PURA) §37.056.
- PUC has 1 year to decide (180 days if the line is deemed critical to reliability by the ISO).

## Laws to Satisfy for Building a New Line (cont.).

Chap 22.52 (<http://puc.state.tx.us/agency/rulesnlaws/procrules/pr-d/22.52/22.52.pdf>)

- Which, when, and how landowners, local gov'ts, agencies, and other utilities must be contacted.
- Must contact landowners within 300' of centerline of 230 kV or less line.
- Must hold a public meeting if at least 25 landowners are entitled to receive direct notification.

Public Utility Regulatory Act (Title 2 of the Texas Public Utility Code), ch 37:

(<http://www.statutes.legis.state.tx.us/Docs/UT/htm/UT.37.htm>)

- Gives authority to the Texas PUC.
- Must fill out PUC application; justify need; consider historical, environ'l, community factors.

Municipal laws (n/a for this line)

Federal laws (FAA, environmental)

## Proposed Line

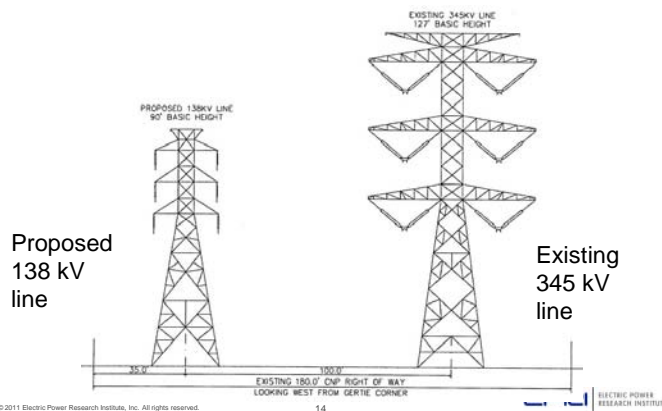
- 138 kV double circuit (6 phases)
- From Zenith Sub to “Gertie Corner”
- 2 x 959.6 ACSS-TW Conductors per phase
- Lattice structures on preferred route. Mix of concrete and steel poles on alt routes.
- Structure Height – 90 to 110 ft lattice, 85-100 concrete poles along road ROW, 120-130 ft steel poles only at highway crossings.

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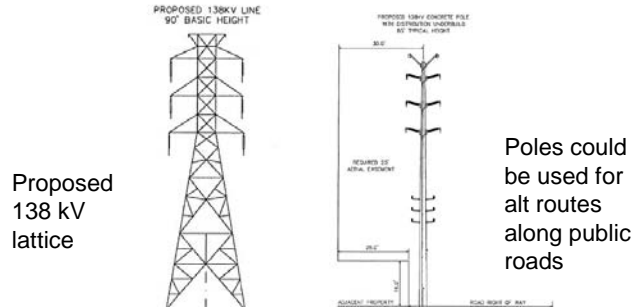
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## Proposed Line: (Lattice in Parallel with Existing 345 kV Line)



The new line doesn't harm the adjacent property values or landscape, since it's parallel to a larger line.

## Poles Require Narrower ROW than Lattice (Allowing Poles used Along Public Road ROW)



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## Reasons for All Lattice Structure Selection

- Cost:
  - Lattice is least expensive for all points along preferred Route - \$6M (no additional ROW needed.)
  - Alternate Routes - \$9M to \$20M (high ROW cost, slightly higher struct cost)
- Public meeting attendees had no clear preference:
  - 30% no pref, 17% underground, 13% concrete, 11% single pole, 4% lattice, 2% steel
- Other reasons for structure choice:
  - Preferred route doesn't affect adjacent land values, since it's along an existing 345 kV line.
  - Lattice allows longer spans & fewer towers than poles (800' vs 400').
  - Matches lattice structures on existing 345 kV line.
  - Poles must be used if the line is along a narrow public road ROW.
  - Steel poles can be higher than concrete, for highway overpass.

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## Right-of-way Description (Land use, Terrain, Schedule)

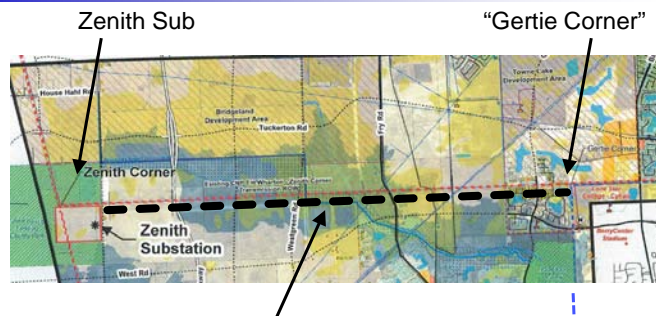
- All route options are within rapidly expanding urban area, but west is now still grazing land.
- Terrain is flat.
- Preferred route is within existing Wharton-Zenith ROW which has a existing 345 kV line.
- Alternative routes require about 6 months additional scheduling time (to obtain ROW).

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## Proposed 138 kV Line Route



4.88 mile new line paralleling existing 345 kV line, from Zenith to "Gertie Corner"  
(West is pastureland, Eastern 12% is residential)

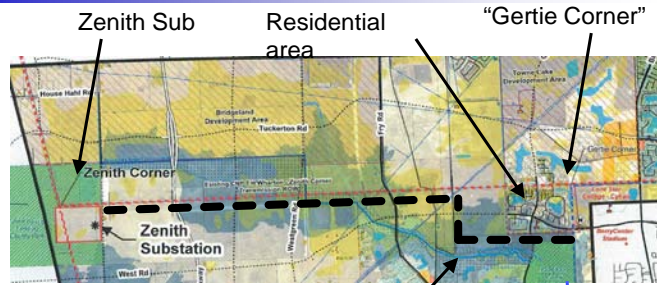
138 kV line to  
Gertie Sub

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## “Alternate 1” Route



Alternate route to avoid residential area (but more house construction is planned in this area also).

138 kV line to Gertie Sub

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## Estimated Project Cost \$

	Preferred Route (A-D-E-I)	Alt 1 (A-D-E-J)	Alt 2 (KLNPQ)	Alt 3 (KRS'U')	Sub Facilities
ROW	0.12M	1.6M	7.9M	9.0M	0
Mat'l & supplies	1.9M	2.3M	2.9M	3.2M	10.3M
Labor & transport	2.0M	2.7M	3.9M	4.1M	2.9M
Stores	0.26M	0.33M	0.43M	0.46M	0.13M
Eng & Admin	1.8M	2.2M	3.0M	3.2M	1.7M
<b>Total</b>	<b>6.1M</b>	<b>9.2M</b>	<b>18.2M</b>	<b>20.0M</b>	<b>15.0M</b>

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## Routing Study

- How did you identify sensitive areas?
- How did you identify the constraints?
- How did you select potential routes and decide on the final route?
- How did you adhere to Prudent Avoidance Policy? (Limit exposure to electromagnetic fields with reasonable investments of money and effort –TAC 25.101)

## Environmental Analysis

- POWER Engineers, Inc. contracted to perform study.

## Comments Solicited From

### Federal Agencies:

- US Fish and Wildlife Service
- US Army Corps of Engineers
- FAA
- USDA
- FEMA
- Nat'l Resources Conservation Service

POWER Engineers solicited these comments.

## Comments Solicited From

### State Agencies:

- Railroad Commission of TX.
- TX Parks & Wildlife Dept.
- TX Historical Commission.
- TX Commission on Env Quality.
- TX DOT.
- TX Water Development Board.
- TX General Land Office.

## Comments Solicited From

### Local Officials:

- Harris County Flood Control District
- Harris County Public Infrastructure
- Harris County Historical Commission
- Harris County Farm Bureau
- Harris County Commissioners Court
- Cypress – Fairbanks ISD, Waller ISD, Katy ISD
- West Harris County Water Authority
- 2 dozen Municipality Utility Districts within Study Area.

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## In This Study Area...

- No State Historical Markers.
- No wild or scenic rivers.
- No National Historic Landmarks, National Trails, or historic cemeteries.
- No outstanding aesthetic resources, designated scenic views, scenic roadways, unique visual elements.
- No National Parks, National Monuments, National Battlefields.



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## Environmental...

- No Ecologically Significant Stream Segments.
- No rare, threatened, or endangered species.

US Fish and Wildlife Service enforces:

- Migratory Bird Treaty Act.
- Endangered Species Act.
- Bald and Golden Eagle Protection Act.

## Municipalities and Utilities

- Preferred and Alt1 routes do not pass through any municipalities.
- No other utilities are affected.

## The Public Meeting

- Purpose:

Solicit comments/concerns from public officials, landowners concerning the routing process and routing options.

Show the need of the project and approval process.

Ensure the project considers community input.

- Dec 10, 2009 4:30-7:30 PM (published in Houston Chronicle, Dec 1 and 8).
- A questionnaire was provided.
- 49 people attended.



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## Why This Route was Ultimately Chosen

- It's the shortest route between endpoints (4.9 miles, vs 5.4, 6.5, 7.3 miles).
- Minimizes the potential environmental impact because it uses *existing* ROW for the whole length.
- No new ROW will need to be purchased.
- This route costs the least (6 M, vs 9 M for next lowest)
- Minimizes reduction of land value because it parallels an existing line.
- Only 7 houses are within 300' of this new line that were not already within 300' of the existing 345 kV line.

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End

## 12. Estimated Costs

	Preferred Route (Route 1) (A-D-E-I)	Alternate Route 1 (Route 2) (A-D-E-I)	Alternate Route 2 (Route 6) (K-L-N-O-P-Q)	Alternate Route 3 (Route 7) (K-R-S-U)	Substation Facilities <sup>3)</sup>
Right-of-way (Easement and Fees)	\$123,000	\$1,570,400	\$7,947,000	\$9,032,000	\$0
Material and Supplies	\$1,925,000	\$2,345,400	\$2,903,000	\$3,172,000	\$10,297,000
Labor and Transportation (Utility)	\$1,960,000	\$2,697,400	\$3,889,000	\$4,110,000	\$346,000
Labor and Transportation (Contract)	\$0	\$0	\$0	\$0	\$2,572,000
Stores	\$258,000	\$330,400	\$432,000	\$464,000	\$134,000
Engineering and Administration (Utility)	\$1,573,000	\$2,040,400	\$2,749,000	\$2,948,000	\$1,488,000
Engineering and Administration (Contract)	\$252,000	\$252,400	\$252,000	\$252,000	\$179,000
<b>Estimated Total Cost<sup>2)3)</sup></b>	<b>\$6,091,000</b>	<b>\$9,234,400</b>	<b>\$18,172,000</b>	<b>\$19,978,000</b>	<b>\$15,016,000</b>

<sup>1)</sup> In addition to the transmission cost shown, the following electric distribution costs will be incurred due to constructing the proposed transmission line over existing distribution lines: Preferred Route (Route 1) \$0; Alternate Route 1 (Route 2) \$0; Alternate Route 2 (Route 6) \$155,000; Alternate Route 3 (Route 7) \$0.

<sup>2)</sup> In addition to the transmission cost shown, the following reconductoring costs will be incurred from the tie point north to Gertie Corner due to constructing the proposed transmission line: Preferred Route (Route 1) \$0; Alternate Route 1 (Route 2) \$526,000; Alternate Route 2 (Route 6) \$912,000; Alternate Route 3 (Route 7) \$1,360,000.

<sup>3)</sup> Substation facilities will cost the same for all routes.



## Case Study 2 – 345 kV Circuit – Connecticut National Corridor Middletown – Norwalk Line 2



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**345 kV Line Siting  
Experience**

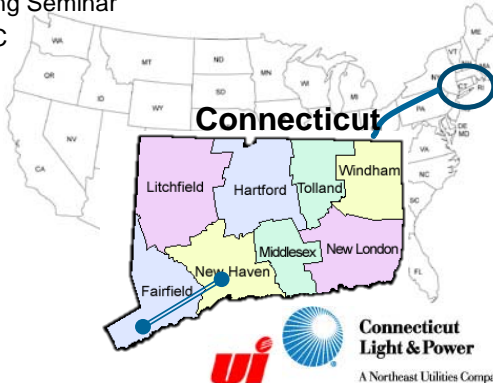
*Joint CL&P and UI Experiences*

**Speaker's Name**  
Dale Douglass & John Chan

**Event**  
September 30, 2011

**345 kV Line Siting Experience  
(Joint CL&P/UI)**

- EPRI TL Siting Seminar
- Charlotte, NC



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- Connecticut Light and Power is a subsidiary of Northeast Utilities (along with Public Service of NH and Western Mass Electric).
- The new line will go through both CL&P and UI territory.

## Middletown-Norwalk 345 KV Line Overview

- 69 miles total.
  - 45 miles overhead, 24 miles underground (6 by United Illuminating).
  - Includes 57 miles of reconstructed 115 kV line.
- \$1.27 B total cost
- Uses more 345 kV XLPE cable than any other project in the US.
- Through 18 municipalities in CT.
- Includes 2 new subs, 1 new switch sta, other sub mods.
- Nov 2001 (start consulting municipalities)
- Apr 2006 (construction begins)
- Dec 2008 (energized a year ahead of sched)



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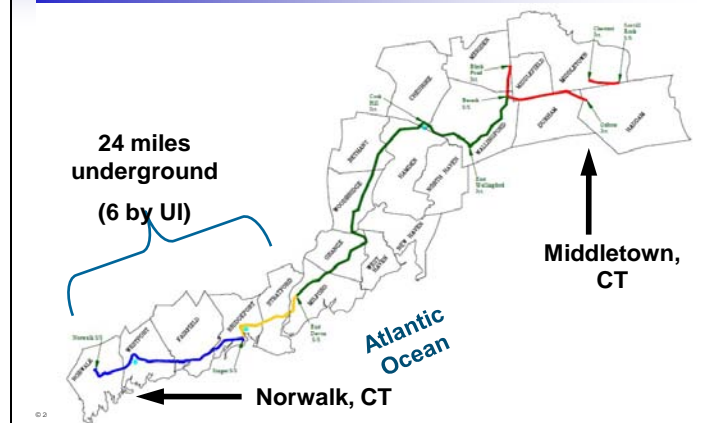
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Burns & McDonnell had the main contract of “Program Manager”.

- The overhead transmission line would be located primarily within CL&P’s existing 115-kV and 345-kV transmission ROW”.
- Only a small amount of privately owned land in Middletown and Haddam will have to be acquired for the overhead portion of the Project.

## 345 kV Line Route Through CT



From Norwalk Sub in Norwalk, CT to Scoville Rock Switching Station in Middletown, CT

## Overhead Lines vs Underground Cables

Overhead transmission would be mainly located along CL&P's existing transmission ROWs and the underground transmission would be located primarily within or adjacent to existing public roadways.

## Originally Planned Overhead, but...

- The line was to pass through a congested area of expensive homes, with little access to existing ROW.
- Overhead was not considered feasible because of the difficulty, expense and time involved in obtaining the necessary ROW.
- The utilities studied several options for undergrounding the sections where OHL was not feasible.
- HPFF was the preferred UG option because of its long, successful operating history at 345 kV.
- However, the relatively high capacitance of HPFF would have created overvoltage problems, so the utilities selected XLPE. It had lower capacitance and there was extensive experience overseas at voltages to 500 kV.

## The Need for This Circuit...

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## Construction of This Line Would...

- Improve reliability by enhancing interconnection of CT to rest of New England.
- Unlock (make accessible) existing generation in SW CT.
- Reduce high current short-circuit problems at subs.
- Eliminate nearly all thermal violations.
- Reduce congestion cost paid by CT customers.
- Allow all the local generation to run simultaneously (which the 115 kV system cannot support).

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- Construction of the Project will complete a 345-kV loop in SWCT that would facilitate the transport of electricity into the area, reduce 115-kV line overloads, improve efficiency with reduced line losses, improve system voltage performance, reduce high levels of available short-circuit current, and generally strengthen the entire New England system by enhancing interconnections between SWCT and the rest of New England.
- New efficient combined cycle plants have a capacity of 600 MW, so the 345 line could support a new plant (unlike the existing 115 line).

## Documenting the Need (in Application to CT Siting Council)

- **ISO-NE.** SW CT is a deficient load pocket, requiring more expensive local generation, since enough power cannot be imported.
- **ISO-NE (2002).** SW CT will have severe reliability problems in 2004 if the one of the largest generators in the area fails to operate.
- **NERC (2003).** SW CT is susceptible to rolling blackouts if local generation is out-of-service or if weather is extreme.
- **Working Group by Gov Rowland (2002).** SW CT requires added transmission to serve increasing load.
- **CT Dept of Public Utility Control (2002).** SW CT is generation deficient. Getting power into SW CT is constrained by transmission. Congestion costs are high for CT electric customers.

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## The Need

- CL&P load growth is about 2.2% yearly.
- Presently, ALL the local generation is required for system reliability. But no more local generation can be added due to the 115 kV line.
- ISO-NE now dispatches power to avoid overload, often without regard to economic efficiency.
- SW CT is the largest load pocket in NE without 345 kV service.
- There is no 345 kV loop in SW CT. A loop would allow providing power from two paths.
- Over 80 115 kV transmission elements exceed emergency limits

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## Regulatory Review Agencies

- The Connecticut Siting Council
- CT Department of Environmental Protection
- CT Department of Public Utility Control
- ISO New England
- Army Corps of Engineers (navigable waters)
- Federal Energy Regulatory Commission



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## CT Siting Council



Has the authority to approve/deny the new line application :

**"Certificate of Environmental Compatibility  
and Public Need"**

CT General Statutes § 16-50/

(a) (1)



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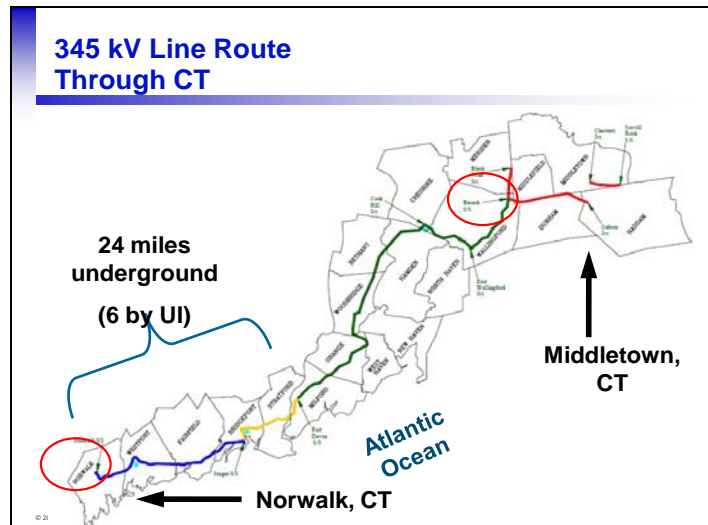
The line application was filed jointly by CL&P and UI.

## Laws Regarding this Line

- **Federal:** Comply with Clean Water Act, Rivers and Harbors Act, Coastal Zone Management Act, National Historic Preservation Act
- **State:** CT Coastal Management Act, Inland Wetlands and Watercourses Act, Tidal Wetlands Act.
- **Local:** Municipality Planning and Zoning Commissions, Municipality Wetlands and Watercourse Agencies or Commissions.

## Alternatives

- Analysis conducted more than a year.
- Analyzed alternatives (conservation and load management, distributed generation, and generation), uses of new transmission technologies, and transmission system alternatives, including DC.
- Confirmed that the preferred solution is an AC 345-kV transmission line that extends from a strong source at Beseck, where supplies from several 345-kV sources could be concentrated, to Norwalk, with intermediate connections at new substations in Milford and Bridgeport. These intermediate terminal points were selected to address reliability criteria violations.



From Norwalk Sub in Norwalk, CT to Scoville Rock Switching Station in Middletown, CT.

### Alternative Routes

Route	Length	# Buildings acquired	ROW easements (acres)	Property acquired for subs (acres)	Cost
Proposed	69 (45 OH, 24 UG)	0	13	18	\$604 M
Alt A	73 (60 OH, 13 UG)	0	66	20	\$620 M
Alt B	74 (72 OH, 2 UG)	29	118	22	\$602 M

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Alt A and Alt B have greater impacts than the proposed route.



## Convincing the Public....

## Informing the Public (May to July, 2003)

- 16 informal open houses.
- 14 public meetings.
- 6 meetings with Planning & Zoning Commissions or Conservation Commissions.
- More than 1000 people attended.
- 3 changes proposed by the public or municipalities were identified and supported.

A public hearing must be held in the county of the proposed facility, or in whichever county the Council deems appropriate for inter-county facilities, with one session held after 6:30 p.m. for the convenience of the public. (General Statutes § 16-50m)

## Involving Local Government.....

Municipalities having a  
boundary within 2,500 feet  
from the proposed facility  
are required to be  
consulted with

Conn. Gen. Stat. § 16-50/  
(b)

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## Open House Offered to Each Municipality

- Mapping program allows visitors to see location of the proposed routes in relation to homes & points of interest.
- Displays & handouts show load growth and need of this line.
- Visual simulations of towers being considered, scale model of splice vault, cross sections of UG cable.
- Information about ROW vegetation management, EMF, property value impacts.

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## Structure Choice Along Route

- Split phase for reduced Magnetic fields at edge of ROW.



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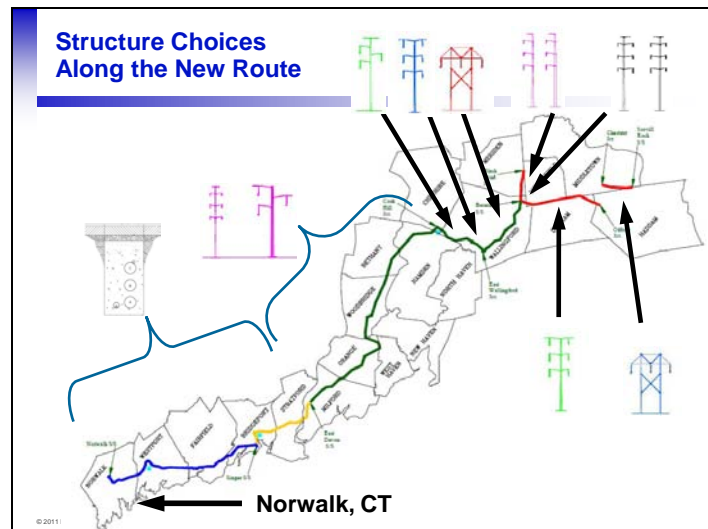


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Slide 23



From Norwalk Sub in Norwalk, CT to Scoville Rock Switching Station in Middletown, CT



## Approved, With Conditions...

- Royal Oak community (Middletown) shall be bypassed for 1 mi.
- ROW shall be shifted farther from buildings of Congregation B'Nai Jacob/Ezra Academy (for EMF purposes).
- Use low EMF structures near the Jewish Community Center.
- Conduct pre-construction survey of threatened species, flag bayonet grass, sweep for box turtle before construction.
- At Cheshire, move 5000' circuit of 115 kV line underground. The remaining 115 and 345 will be on one tower.
- Route changes at Bridgeport, Westport, Norwalk.
- Submit a post-construction EMF monitoring plan.
- Submit construction details regarding wetlands, erosion, etc. (Called "Development & Mgt Plan").

April 7, 2005

Pamela B. Katz, P.E., Chairman

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From "Decision and Order" on ct.gov website

## Development & Management Plan

- Required by CT Siting Council.
- UI and CL&P submit plans for their own sections.
- Each line segment and substation requires its own plan.
- Includes such items as:
  - Grading, dust control, endangered species, disposal of non-contaminated soil, erosion and sediment control, access points for const., foundation locations, environmentally sensitive areas, traffic mgt, splice vault justification and installation, clearing, staging areas, water crossing, herbicide use, blasting procedures, wetland restoration, invasive species, dimensions and dwgs of all equip, cable splicing and pulling, excavation, cutting pavement, protection of cultural resources, shellfish mgt, EMF monitoring, etc.

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## System Studies Performed

- It was clear early in the planning stage that substantial amounts of cable would be needed in order to allow the line to be constructed.
- Numerous system studies were performed to evaluate the effect of adding so much cable (capacitance) to the system – high cable capacitance can create problems during both normal and emergency system operating conditions.
- The ultimate choice of 24 miles of XLPE-insulated cables was determined based upon the maximum amount of capacitance that the system could support.

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## Economics of UG Cable

- Underground transmission cable costs are often stated to be 4-7 times as high as costs for OH construction and can be higher depending upon location and costs for OH line construction.
- In the case of the SW Connecticut project, OH and UG costs were determined to be similar for the final 24 mile length into the Norwalk Substation.
- This was due to the extremely high cost of obtaining ROW and the high cost of OH line construction in this congested area.
- In addition to the cost parity, the project would not have been feasible if UG cable were not installed because of esthetic objections by homeowners.

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## Underground Cable Suppliers

- In view of the large amount of cable to be used (totaling more than 144 miles of single-conductor cable) for the SW CT project, CL&P and UI jointly conducted a detailed review of experience and capabilities of all potential cable suppliers worldwide, including factory visits to top candidates.
- Three separate suppliers were selected – because of the plant capacity needed to produce the large amount of cable, and because of the desire to have alternate suppliers should there be a problem with one supplier's cable.

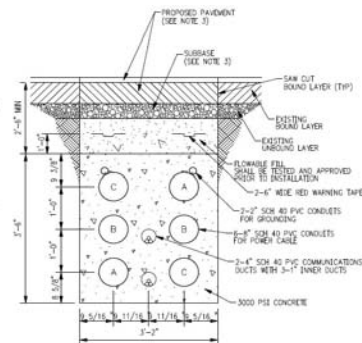
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## Cable Installation

- The majority of the cable installation was in congested city streets and used a conventional duct-and-manhole system. Note phase reversal to reduce external magnetic field.



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## Cable Installation (Continued)

- Trench openings were large in some locations & construction disruptive to residents.



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## Crossing Rivers

Horizontal directional drilling technology (HDD)

*Saugatuck River, Westport*

*Housatonic River, Milford*

*Ash Creek, Bridgeport*

Allows cables to be buried without disturbing the water bottom. HDD was considered for installation in city streets, but was too costly and required too much installation time and setup area



Drilling under the  
Housatonic

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### Drilling Under Ash Creek



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Avoids disturbing the waterway by excavating

### Splicing Conduit Before Pulling Through the Boring Under Ash Creek



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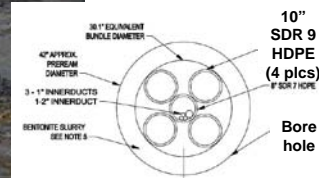
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## Conduit Under the Housatonic



After pulling the conduit through the boring

Boring cross-section:



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## Summary

- What started as a necessary new 345 kV overhead line circuit became a “hybrid” OHL-UGC circuit due to a combination of economics and esthetics, and extreme difficulty in siting an OHL in congested urban areas.
- The initial application for the line included UGC because the utilities recognized that the time to obtain approval for an OHL was far too long – if approval could be obtained at all.
- The use of XLPE UGC greatly reduced the impact of UGC capacitance on the system.

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## Summary, Continued

- Not only did the siting process involve the usual limitations on line placement in environmentally sensitive and congested areas but also the question of overhead lines versus underground cables where the cost of cables was comparable to that of lines.
- In many areas of the US and Europe, this project is the future of transmission line siting.

**Together...Shaping the Future of Electricity**

## Case Study 3 – 765 kV line – Complex UHV

### Wyoming – Jackson Ferry 765kV Line



90 miles long, from Wyoming sub in WV to Jackson's Ferry sub in VA

#### Wyoming (WV)-Jackson's Ferry 765 KV Line – Key Points

- This line siting is an example of a very complex, potentially litigious case study  
(13 yrs to permit, 3 yrs to construct, \$306 M).
- 90 miles through mountainous terrain, 11 miles through federal land. 38 miles in WV and 52 miles in VA.
- Required 168 separate ROW agreements
- 1450' spans with avg tower height of 132' & frequent dead-ends.
- 333 steel lattice towers.
- 6-conductor bundles to reduce audible noise.

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### Time Line for 765 kV Project

- 3/90 – Project Announced
- 8/90 – Siting Teams Officially Began
- 3/91 – WV CPCN Filed
- 8/91 – VA CPCN Filed
- 5/98 – WV CPCN Approved
- 5/01 – VA CPCN Approved
- 3/02 – WV CPCN Re-approved with revised route
- 12/02 – US Forest Service Approved
- 12/03 – Construction Began
- 6/06 – ISD

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### Must Minimize the Visual Impacts (Hence Opposition) in a Scenic and Culturally-rich Area (VA and WV)



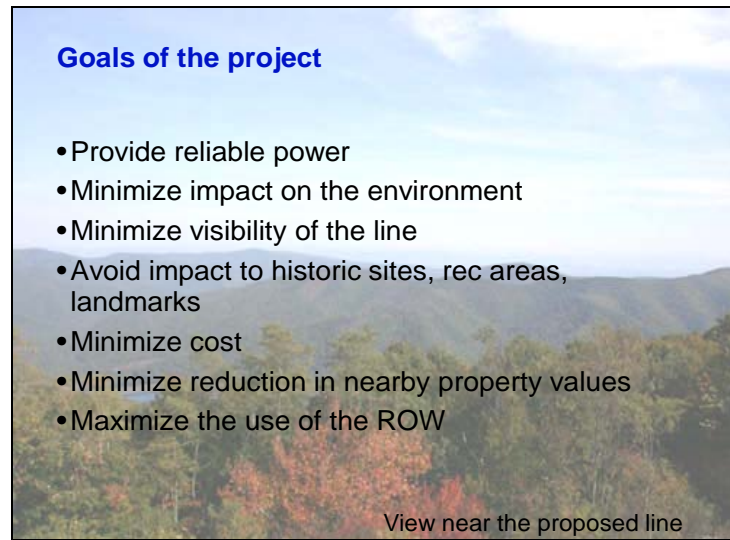
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The line crosses the Jefferson National Forest (11 miles), Appalachian Trail, New River Trail State Park in VA, old growth forest.

The Appalachian Trail is a “National Scenic Trail” under the control of the National Park Service now (not when the project was started). A Special Use Permit from the National Forest Service required a full NEPA review.



Minimize visibility of the line: Especially at key locations.

Run parallel or near existing similar land uses if possible.

Maximize the use of the ROW: Efficient designs. Use underbuilt distribution. Maybe combine two smaller circuits into one larger one (though this shouldn't be done with bulk transmission lines, due to reliability.)

Original Route selection and approval started in 1990

Project was called Wyoming – Cloverdale

Approximately 140 miles long

Started the CPCN process and meet major opposition in VA

During hearings VA opposition suggested ending at Jackson's Ferry

50 miles shorter in VA

## Methodology

Identify corridors from Wyoming to Jackson's Ferry Sub

Minimize overall env. impact across natural, cultural, visual resources

- Based on cumulative impact across length of corridor
- Shorter is better, with other factors being equal
- Intensive study of critical crossing points
- Minimize impact on housing and cultural issues
- Identify irreversible vs mitigable impacts
- 1000 ft corridor, 200 ft ROW once permitted
- Massive database, GIS technology with extensive field verification
- Numerous mitigation measures proposed
- Reduce and mitigate visual impact.

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Routing done by outside group of University Professors / Grad Students from WVU & VPI

Their Charge – “Select Best Environmental Route”

Cost and Engineering was not in the Selection Criteria

### Original Route Pursued for 1<sup>st</sup> 8 years

- Began in 1990
- Project was called Wyoming-Cloverdale
- 140 miles long
- Met major opposition in VA
- Re-route to Jackson's Ferry came up in hearings.
- 50 miles shorter
- Indicates importance of system planning & identification of alternatives at onset of project

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## Over the River (and Appalachian Trail) and through the Jefferson Nat'l Forest – revised route 1998.



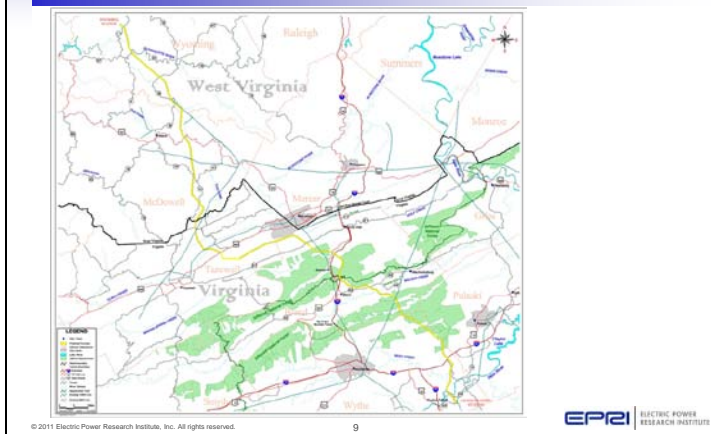
Will cross the Guyandotte River in WV and New River in VA

Routing done by outside group of University Professors / Grad Students from WVU & VPI

Their Charge – “Select Best Environmental Route”

Cost and Engineering was not in the Selection Criteria

## More Detailed Route Map





## Crossing the Appalachian Trail

- Required US Forest Service & Appalachian Trail/NPS approvals.
- Was done at the same location as the trail crossed a highway (not pristine).



- Crossing Interstate 77, between Bland, VA and Bastian, VA
- This location was chosen because hikers are already affected by visual and sound of the highway.

## Crossing the Appalachian Trail



The view from this point on the Trail won't suffer too badly!

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- This picture was taken from the App Trail crossing of I77.
- See the 765 tower in the background.

## Crossing the Jefferson National Forest

- This federal land requires federal approval (US Forest Service).



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## Crossing the New River (VA) and Guyandotte River (WV)

Navigable water requires Army Corps of Engineer approval



Guyandotte River near Wyoming, WV



New River and New River Trail State Park at Foster's Falls, VA

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**Guyandotte (pronounced guy-an-dot') River in WV.** The Guyandotte is right at the Wyoming substation, WV end of the line. The Army Corps of Engineers acquired 19,000 acres of land and dammed the River to form Bailey Lake, which is downstream of the crossing. This is to provide flood protection. This land is leased to the West Virginia Division of Natural Resources as a wildlife management area.

**New River in VA.** The line crosses the New River and New River Trail State Park in Virginia. This crossing is just downstream from Foster's Falls and 2 miles from Jackson's Ferry sub. Tall trees in leaf largely shield view of the line from the New River Trail.

**Floodplain and wetland.** The line crosses 2 acres of FEMA floodplain along the Guyandotte River. This is managed by the Corps of Engineers. Due to the small size, it could be spanned to avoid direct disturbance. There is some wetland on non-federal land which could also be spanned.

### Guyandotte & New Rivers, Floodplain/Wetland

- **Guyandotte River in WV** - The Guyandotte is close to Wyoming substation (WV). The Army Corps of Engineers acquired 19,000 acres of land and dammed the River to form Bailey Lake, which is downstream of the crossing. This is to provide flood protection. This land is leased to the West Virginia Division of Natural Resources as a wildlife management area.
- **New River in VA** - The line crosses the New River and New River Trail State Park in Virginia. This crossing is just downstream from Foster's Falls and 2 miles from Jackson's Ferry sub. Tall trees in leaf largely shield view of the line from the New River Trail.
- **Floodplain and wetland** - The line crosses 2 acres of FEMA floodplain along the Guyandotte River. This is managed by the Corps of Engineers. Due to the small size, it could be spanned to avoid direct disturbance. There is some wetland on non-federal land which could also be spanned.

## Stay Clear of the Karst

20% of the line length is over karst. This is land over limestone or gypsum and is characterized by sinkholes, caves, and flowing groundwater.



- US Forest Service: Geologists should study the area & help site towers and access roads but not Forest Service land.
- Accidental fuel spills would contaminate ground water without filtering.
- Disturbing karst would disturb groundwater flows.
- Sinkholes should not be filled.



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None of the karst is on federal land, though the US Forest Service noted the karst in it's report.

## Crossing the Scenic Highway

Very high clearance to reduce visual impact



This was a major concern since so many people pass by.


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The road crossing here were carefully selected during the routing study based on visual impact which was a big issue during the state hearings and the federal EIS hearings

## Visual Simulations




**Before**



**Simulation**

-To easily describe project to decision makers and the public.

-Putting a balloon at the tower location for those who don't trust the simulation.



**As Built**

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These types of simulations are commonly used today but were a big deal during these hearings since visual impact was such a big deal.

## Authority Structure for New Line Approval (Now but not During Line Approval)

**FERC** and the Federal Energy Policy Act of 2005:  
Authorized FERC (Federal Energy Reg Comm.) to designate NERC (North Am Electric Reliability Corp) as the Electric Reliability Org for the U.S.

**NERC**: Ensures that the bulk power system in North America is reliable. Develops standards for power system operation, monitors and enforces compliance, & assesses power equipment adequacy.

**RFC**: ReliabilityFirst Corp. One of 8 regional reliability entities that NERC oversees. VA and WV are in it's region.

**VA SCC**: Given authority by Virginia Constitution (Art 9) and the Code of VA. VA SCC issues the new line applic(CNCP).

**WV PUC**: Given authority by West Virginia Code (24.2.11). WV PUC issues the new line application (CNCP).

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CNCP-” Certificate of Public Convenience and Necessity”.

USF&W controls all endangered species studies. Not technically a permit but a required sign-off for NEPA/EIS.

## Laws and Agencies






**Major federal agencies contacted:**


- US Forest Service (part of USDA), Jefferson Nat'l Forest
- National Park Service (Appalachian Nat'l Scenic Trail)
- US Army Corp of Engineers (New River)
- US Fish and Wildlife Service

**49 State & local agencies contacted in VA and WV.**

- WV Public Service Commission
- VA State Corporation Commission

(These two make the decision for non-federal lands and issue a CPN if they determine the line is both needed and the particular route minimizes adverse impact.)


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- Proposed line crosses 11 miles of federal lands (Jefferson National Forest)
- **AEP** has a statutory obligation to provide reliable electricity to it's customers.

## Public Input

**Public input**

- Bland, Pulaski, Tazewell, Wythe Counties, Montgomery, Floyd, and Craig in Virginia and Wyoming, Monroe and three additional counties in West Virginia.
- public information gathering sessions

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## Endangered Species

### Indiana Bat

- Federally listed endangered species.
- Known to utilize parts of the corridor.
- US Forest Service says there should be no adverse impact.



No federal or state endangered plants are listed for the proposed line corridor.

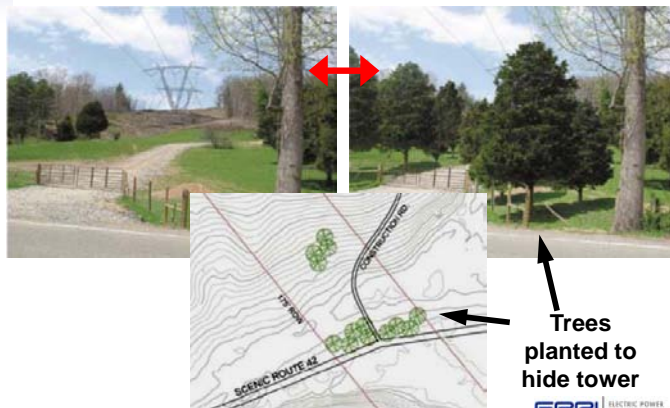
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This bat required extensive field studies to determine if he was present. I believe that he was found in few areas which restricted the construction zones and impacted the construction schedule. WV does not have any state listed endangered plants with made botany studies much easier.

## Placing Trees at Strategic Locations



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Great example of the visual mitigation work that was done in selected areas.

Line Route JF-WY Alternatives					
	Overall	Forest Service	Nat'l Park Service	Corps of Engineers	Non-federal
1. Proposed Action	89.8	11.3	0	0.1	78.4
2. Rich Mountain Alternative	89.9	10.8	0	0.1	79.1
3. Hogback Ridge Alternative	89.7	11.0	0	0.1	78.7
4. Crockett Cove Alternative	89.8	11.3	0	0.1	78.5
5. Gunton Park Alternative	89.7	10.9	0	0.1	78.8
6. No Action Alternative	0	0	0	0	

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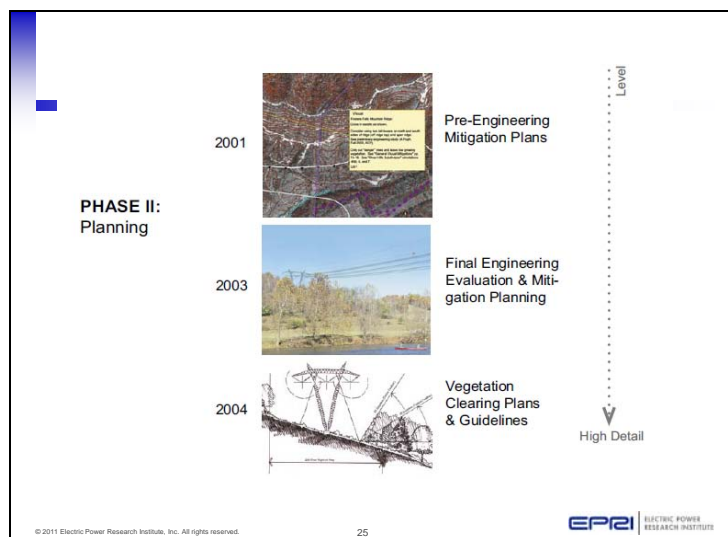
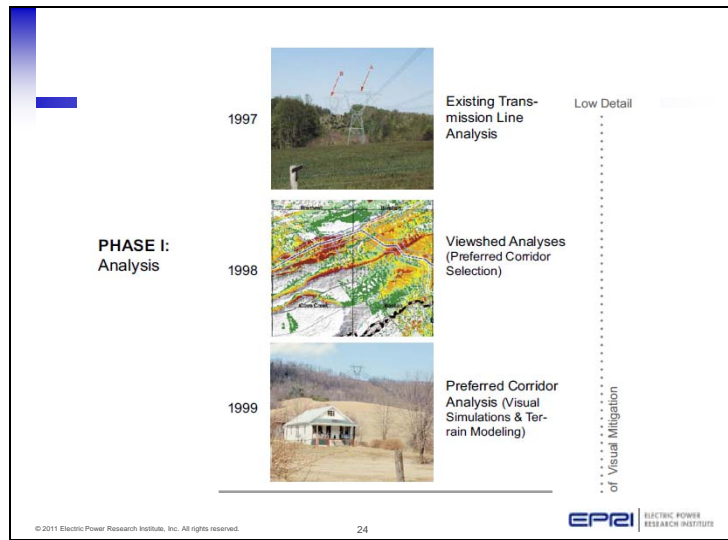
All alternatives occur in Virginia.

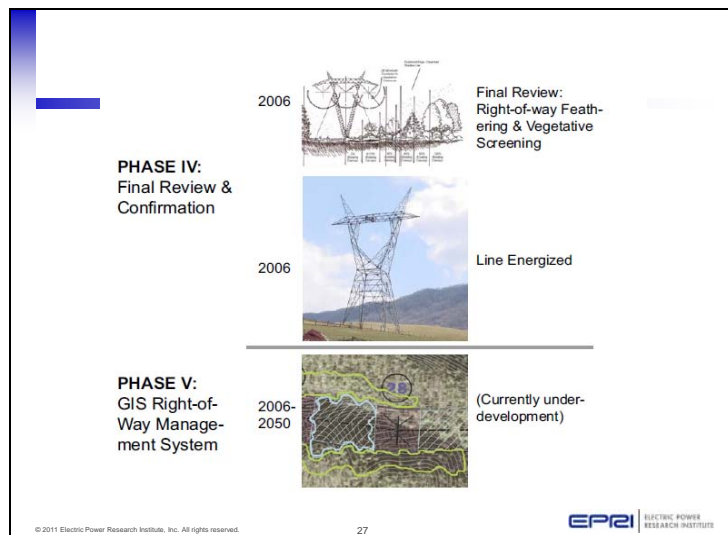
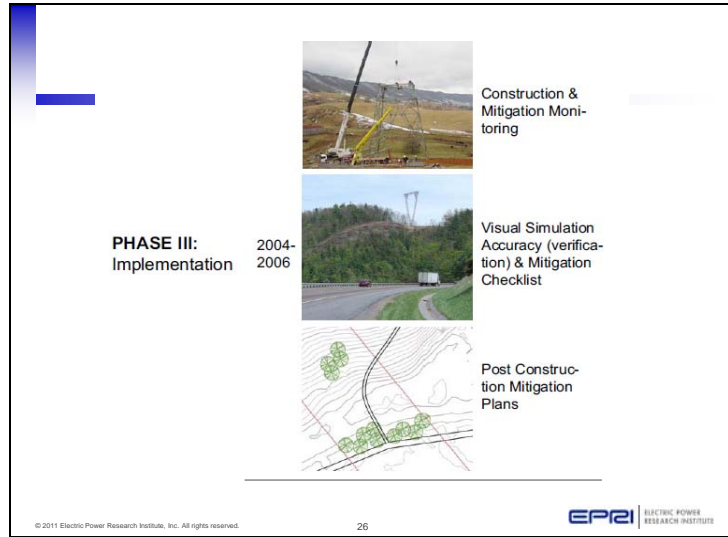
All alternatives still cross federal lands.

Each of these alternatives affects the visibility of the line from different locations.

Remember this was the second routing study after the first route was stopped during CPCN hearing in VA. This explains the point about state approvals vs. federal approval. WV approved the original route, VA rejected it. VA approved a different route, and then AEP had to re-file in WV and get a second approval. Then after all this the feds under NEPA approved this second route. But under worst case scenarios they could have approved a 3<sup>rd</sup> route and it all starts again. As a side note this is what is currently happening with another project in Pennsylvania/New Jersey.







## Preparation for Line Siting Hearings

- Development of special, non-reflective structural steel lattice members and non-specular subconductors.
- Design of self-supporting and guyed-V lattice structures with allowance for frequent dead-ends to handle frequent changes in line direction for visual purposes.

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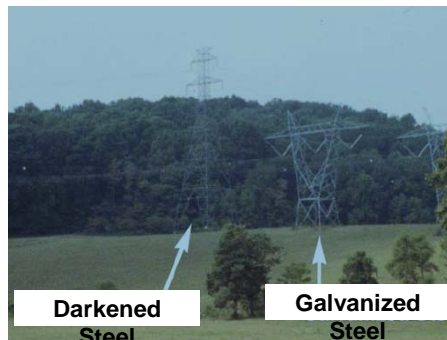
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## Reduced Visual Impact of Structures

Standard Galvanized



Darkened Steel

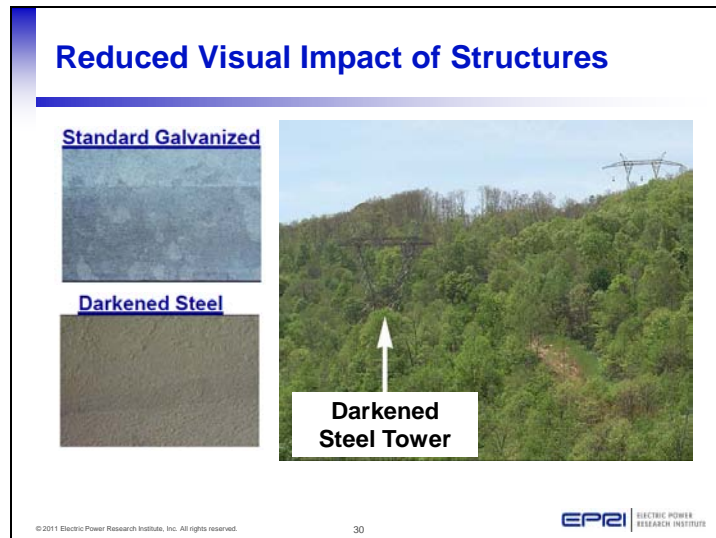


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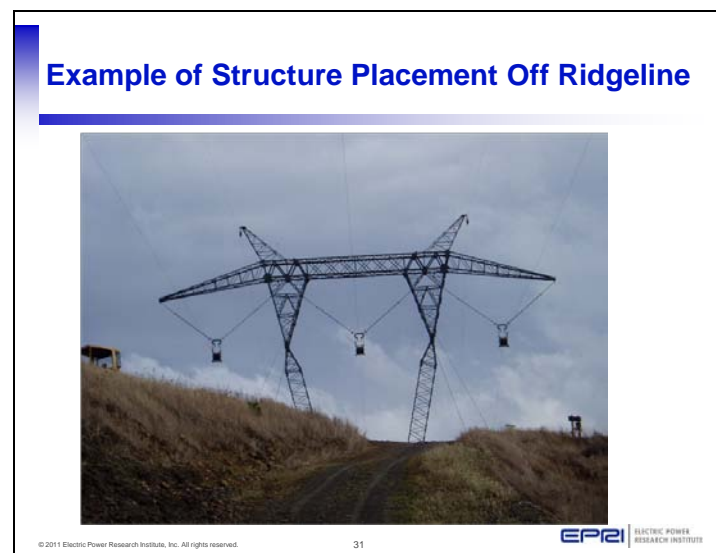
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Darken steel was done using an added acid dip that is done immediately after/during the galvanizing process. On very large orders such as this 90 mile line this addition to the manufacturing process was relatively inexpensive. On this project where visual impact was very important, this was huge.



This is a good example of where towers were placed below the ridgeline so large back light silhouette were not made. It was an inefficient line design because it frequently made for 2 towers on a hill top instead of one. This was done for reduced visual impact.



## Poles vs Lattice Structures?



- Lattice is lower cost than poles in this low-populated and mountainous area.
- Lattice allows longer spans & fewer towers than poles. This means less ROW clearing and less visual impact.
- Lattice has more of a presence in the near view, but less in the distant view (since there are less of them which results in less ROW clearing).

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A point to be made here under bullet #2 was that to limit environmental impacts that no R/W was cleared if the span was over 100' above ground.

## Structure Choice Along Route

- Erosion and sediment control & National Pollutant Discharge Elimination Systems
- Variations in lattice structure choice along route:
  - Self-Supp Suspension lattice – 41
  - Self-Supp Deadend lattice – 70 (!)
  - Guyed-V lattice – 222
- Foundations include grillage, piles, and anchors (guyed-V) to fit terrain & land use.

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A lot of dead-ends!

## Guyed V Close-Up With No-concrete Foundation



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## Guyed Tower in a No-Road Location



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- Reduce noise especially at high altitudes.
- Each phase conductor was slightly less in diameter than the equivalent 4 conductor design, supposedly making the conductors less visible.
- The picture on the right shows a person riding a “spacer buggy” to installing a spacer.

### ROW Clearing & Maintenance

- Selective clearing in ROW.
- Low growing foliage is allowed in ROW.
- Agree with landowners to select tree cuts, and remove or disperse wood on ROW.
- No ROW clearing when the conductor height exceeds 100 ft.

Trees marked that should not be cut. →

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Redbud and Dogwood are low growing trees allowed to grow in ROW.

## ROW Clearing & Maintenance



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## No ROW Clearing When Conductor Height Exceeds 100 Feet.



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## Helicopters Used to Limit Road Construction & Limit Environ Impact



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Chinook helicopter used to bring in 21,000 lb tower bridge.

This reduces the construction road usage (which would be required to bring in a land crane).

## US Forest Service Verdict



They recommend the Proposal Action Alternative to cross federal land.

- It fulfills AEP's statutory mission to provide reliable power.
- It best addresses the economic, environmental, and technical factors.

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## US Forest Service Verdict



### Stipulations:

1. Remove Bluefield-Wythe 69 kV line from fed land within 15 yrs.
2. No access roads may be built on Rich Mtn. (helicopter is option)
2. Access roads in Wolf & Peek Creek drainage must be graveled if they are to be used longer than the initial construction.
3. Unfragmented forest on Brushy Ridge, Big Walker Mtn, and Little Walker Mtn must be mitigated. If ROW is cleared in this location, off site mitigation must compensate.
4. ROW maintenance must control evasive/exotic species.
5. AEP must prevent access roads from being used by vehicles.
6. AEP must offset the impact to the AP Trail by removing the line from a 100 acre tract of land to be acquired by the Forest Service.

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- Sediment production must be limited on Rich Mountain
- Graveling reduces sedimentation.
- There were several tower sites that had to have everything flown in by helicopter. This greatly affected construction methods and schedule.

## Comparison Between 765 kV and 138 kV Line Construction

### **765 kV line:**

- Important to limit ROW clearing
- Doesn't parallel any existing line
- Must limit roads for const & maint
- Crosses federal land (Nat'l Park, App Trail)
- Crosses state land (New River State Park)
- 6 cond design to reduce audible noise
- Some old growth in ROW
- Reduce visibility (darkened tower and cdr)



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## Case Study 4 – A Case Study on Public Involvement Failure

Project: New Transmission Line

Length: ~ 2.1 miles

Voltage: 230 kV

Circuits: 2

Siting Alternate Routes Studied: 4 original and 12 at conclusion of hearings.

CPCN Hearings: multiple hearings over 2 + years

Issues: Need, Public Involvement, Alternate Routes studied, Substation Location, and Preferred Route Selected.

Result – project denied and never built.

This case study will review:

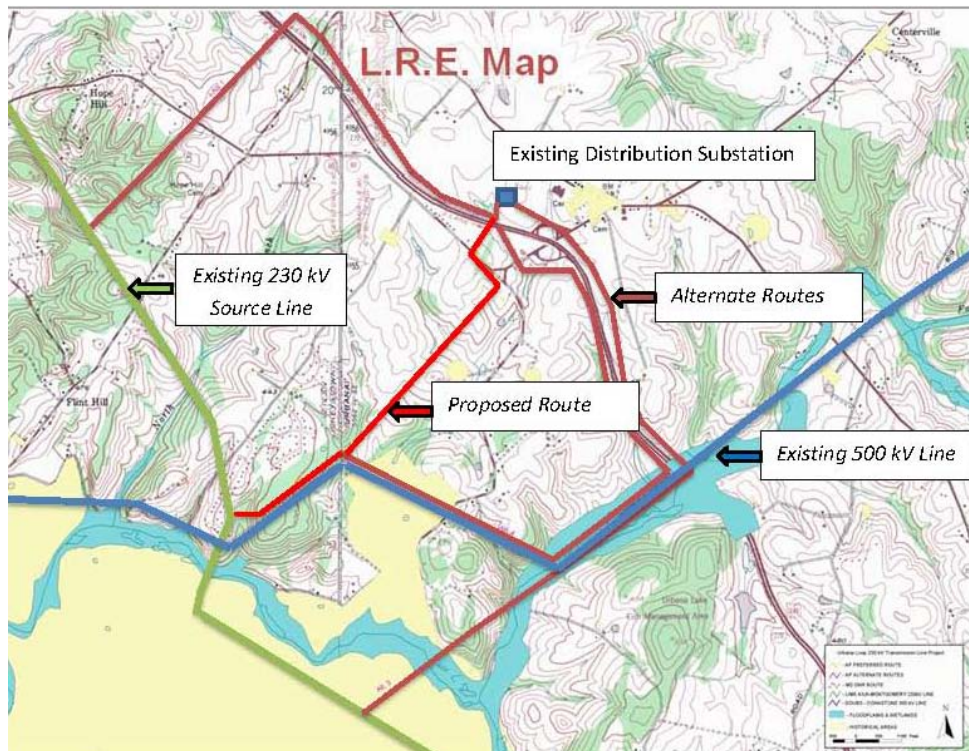
- the process used by the utility (unnamed)
- the siting study and results
- The public opposition and why
- The hearing process
- The undesirable outcome.



In 1977, the property for the substation was purchased with plans to serve the substation from a nearby 230kV transmission line. After several project delays a Distribution Substation was built on the site in 1992, and with forethought the substation pad was constructed large enough for the ultimate 230 kV design.

In 2001, System Planning initiated a new Capital Construction plan, reattempting the project to supply 230kv to the existing 34.5kv distribution substation. In 2002, a new routing study was conducted, and selected a variation of the original route proposed in the 1970's. The route was adjusted to avoid a new small housing subdivision. The line projected cost was \$3.2 million and did not include the substation upgrade costs of about \$3M.

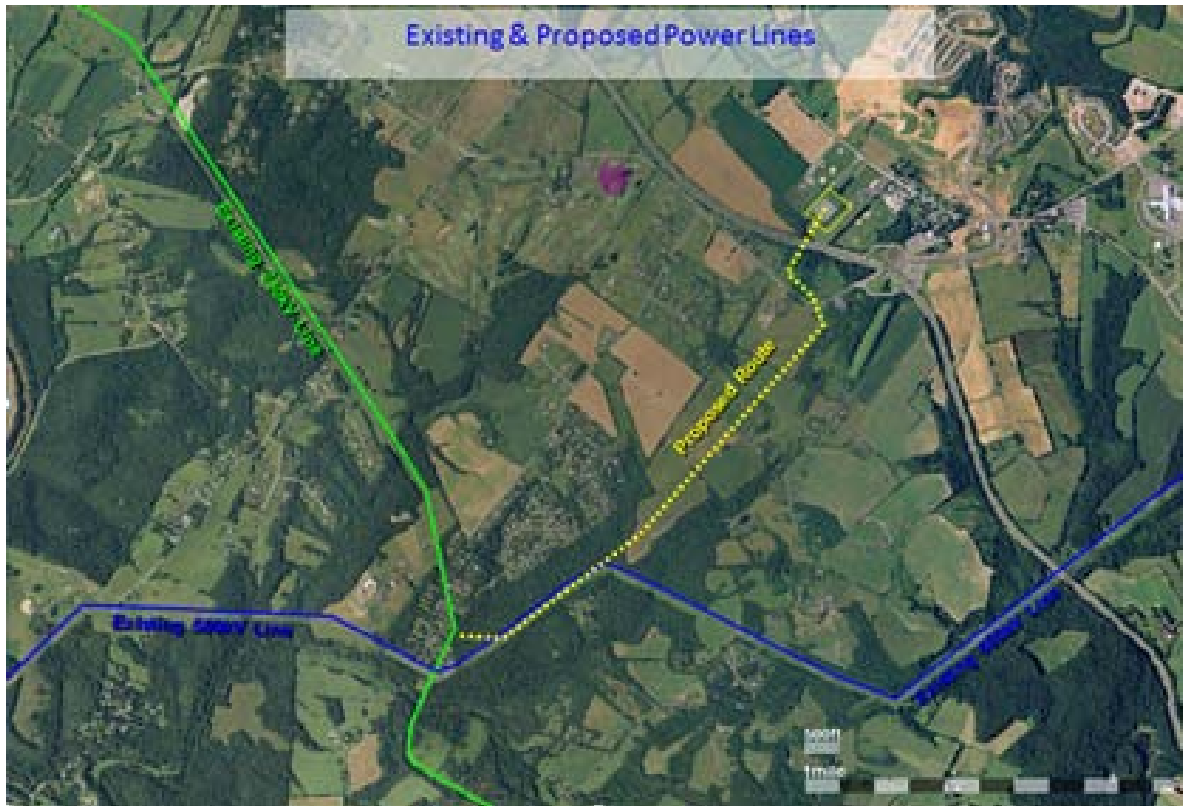
Four alternate routes were investigated. Environmental, engineering and cost assessments were prepared for each of these routes. Both state and local government agencies were contacted, reviews were conducted and a final selection was made. This site study was later documented in a report known as the Line Route Evaluation or LRE.



It was concluded that the proposed route was the best overall alternative. But this route had issues, which included a known R/W problem. One property owner owned 90% of the route and negotiations had been attempted on 3 different periods over the previous 25 years, all unsuccessfully. The route was near some residential housing, but this was not seen as a very burdensome impact, particularly since 2 existing transmission lines were in the area already.

Field Survey began on the route in February 2003 and was halted when field survey staff members were told to stay off a property. Legal action to allow access to the property was initiated, but was stuck in court for over a year. Action to gain property access was withdrawn, and the CPCN was filed without detailed engineering or R/W in August 2004.

The application included a planned in service date (ISD) of June 2006, which was highly unlikely.



The Proposed Loop line was 2.1 miles in length and to be built on a 125' wide R/W using double circuit, self-supporting (no guy wires), steel pole construction on concrete foundations.

- Testimony preparation began in the fall of 2004.
- Expert witnesses were hired to support the case
- Underground Expert was hired to refute high voltage underground
- EMF expert was retained to refute health issues and concerns
- Visual Simulation experts were engaged to try and address local visual concerns

At a local government meeting, the county commissioners formally opposed the project, rejecting the recommendations of their professional planning staff. They claimed that all four alternatives investigated were unacceptable and that the Substation was in the wrong location. They then wrote a letter to the State Public Utility Commission stating their findings. The government hired an electrical consultant to review the load flow studies, but nothing more was heard from them, and so it was assumed they would have supported the utility case.

Opposition from the local government and the general public sited numerous issues including:

- Lack of need for the project
- Visual impact to the residential areas
- Devaluations of homes/can't resell homes
- EMF/Health effects
- Underground transmission lines should be used

- The public had no say in the route selection process
- The selection of the substation site was based on 20 year old information and was in the wrong location.

The CPCN case went on for almost 3 years. The judge allowed most anyone who applied to be included in the case. Over 25 interveners were admitted as a legal party to the case, this meant each witness was cross-examined 25 times. As new issues were introduced, witness were recalled and re-examined. As a result the case proceeded at a snail's pace, with little accomplished during each day of hearings.

New routing studies were requested by the utility commission and were conducted with extensive public involvement. These new studies found only longer alternate line routes with more impacts to the environment and residents of the area. Interestingly as the hearing proceeded, and because of the new routing studies, more and more of the public petitioned for admittance to the case. People who originally were not involved saw the new alternate routes getting closer to their homes and became involved. The "public opposition" then splintered into two groups, one fighting to move the line, the other arguing to keep it in the proposed location. This is an excellent illustration of the "not in my back yard" (NYBY) stance.

After almost 3 years, the Public Service Commission (PSC) denied the CPCN case, directed the utility to start over, and stated that the utility had to include the public in the route decision process. The feeling was that while, under state law, the PSC could not force the utility to place the line underground, but by denying the application for a CPCN, the utility would have little recourse and so would voluntarily place the line underground.

In conclusion, significant money was spent on studies, expert testimony, land acquisition and attorney's fees and nothing was accomplished but bad publicity and delays. The route that was selected during the initial study was probably the best route, however, it gained so much opposition that the politics of the situation outweighed the good study and resulted in failure of the project.

On a side note: With the downturn of the US economy, several major commercial customers served from the existing distribution substation went out of business, thus significantly reducing the electric load needed in the area. This change in the load need, afforded the utility the opportunity to develop several lower voltage solutions. To date no transmission project has been developed in this area.

## **Case Study 5 – 500 kV line – Complex EHV**

### ***Susquehanna – Roseland 500 kV Line***

This case study describes a multi-state, complex project, and illustrates that the use of good siting plans, process and procedures. It also shows that even when using best practices, difficult approvals with the corresponding challenges, can still cause significant delays and unexpected cost increases.

#### **The Project**

A 147-mile, 500 kV transmission line from the Berwick area in Susquehanna County, Pennsylvania to the Delaware River and continuing onto Roseland, New Jersey was proposed. PPL Electric Utilities' (PPL) was responsible for the 100-mile Pennsylvania portion of the line; Public Service Electric & Gas (PSE&G) was responsible for the 47-mile portion of the line in New Jersey.

In this Case Study, we will review the following steps which are shown in the Flow Diagram illustrated in Chapter 11. This discussion will concentrate on issues surrounding route selection, public outreach, approvals, and permitting. The items for discussion include:

1. Determine Need / Scope of the Project
2. Define Study Area
3. Begin Data Collection
4. Approve Routing Guidelines
5. Develop Potential Routes
6. Select Alternatives for Analysis
7. Public Involvement
8. Final Route Selection
9. Line Route Documentation
10. State Approvals
11. Federal Approvals
12. Design, Acquire, and Construct the Project

#### **1. Need/Scope of the Project**

The 2007 PJM – Regional Transmission Expansion Plan (RTEP) identified the need for the Susquehanna-Roseland 500 kV Transmission Line Project and was approved by the PJM Board on June 22, 2007.





### Scope:

- Build a new 500 kV transmission line Susquehanna – Lackawanna – Hopatcong – Roseland
- In Pennsylvania, upgrade six 230kV and one 500kV substations, and develop one new 500kV substation with 500/230 kV transformation at Lackawanna
- In New Jersey, upgrade a 230kV and install two 500kV substations, one with 500/230kV transformation at Roseland.

The need for this project was reviewed and confirmed by PJM, the Regional Transmission Organization (RTO) for this area. PJM coordinates the movement of wholesale electricity in all, or parts of 13 states and the District of Columbia. PJM is the largest RTO in the country. Based on the latest PJM analysis of 2012, the Susquehanna – Roseland project is required to resolve reliability criteria violations starting June 1, 2012. The line construction is currently underway (2013) but will not come close to meeting the required in-service date.



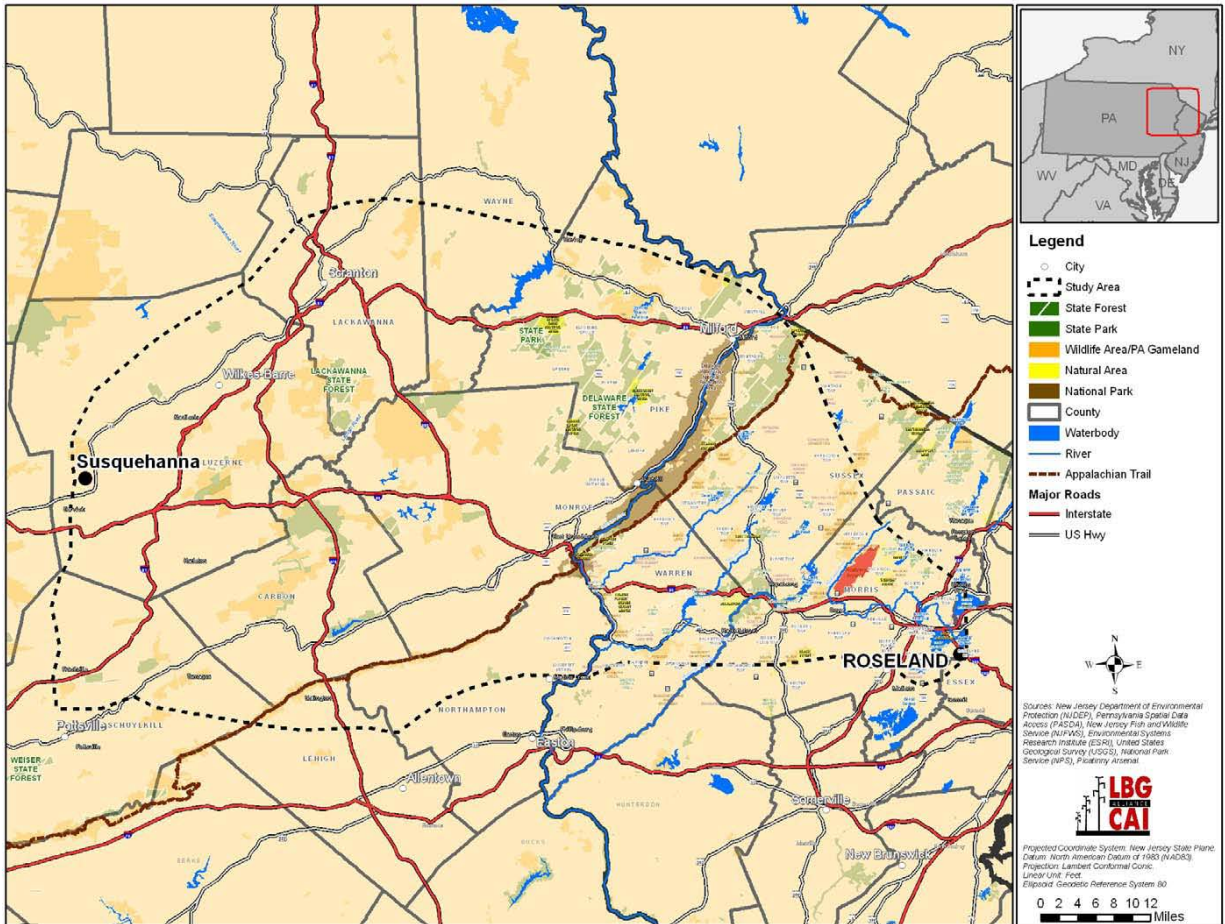
- PSE&G - the Roseland to Hopatcong portion of the Project is currently expected to be in-service by June 2014.
- PPL and PSE&G are now targeting in-service of June 2015 for the remainder of the Project.

### **2. Define Study Area, 3. Begin Data Collection, 4. Approve Routing Guidelines, 5. Develop Potential Routes, 6. Select Alternatives for Analysis**

For brevity all of the details for selection of study areas through selection of alternative routes for analysis will not be reviewed. Suffice it to say the processes described in the previous chapters were carefully followed to arrive at the alternatives.

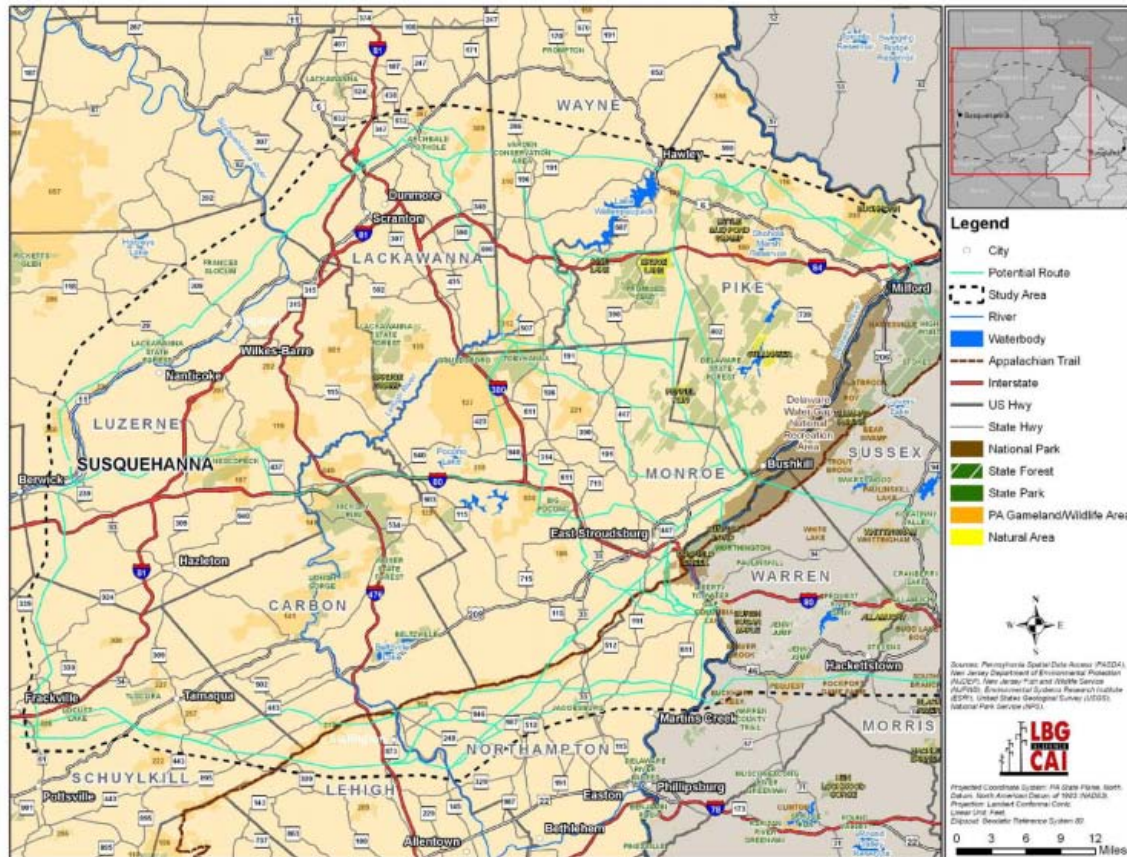
The study area was defined and included an area of approximately 4,118 square miles.





Route Selection Criteria was established.

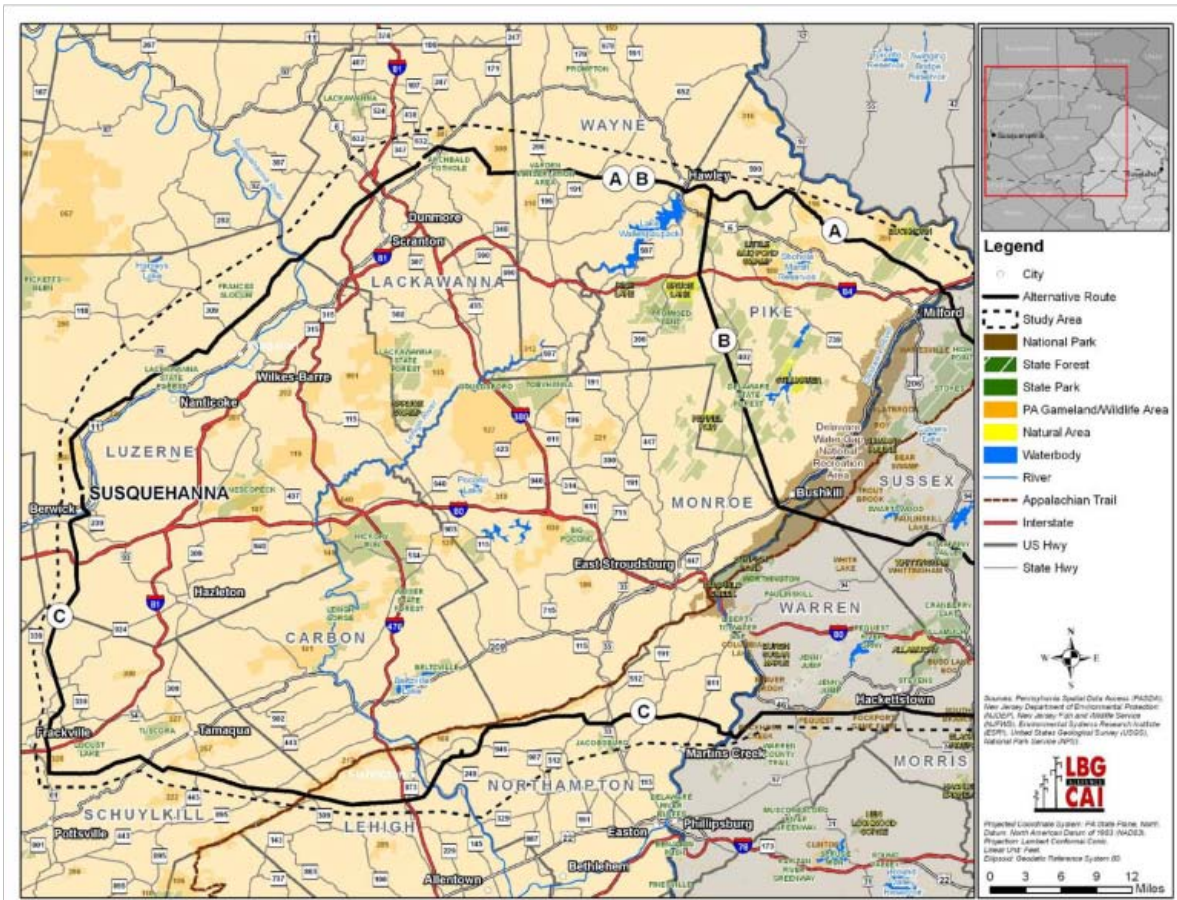
- Maximize the use of, or paralleling of, existing rights-of-way;
- Minimize impacts to the natural and human environment;
- Minimize route length, circuitry, and cost;
- Use transmission line design criteria developed for this project;
- Minimize the removal of existing residences;
- Minimize the removal of barns, garages, or other structures;
- When not following existing rights of way, maximize the separation distances from residences, schools, cemeteries, historical resources, recreation sites, and other important cultural sites;
- Minimize crossing designated natural resource lands such as state forests, national and state parks, wildlife management areas, designated game lands and wildlife areas, and conservation areas; and
- Avoid new crossings of large lakes.



Utilizing a project GIS, the routing teams from PSE&G and PPL determined routing constraints, opportunities, and potential routes. They then selected a series of potential routes for evaluation. Shown here in blue is the Pennsylvania portion of these potential routes.

The routing teams assessed the Potential Routes from an environmental and engineering perspective and selected three Alternative Routes for detailed consideration for the Preferred Route (Alternatives A, B, and C). Shown here is the Pennsylvania portion of these potential routes.





The most significant of the environmental findings during this study phase was that the transmission route alternatives under consideration would pass through or over the following designated national recreational and scenic resources.

### The Appalachian National Scenic Trail

This 2,175-mile footpath stretches through 14 eastern states from Maine to Georgia and traverses wild, scenic, wooded, pastoral, and culturally significant lands of the Appalachian Mountains. All Routes crosses the Trail.



## **The Delaware Water Gap National Recreation Area**

This nearly 70,000 acre park is located on the Pennsylvania-New Jersey boundary and contains the middle Delaware National Scenic River (see below). The Delaware Water Gap National Recreation Area (DEWA) provides recreational opportunities such as camping, hiking, canoeing, and rafting. Route B would traverse approximately 1.54 miles of the DEWA in Pennsylvania on an existing 230 kV transmission line right-of-way. Route A would cross through 300 feet of the extreme northernmost portion of the DEWA.



## **The Middle and Lower Delaware Wild and Scenic Rivers**

Sections of the middle and lower Delaware River are designated under the Wild and Scenic Rivers Act. The middle Delaware covers about 40 miles and is classified as “scenic” and is located in the vicinity of Route B. The lower Delaware is included in the Wild and Scenic River system, and a 38-mile section of the main stem of the Delaware is classified as “recreational.” Route C crosses this section of the river near Martins Creek.



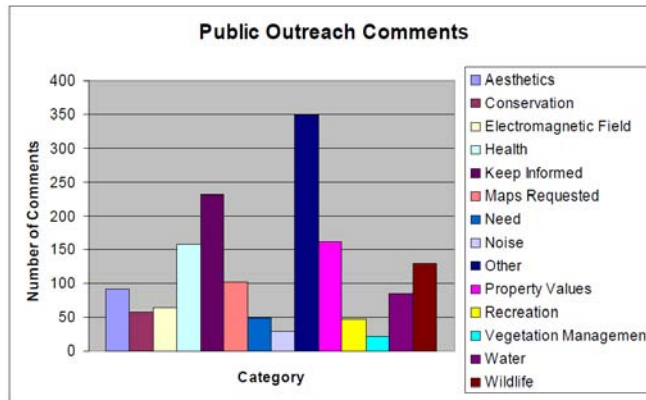
These three resources would later become the focal point of the delay in construction.

## **7. Public Involvement**

In the Pennsylvania section of the project, PPL began Public Involvement in early 2008. It included a project website and a toll free 800 number, which resulted in approximately 1,200 inquiries. Public involvement also included outbound phone calls, meetings with property owners, community leaders and elected officials, a webcast for municipal supervisors, mailings to people who own property within a 1,000-foot corridor along each proposed route, posting of newspaper advertisements in various papers, distribution of a press release to local newspapers, postings on the project website, and 18 public workshops held in three time periods between June 2008 and November 2008 along each proposed route.

For PSE&G, in the New Jersey section of the project, Public Involvement also began in 2008 with a project website and an e-mail address for comments, which resulted in approximately 460 inquiries. It also included meetings with community leaders and elected officials, posting of newspaper advertisements in various papers, distribution of a press release to local newspapers, postings on the project website, and 3 public workshops held three days in June 2008.

All comments were catalogued, analyzed, and summarized, and based on these findings, adjustments were made to the routing alternatives being evaluated. These comments were also used in the selection of the final preferred route. A summary is shown below.



## Final Route Selection

The goal of the Line Route Study was to select the most suitable route for a 500 kV electrical transmission line between the Susquehanna and Roseland substations. The most suitable route was previously defined by the routing team as minimizing the effect of the transmission line on all factors of the natural and human environment, while minimizing overall project costs, and avoiding unreasonable routes and non-standard design requirements to the extent possible.

The three alternative routes were analyzed using only the qualitative approach; reviewing the pros and cons of each route. No comparative values were selected for the catalogued natural resource, cultural resource or land use items in order to perform a quantitative analysis approach.

Based on all of these factors the line route study result was that PPL and PSE&G's routing teams selected Route B as its Preferred Route in August of 2008. This route utilized existing transmission line corridors for almost its entire length.



## Line Route Documentation

All routing decisions were documented into two separate reports, one was for the PPL/Pennsylvania portion of the project and the second was for the PSE&G/New Jersey portion of the project. These were broken into separate documents since they would be individually filed in each state approval process. Both of these documents were filed in the respective Certificate of Public Conveyance and Necessity (CPCN) siting hearings to support their cases.

## State Approvals

As soon as the preferred route was selected, applications by each utility were started for submittal to the state utility commissions for CPCN approval. Based on the information received during the public involvement phase of the siting study, it was already known that these approvals were going to be hotly contested and there would be extensive opposition by residents and special interest groups. The public involvement phase also identified areas of public concern and items that would need to be addressed during the hearings. So preparation of the





applications and the testimony that was filed in support of the case was targeted to address these concerns.

On January 6, 2009, PPL filed its application for authorization to construct the new 500 kV transmission line to the Pennsylvania Public Utilities Commission (PA PUC). The PA PUC indicated that as part of its review process there would be public hearings. The public hearings would provide another opportunity for the public to comment on the project and comments would become part of the legal record. Public input hearings were held in June and July 2009.



Also in January 2009, PSE&G submitted its application to the New Jersey Board of Public Utilities (NJ BPU) to construct the Susquehanna-Roseland transmission line. At that time, the NJ BPU also stated that as part of its review process there would be public hearings. Three public input hearings were held in June 2009.



The formal CPCN Hearings, and the public input hearings, were held in both Pennsylvania and New Jersey to review every aspect of the project. The formal hearings were for expert testimony to be presented. Every System Planning decision by PJM, every siting decision by the siting teams, and every aspect and detail of design and construction were completely vetted. Witnesses were hired to present details on EMF studies including measurements along the route and calculated expected values after construction. Witnesses were cross-examined extensively by opposition groups and the hearings lasted through the summer and into the fall 2009 in both states.

The NJ BPU issued its decision and order approving the project on February 10, 2010. They approved the majority of the route except for a recommended minor relocation near an elementary school as proposed by some opponents.

The PA PUC Administrative Law Judge for the case issued a recommendation to approve the Route B alternative but said no construction can begin until all approvals are in place. The PA PUC agreed with this ruling and formally approved the project on February 12, 2010. It also required that a Community Education Plan be prepared and approved before construction. This required more public meetings to be held along the transmission line route prior to the start of large-scale construction in that area. They were to be staffed by PPL employees and affiliated contractors, in order to review all aspects of the planned construction with the public.

Appeals to these CPCN decisions were filed in both states but ultimately the rulings were upheld.

In New Jersey, a few other state approval hearings were required for the environmental and construction permitting. These additional hearings included the New Jersey Highlands Council and the New Jersey Department of Environmental Protection. Hearings, as well as the extensive field studies (surveying, wildlife studies, archaeological studies wetlands and core borings etc.) were required and created extensive work packages and very detailed mitigation plans. Although these efforts were costly and time consuming, they created no significant or unanticipated delays to the project.



## Federal Approvals

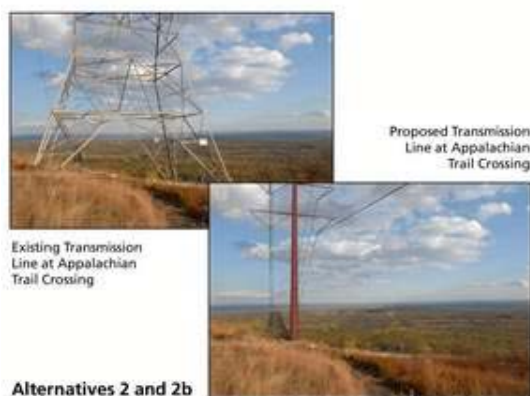
The recommended Alternate B route, affected the three national parks as discussed above. So, Federal approvals were required. In the original project schedule, the plan was to begin line construction while the federal approvals were working their way through the long, protracted National Environmental Policy Act (NEPA) approval process. However, since the PA PUC ruling required that all approvals be obtained prior to construction, construction was delayed awaiting these approvals. This was the largest reason that the project did not meet the proposed Need In-Service date requirement of 2012.

In 2009, PPL and PSE&G requested a construction and right-of-way (ROW) permit from the National Park Service (NPS) for the expansion of an existing electric transmission line that crosses NPS lands within Pennsylvania and New Jersey. The proposal was to expand an existing ROW, which currently contained a single 230,000 volt (230kV) electric transmission line. The existing towers would be replaced with new, taller structures, updating the structures so both the existing 230 kV and the new 500 kV circuits could be built on the same transmission line. This required widening the existing ROW and constructing new access roads. The expanded line and new structures would impact three NPS park units: the Delaware Water Gap National Recreation Area (DEWA), the Middle Delaware National Scenic and Recreational River, and the Appalachian National Scenic Trail (APPA).



Following the National Environmental Policy Act (NEPA) of 1969 and the Council on Environmental Quality regulations, the National Park Service (NPS) was required to prepare an Environmental Impact Statement (EIS) to evaluate the proposal.

This began with public scoping for the project, which was conducted between January and March of 2010. A preliminary alternatives newsletter was developed describing the range of alternatives being considered by the NPS. Three public meetings were held in August 2010, in the local area, to present information to the public and to receive public input on the preliminary alternatives. A report was prepared summarizing the comments received.



At this point, (even though the new line had been shown in the state approval processes to be the best overall route for the new line), the NPS decided to include a review of the original Alternate Routes A, B and C, as well as new alternate routes they had developed during public scoping. If one of these alternatives was chosen, it would invalidate the two state CPCN approvals. During

this formal process, the leaders of the three parks involved, were also publically vocal in opposing the project plan.



President Barack Obama fast-tracked the project in October 2011 through a new Rapid Response Team comprising nine federal agencies. This team's goal was "to improve the overall quality and timeliness of electric transmission infrastructure permitting, review, and consultation by the Federal government on both Federal and non-Federal lands".

The park completed the Draft EIS and released it to the public for a 60-day review and comment period in November 2011. Public meetings were held to follow-up in January 2012. After a review of the public and agency comments received in reaction to the draft EIS, the NPS identified Alternative 2 (known as Alternate B in the CPCN hearings) as the preferred alternative.

The National Park Service selection of the route preferred by Public Service Electric and Gas Co. and PPL Electric Utilities Corp., a route already approved by utility regulators was a major step forward for the Susquehanna-Roseland project and a significant milestone.

As a part of the EIS review, a mitigation plan was proposed by the utilities. Mitigation is a routine part of the environmental impact review process. When power lines or other infrastructure improvements needed by society impact federal lands; mitigation for unavoidable impacts are typically required by federal agencies.

Under the mitigation package proposed by PPL Electric Utilities and PSE&G, thousands of acres of land would be purchased or preserved. The total value of the package depends on the final assessment of impacts by the park service. The utilities' current estimate is at least \$56 million, but others have estimated it to be greater than \$65 million.

These acquisitions would, according to the press releases, "protect scenic vistas for hikers on the Appalachian Trail and could significantly expand National Park Service and U.S. Fish and Wildlife Service land holdings. In addition, the mitigation package could potentially bridge gaps between existing federal and state lands. This would create a half-million-acre swath of contiguous publicly owned or preserved natural lands for recreation and wildlife preservation."

The NPS moved forward in the development of the Final EIS and continued consultations with agencies and consulting parties. On July 17, 2012 the NPS published a draft "Wetland and Floodplain Statement of Finding" for a 30-day public review and comment. On August 31, 2012 a "Notice of Availability for the Final EIS" was published in the Federal Register. The Final EIS was made available to the public at this time.

The Final EIS describes and analyzes: the potential impact of the proposal, the no action alternative, and four additional action alternatives for the transmission line. The Final EIS is a detailed impact analysis of the alternatives for: geologic resources, floodplains, wetlands, vegetation, landscape connectivity, wildlife habitat and wildlife, special status species, rare and unique communities, archeological resources, historic structures, cultural landscapes, socioeconomics, infrastructure, access and circulation, visitor use and experience, visual resources, soundscapes, wild and scenic rivers, park operations, and health and safety.

On October 1, 2012 the Regional Director signed the Record of Decision, granting the applicant's request for right-of-way and special use permits to construct the Susquehanna-



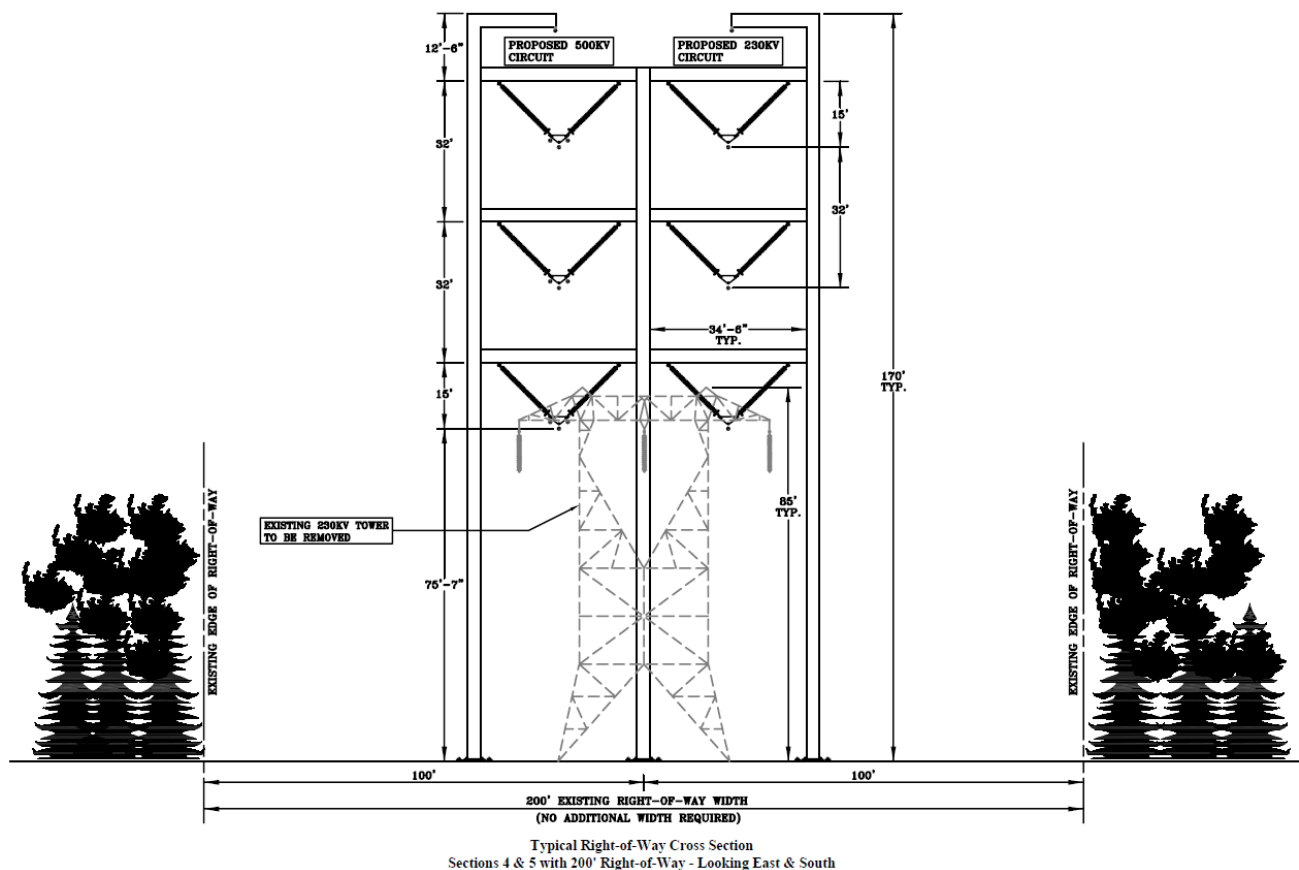
Roseland Transmission Line (Alternative 2) on the existing alignment as it crosses the three parks.

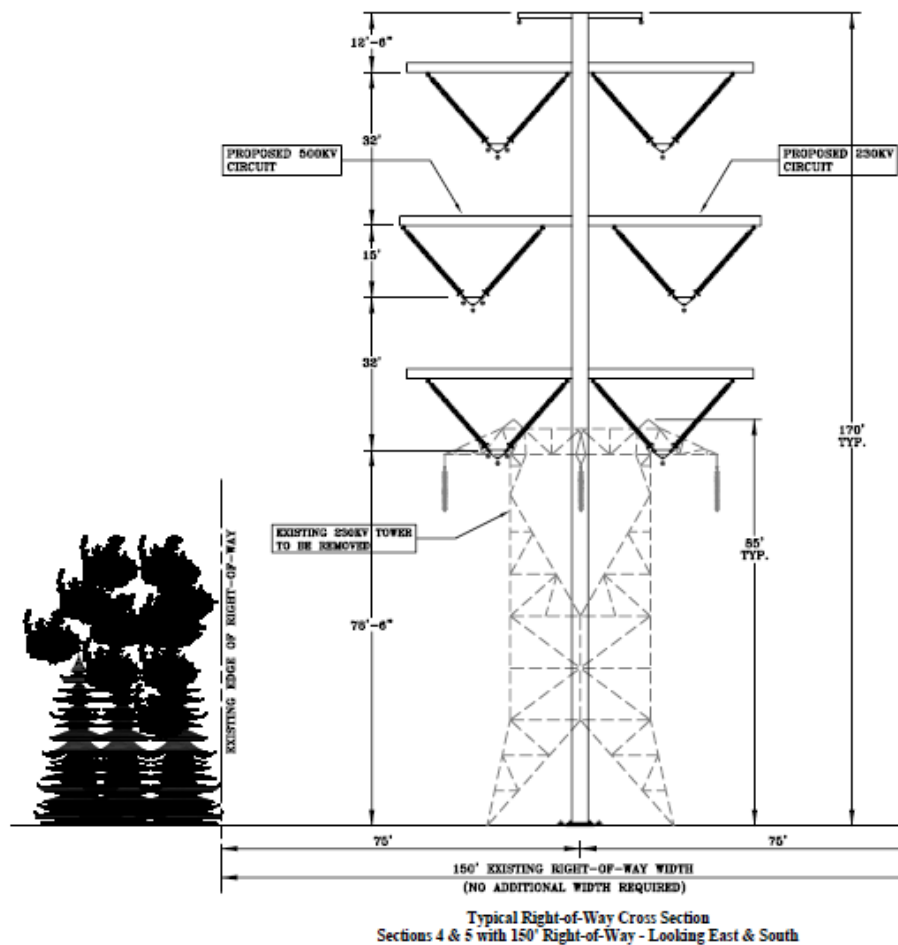
As suspected, appeals were filed on this decision; however, on August 30, 2013 U.S. District Judge Richard W. Roberts rejected 11 claims by an environmental coalition against the park service, charging that NPS violated three federal laws by granting approval for the utilities to cross the Delaware Water Gap National Recreation Area, Delaware River and the Appalachian Trail. The ruling in favor of the utilities, PPL and PSE&G, means they can proceed with scheduled land clearing and construction in the NPS parks.

In summary, to take down a 60+ year old steel tower line in poor condition, and replace it with a modern steel pole line, the NEPA review took more than 3.5 years to get approved. This is a major factor to consider, and it is important to note that this project was even fast-tracked by the President of the United States, and has a mitigation plan potentially valued at over \$65 million dollars!

### Design, Acquire, Construct

The preliminary line design was done to support the CPCN and NEPA processes. Several different designs, depending on the location, were planned to allow for single circuit, double circuit, compact construction, and long span construction. The two most typical structures proposed were a steel 3-pole structure, and a steel-monopole design.





As a result of public concern over the 3-pole structure many of these structures were replaced by a 2-pole design during final engineering.

PSE&G began construction in June 2012. Pre-construction activities in PPL/Pennsylvania for the power line project began in the Scranton area in mid-July 2012. On October 1, 2012 the contract for Pennsylvania was awarded for construction, and construction is currently underway (2013).



## Conclusions

- This case study illustrates the extensive amount of public involvement required for a successful transmission line siting project. There were over 30 public meetings and/or hearings conducted to complete this project. There was extensive planning and involvement of the siting team throughout the project. However, even with this planning there were still some surprises: The rulings in the PA PUC approval process requiring all approvals for all parts of the transmission line before any construction start
- The approval delays during the extensive NEPA review process

- The extremely large mitigation payment as a result of the NEPA process
- The need to have multiple public information meetings prior to construction to review in detail the construction efforts that were planned

The real lessons to be learned here is that public involvement is absolutely crucial to getting regulatory approvals and these approvals are frequently much more difficult to obtain than the design and construction of wires, structures and foundations. Significant time must be allowed in the project schedule for obtaining all needed approvals. In summary, the project will meet all the design requirements set forth in the original project need statement, except for:

- The In-Service Date, which will ultimately have a delay of almost 3 years
- The final project cost will be significantly over the original budget. Therefore it is hard to say this project was a complete success, but it will be completed and carrying the designed electrical load shortly.





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