Kyle and Weber Wind

University at Buffalo
School of Engineering and Applied Sciences

EE482: Power Systems Engineering I

Fall 2019

Preliminary Analysis for Transmission System To Connect KWW Generation Substation

---

Siddhant Khera
Eric Johnson
Daniel Giovino
Catherine Rogers

December 11, 2019

Preface

We collectively that attest Engineers: Siddhant Khera, Eric Johnson, Daniel Giovino, Catherine Rogers are the owners of this report and produced all parts of the preliminary analysis presented. We further confirm that the works presented in this document are fully Ours and were completed between October 2019 and December 2019. All material used from external sources is referenced appropriately.

Document Scope

This document serves as a record, documentation, and a proof our work. The main purpose of this document is to record and define the work in EE482 during the Fall 2019 for a project sponsored by Kyle and Weber Wind (KWW). This document covers the preliminary analysis to add KWW's new wind farm to the existing transmission system owned by the local utility. A final design solution is presented to the sponsor, including alternate solutions simulated as well as an engineering analysis about how this least-cost design was achieved. This analysis also covers socio-political, environmental and economic factors along-with the effect on the local area if the final design is implemented.

Contents

List of Figures

List of Tables

List of Equations

1 Executive Summary

Kyle and Weber Wind (KWW) requests a preliminary assessment design of a transmission system to connect a wind turbine to the northwest of the Metropolis urban area to the rest of the surrounding grid in a cost-efficient way. The design we are recommending passes all requirements given by our supervisors. The proposed design reduces the total losses in the system compared to the original system, while also maintaining a successful base case contingency analysis.

The recommended design includes two different 3-phase, 69KV transmission lines from KWW to PAI69 and KWW to PETE69. These two transmission lines are made of Condor, despite being more expensive to install, the losses in the system are significantly lower with a Condor conductor in these transmission lines. These transmission lines will be supported with a Tangent Double Circuit Suspension and Tangent Single Pole Suspension tower configurations due to the towers cost efficiency in the design. These towers are single poles, which have low costs, and are all that are necessary for 69KV transmission lines.

The cost of this design is determined by the total installation costs of the design minus the total amount of money saved by the reduced losses in the design over a five year period. The total installation costs are estimated to be $5,987,500 for the two transmission lines, and the estimated recuperated money from the losses is $657,000 over five years, for a total cost of $5,330,500 for the project.

Safety and environmental factors were also considered with this recommendation. Different OSHA regulations impact the types of construction equipment used when building and servicing the transmission lines. There are some carbon emissions associated with the design, but these should be outweighed by the reduced role of fossil fuels for generation due to the addition of the wind turbine into the grid. Also, the possible impact on native species is considered with the recommendation. Other societal and political impacts factors are still under review.

2 Introduction

Kyle and Weber Wind (KWW) are looking to build a new 200MW wind farm in the rolling hills to the northwest of the Metropolis City in Western NY. It will connect to the transmission system owned by Metropolis Light and Power (MLP), a local utility in the area. As national leaders in wind energy developers, KWW is presenting a preliminary analysis of how this addition affects the present transmission system of the area over the course of 5 years. This is a great opportunity for KWW as well as MLP since this will be the highest capacity wind farm in Western NY as of 2019, and one of the first steps for KWW into the area. With New York shutting its final coal plant in 2020 [4], this helps accelerate the state's transition to sustainable energy.

This design proposal presents KWW's finding from a preliminary analysis. The preliminary analysis includes the design for the new power distribution system —transmission towers and conductor types that could be used — as well as any upgrades required to the present transmission system, Right of Way and opportunity for further upgrades after phase 1 is complete. The proposal also includes a cost analysis of all the required additions and the overall effect of changes over 5 years. Finally, the proposal also discusses socio-economic & environmental factors and impact of sustainability on the local ecosystem of flora & fauna and the economy.

3 Objectives

At KWW, we plan to cover the cost of the system additions of the new 200MW wind farm as well as any changes that are required to the pre-existing system as part of the preliminary design proposal. The target objectives include to, first, determine a least cost design with the addition of a 200MW wind farm to the present transmission system. Since the cost of all and any design changes that are required to accommodate this plant will be covered by KWW, in addition to the cost incurred by the increase or decrease in system losses over 5 years, the goal is to find the cheapest solution within the design constraints of the interconnection [1]. Secondly, keeping in line with KWW's tradition, this design proposal also covers if the new addition or upgrades affect the local ecosystem in a negative way [1]. While doing the local area assessment, the design proposal will cover safety, health, environmental, and ethical issues that will impact the area once the proposed design is implemented.

The design constraints for the KWW's 200MW wind farm include voltage set-points, reactive power limits and a set interconnection point to other substations. A value of 1.05 per unit is required for the voltage set-point, and reactive power is limited to ± 100 Mvar [1]. The interconnection point of the wind farm to the existing lines/substations is required to be at 69kV [1]. Additionally, for reliability, at least two separate transmission line feeds are required from KWW to existing or new substations [1]. Finally, the addition of the wind farm to the transmission system should clear the contingency analysis for the base case and the first contingency loading situation [1].

4 Assumptions

The following simplifying assumptions were made in this design:

- We are using a straight transmission line; no need for small, large and other structures [5].
- All tangent wood pole towers cost the same [5].
- The ground is flat (no vertical distance required for the transmission wire) and the connections between each Right of Way are exactly perpendicular to each other.
- Cost for cardinal for 69kV lines not given by project sponsor. A reliable source of information for the cost of 69kV Cardinal lines has not been found. Currently, assumed a 69kV Cardinal

line costs $260,000. Therefore, it is not the preferred conductor type for 69kV lines in the design since we cannot substantiate the cost.

- Only the base case loading level contingencies have been considered.
- System losses remain constant over 5 years, and electricity is always priced at $50/MWh for 5 years from installation.
- KWW generator at the wind-farm has a constant 200MW output throughout its use.

5 Design

The goal for this preliminary analysis was to provide a least cost design over 5 years. The least cost design includes the cost of system additions added to the cost of increased or decreased losses over 5 years. Over the following sections, the design decisions are discussed in detail.

5.1 Transmission Line Design to Connect PETE69 and PAI69 to the System

In the design approach, transmission lines were added to PETE69 and PAI69 from the KWW wind turbine substation. The system additions proposed were simulated in PowerWorld to check for system losses, as well as solving any contingencies that arose if any one transmission line was or component was taken offline. PowerWorld, a power simulation program provided by the textbook publisher used in EE482 in Fall 2019 [2], was used primarily used to simulate the proposed design.

5.1.1 Solution Approach

The main priority was to connect the KWW wind turbine to the existing infrastructure. Since a least-cost design was required, adding or upgrading infrastructure might have been cost-prohibitive. Although, if it resulted in savings due to better system efficiency, it would have reduced the system cost over 5 years. First, we chose four types of transmission towers through educated guessing which we would like to use in the area. Then, we were given 8 Right-of-Ways that we could have used [1]. Finally, 4 given conductor types could have been used [1].

Using basic permutation theory, 4 (Transmission Towers) $\times$ 8 (Right-of-Ways) $\times$ 4 (Conductors) = 128 base cases to test. Each base case includes the cost of connecting a single transmission line, using a single tower type, a single conductor type to a single particular Right-of-Way. All 128 base cases are tabled in Appendix D in Table 17 with the respective per-unit values and total costs per case.

Looking at the cost trends in the 128 base cases, we made further educated cases based on total distance and total cost to combine *at least* two base cases to achieve the minimum two interconnections needed. The focus then was on combining as many cases (interconnects) possible to achieve the lowest cost either due to cheaper construction costs, or savings due to fewer losses.

After over 30 simulations, it was realized that the cost differences between various tower types were not significant enough to impact the overall cost of the system by a lot. Therefore, the focus was then on optimizing cost using mainly different types of conductor types and different interconnects.

While different conductor types did have an impact on the overall cost, Condor was usually better as can be inferred from Table 18 in overall cost. Using Rook was the cheapest in its absolute cost [1], but the system was more expensive due to higher losses. Condor is a more expensive conductor than others [1], including Rook, but it has lower losses because it is thicker and has a higher current rating [6].

For Right-of-Ways, as can also be inferred from Table 18, PETE and PAI were the cheapest since they are the shortest distance after GROSS (from Table 2). PETE and PAI should logically be some of the cheapest lines to build to since they are two of the closest.

Finally, we used simulations to determine that using Condor to PETE and PAI gave the lowest system losses at approximately 10.41MW (0.3 MW less than the previous system) when compared to the cost of installing the lines. The total cost of the system is, including building the towers, three-phase circuit breakers, associated relays, and changes to the substation bus structure, approximately $5.3m.

Other solutions were considered before arriving at the final one, as mentioned in Table 18 and discussed in Appendix C, and they were overall more expensive over 5 years compared to the final design solution.

5.1.2 Conductor Type

The conductor type chosen had a significant effect on the overall cost of the design. Multiple design cases using different conductor types at the same and different Right of Ways were simulated, as noted in Appendix D and Table 17. Through repeated simulations, it was realized that the cost of the conductor type used is about finding the appropriate trade-off between the cost of the cables and increase/decrease in system losses. Even though the cost of Rook was the cheapest at $200,000/mi [1], it was also the lowest rated, at 784A [7], among the information for the three conductors provided for a 69kV line [6, 7]. Even though cabling using Rook was consistently cheaper, system losses were higher in some cases which increased the total cost of the transmission line over 5 years. On the other hand, even though Condor conductor type is a little more expensive per mile at $240,000/mi [1], using it leads to fewer system losses since the cable is thicker and is rated at 889A [6].

It was also realized over multiple simulations that using PETE69 and PAI69 were the cheapest compared to others. Therefore, further simulations using Rook and Condor were performed using different tower types to PETE69 and PAI69 from KWW.

Finally, a Condor-only solution was the cheapest instead of using a combination of Condor-Rook or Rook-only. Using Condor, since it is a thicker cable and is higher rated, decreases system losses that offset the initial higher cost of installation. The effect of choosing Rook or a Condor-Rook combination is further discussed in Appendix C.

5.1.3 Final Connection Solution

It was concluded that using Condor with connection to PETE69 and PAI69 was the cheapest, as discussed in Section 5.1.2. Even though Condor is a more expensive conductor due to better materials and thicker cabling, the cost-savings are gained by reduced system losses. The line impedance values for the transmission line using Condor that connect KWW to PETE69 and PAI69 are calculated in Appendix D. Since Line Impedance Calculator was not available in PowerWorld, we setup a spreadsheet that provided the line impedance values for various conductor types (including Condor) and all available Right of Ways (including PETE69 and PAI69). More details about respective calculations for the design parameters chosen are discussed in Appendix B.

5.1.4 Alternate Solutions

The previous section closed by mentioning that using a Condor-only solution was cheaper than Condor-Rook or Rook-only solution. To illustrate that, let's look at another solution that was considered. Sim #23 in Table 18 represents a connection to PETE69 using Condor and PAI69 using Rook, both using Tangent Wishbone - Single Arm tower configuration, and we can see that total losses are at 10.69MW. The losses in this case are only 0.02MW lower than the present system, and the total cost comes to approximately $5.7m.

Likewise, let's consider Sim #24 in Table 18. Sim #24 represents a connection to PETE69 using Condor and a Tangent Single Pole Suspension - With Brackets tower configuration. The second interconnection to PAI69 is using Rook and Tangent Wishbone - Single Arm tower configuration. In this case, we can see that total losses are at 10.65MW. The losses in this case are only 0.06MW lower than the present system, and the total cost comes to approximately $5.6m.

Using different tower types only made a difference of $100,000, which is not significant when compared to changes in cost by changing the Right-of-Way used or a different conductor type.

Finally, let's look at a Rook-only solution. Sim #16 in Table 18 represents two interconnections using Rook. The first interconnect using Rook is to PAI69 using a Tangent Wishbone - Single Arm tower configuration. The second interconnection using Rook is to PETE69 using a Tangent Wishbone - Single Arm tower configuration again. The total losses are increased to 11.03MW, an increase of 0.32MW from the original system, at a total cost of $6.2m.

Looking at Table 17 in independent cases, we can see that building a transmission lines using Rook for these interconnects is cheaper. Although, since electricity is charged at $50/MWh, over 5 years, these additional losses cost approximately $700,000. For comparison, using Condor-only in our chosen solution, there are savings from losses over 5 years of approximately $700,000 that make the chosen solution over one million dollars cheaper.

Other solutions were considered but discarded since the objective of this preliminary analysis is to find the least-cost design. One benefit to using different conductor types and different tower types would be to suit them to the local conditions of the area; however, these were not considered as deliverables in the least-cost preliminary analysis. Further analysis of the local area would be needed before conclusions can be drawn to suit the needs.

Another benefit of using a combination of different conductor types in the same local area would to find the failure rate of them in the area they will be used in. Different conductor types can have varying lifetime under different conditions. Since this is KWW's first foray into the WNY area, these factors might be helpful. Although, these ideas did not play a role in the recommendation of the final design since these are not included in the objective of this preliminary analysis.

Conclusively, since the objective of the preliminary analysis was to find the least-cost design, other solutions that were more expensive were not accepted.

5.2 Materials for Transmission Line and Towers

Since we require a least cost design, all proposed additions need to minimize costs over 5 years. As noted in section 5.1.2, Condor minimizes losses over 5 years since it reduces system losses significantly. Therefore, Condor was chosen for 69kV above ground, and Tangent Double Circuit Suspension [3] & Tangent Single Pole Suspension [3] tower designs were chosen for both the transmission lines.

5.2.1 Conductor Selection

The conductor type chosen is Condor. It is an Aluminum Conductor Steel Reinforced (ACSR) cable with a diameter of 1.092 inches and a rated current capacity of 889 Amps [6]. It's resistance value per mile is 0.1378Ω at 75% capacity at 60Hz, and an inductive reactance of 0.401 per mile at 60Hz [1]. It's Aluminum content is 73.25% and Steel content is 26.75% [6]. Finally, it's rated breaking strength is 28,200lbs [6]. Even though this conductor is more expensive than others according to the information provided [1], the cost savings accrued by fewer system losses over 5 years in the final design solution makes using this conductor cheaper in the long run.

5.2.2 Tower Selection

The Tangent Double Circuit Suspension [3] was selected for use in the transmission line installation between and KWW to PETE and Tangent Single Pole Suspension [3] was selected for KWW to PAI. The primary selection factor for this tower type was their effect on the Geometric Mean Distance (GMD) (See Appendix A for more information). The tower types that considered were

Tangent Wishbone - Single Arm, Tangent Single Pole Suspension, Tangent Single Pole Suspension – With Brackets, along with the Tangent Double Circuit Suspension [3]. The Tangent Wishbone - Single Arm tower type was eliminated because it did not support the necessary 69KV for these lines. The rest were then judged based on their GMD effects on the system. Due to time constraints, these were the only tower types considered.

All the towers we considered are in the classification of tangent towers. All tangent towers at 69KV need 9 structures per mile along each Right of Way [5]. The number of towers per mile is multiplied by the distance (in miles) of the Right of Way before adding 1 to find the number of towers in each transmission line. An extra tower is added since it is the starting point of the transmission line. This assumes there are no roads, railroads, rivers, or any other obstacle in the way of each ideal tower location, and also assumes there must be a tower at both substations to increase the height of the wires (hence the plus one in the number of towers equation). If these towers are included in the given prices of the substations, the addition of one can be changed to a subtraction of one instead. The cost of all the considered tower types is $20,500 per tower since they are all of the same type (Tangent structure – single circuit – wood pole, 69KV) [5].

5.2.3 Underground Transmission Lines

The company excluded the use of underground transmission lines for a few reasons, being price, maintenance, and detriment to installation site. In research is was founded that underground transmission lines most often cost more per mile than overhead lines. It is difficult to quantify since the price will be determined on a site by site basis, but on average, where an overhead transmission line may cost $285,000 per mile, the same site cost would be $1.5 million per mile for an underground transmission line [8] Where an overhead transmission line may cost $390,000 per mile, the same site cost would be $2 million per mile for underground [8]. Repairs also come with addition cost, as it may cost between $50,000 to $100,000 just to locate the leak or break in the line [8]. Being in a hilly area as well, we determined that the site damage is a detriment we did not want. To install the transmission lines underground would require tunneling and trenching to make an enclosed area underground to house the line, and leave room for a maintenance tunnel [8]. For these reasons, we determined not to proceed with underground lines, though it could be an impressive future investment to limit the exposure to weathering, and access to the public.

5.2.4 Line and Tower Selection Environmental Concerns

Further analysis needs to be performed regarding the types of towers which should be used in the design. Localized information that might affect these decisions was not available at the compilation of this proposal. Generally, climate analysis may determine the wooden poles to be inadequate for the region's climate. Next, the different species in the area may impact the tower type used. If there is a species which is likely to be hurt by and/or damage the transmission line due to the tower type we are recommending, a different tower may be necessary. Lastly, the soil composition may either greatly increase the cost of installing these towers or may make them infeasible to implement. The recommended tower types may not be adequate or

5.3 Right of Way

The Right of Ways used in the various solutions were directly pulled from the initial case documentation [1]. These Right of Ways pertain directly to pre-existing pathways and components within the design case. They are mentioned in Table 2 in Appendix A.

5.3.1 Stray Voltage

To avoid stray voltages, the team focused on the common sources for elevated stray voltage levels. We noticed the most common sources of stray voltage are faults, lack of separation between equipment grounds and neutral wires, excess voltage drop on neutral wires, poor grounding, and unbalanced loads [9] In the design of our tower, the team will ensure that all the proper standards and protocols are being upheld. The team will be trained to comply with the 04-M0159: Electric Safety Standards presented by the Department of Public Service of the State of New York [10]. We will be in contact with the department to gather training material as the system begins installation and operation.

5.3.2 Safety Restrictions

OSHA has dictated that for any overhead transmission line above 50kV, which the 69kV would be, must have a ten foot clearance when working with ladders or long tools [11]. Additionally, Cranes and Derricks must be a minimum of twenty feet away from these transmission lines. These minimum distances increase as the voltage on the line increases [12].

As part of the construction process for our Right of Ways, trees and other potential conductors or risks to the transmission lines will need to be cleared out along the route. This includes things such as signage and fencing along the route, as the high voltage can induce an electrical charge across vehicles and other conducting materials. The cost of removal and implementation of protective barriers is taken into account in the cost per mile breakdown for the different Right of Ways [1].

5.4 Fault Prevention and Handling

The following are recommendations for fault prevention methodologies:

- Increase insulation in locations that are more to prone weathering or interference.
- Identify that all components are up to date to avoid outdated materials
- Test equipment to ensure proper functionality.
- Implement fuses and breakers in key locations.

5.4.1 Fault Prevention Motivation

Consumers value cost-effectiveness and reliability for electric sources as the most important aspects [12]. The (Right of Ways of solution) will allow for the KWW turbine to be connected to the overall system. This addition will allow for more energy to be added to the grid, decreasing the total losses of the system, thereby decreasing the cost as discussed in Appendix B.

This addition also has the potential to cause faults when added, which can knock out part of the system, leading to a decrease in the reliability of the system. The designed system has been tested in PowerWorld to ensure that no blackouts will occur and no lines will carry voltage above or at their rated voltage and current values.

5.4.2 Voltage Sagging

Voltage sagging is a reduction in voltage for a brief period of time. This time frame only lasts between milliseconds, and 1 minute. Some common events that cause voltage sagging, which are relevant to our system, are lightning, wind, and equipment failures [13]. These causing factors cannot be entirely avoided, but we will work to implement the proper lightning dissipation systems, and include safety switch mechanisms to keep the system running if the equipment failed for a short period of time.

5.5 Budget

The overall cost of this project is defined as the one-time cost of the transmission line construction minus the costs saved by the decrease in losses in the system over a five-year period [1]. Tables 5, 6, 7 and 8 provided in Appendix B computes the total installation costs of both transmission lines, the costs recovered by the reduction of losses in the system over five years, and the total cost of the project over this period.

5.5.1 Hardware Installation

The cost of installing the transmission lines rely on the conductor type used, voltage of the line, and the tower type used to support the line. The conductor, Condor, costs $240,000/mile [1]. Each tower of type Tangent Double Circuit Suspension costs $20,500 [1] and can be spaced at 9 towers/mile [5]. This means for the KWW to PAI69 line, there are 55 towers in the 6 mile Right of Way [1], and for the KWW to PETE69 line, there are 68 towers in the 7.4 mile Right of Way [1].. The fixed cost of each line, which is assumed to include cost of labor, terrain clearing, etc. is $125,000 [1]. This means the total cost of each line is $2,692,500 for KWW to PAI69 and $3,295,000 for KWW to PETE69. Thus, the total cost of the transmission lines is $5,987,500. This cost includes three-phase circuit breakers, associated relays, and changes to the substation bus structure [1].

5.5.2 System Losses

The base system (without any additions) has losses of 10.71 MW. The line impedance values in Table 17 in Appendix D were put into the transmissions lines placed on the proper Right of Ways in PowerWorld to find the losses in the proposed system, which were 10.41MW. This results in a total of 13140 MWh saved over five years. Since the price of power is $50 per MWh [1], this means $657,000 are saved by reducing losses in the system.

5.5.3 Proposed Budget

The budget takes into account the two transmission lines being constructed and the cost of the losses that are being eliminated. Since there are less losses in the proposed solution than the original system, the savings are subtracted from the total cost of the transmission lines. Thus, the final cost of the project is estimated to be $5,330,500.

6 Environmental Impact

6.1 Carbon Emissions

The installation of power lines will lead to an increase in carbon emissions through the installation and fabrication of the towers and the associated wires and semiconductors. However the proposed system has less losses than the pre-existing condition, and uses wind energy to generate electricity. This can be a great way to reduce carbon emissions as a whole for the system as, once the installation and fabrication is completed, it is a clean energy source. Over five years implementing our solution would lead to a decrease in CO_2 by 7,072 pounds metric tons $\frac{CO_2}{MWh}$ when comparing the wind farm to a greenhouse gas generation methodology. Assuming a fully clean energy production over five years this would be 309,737,131 metric tons, or approximately 300 million metrics tons, of $\frac{CO_2}{MWh}$ [14].

6.2 Effects on Locally Endangered Species

A hazard to the environment is deforestation for installation of the towers and the power distribution plants. These power lines can disrupt local ecosystems such as removal of trees and greenery that provided shelter or food sources. The sound of installation can also scare off the local wildlife causing them to be displaced from established habitats as well as the trimming due to following the safety standards [11].

A specific example of an endangered species that could be impacted by the installation of power lines is the Kirtland Warbler. The Kirtland Warbler is a species of bird that nests in jack pine forests, whose habitat could be infringed on by the installation of power lines [15].

Another potential threat would be wildlife forming a connection between two conductors. This threat can be decreased by having towers with less compact conductors.

A final threat would be from the wind farm itself, the spinning blades, if hit by wildlife could not only be detrimental to the blades but also very dangerous for the wildlife.

7 Economic & Social Impact

By using the Jobs and Economic Development Impacts (JEDI) transmission line economic model, we have estimated that this project will create about 130 jobs through the construction and installation period [16]. This included onsite labor, equipment and supply chain, and induced impacts of the project [17]. Onsite labor considers the contractors and crew needed for excavating, installing, and operating the line. Equipment and supply chain considers the booming economic effect of vendors and manufacturers receiving business. Lastly, induced impacts consider the local household earnings of a project developing in a sub-urbanized area. Induced impacts consider increased impacts at restaurants, retail, hotels, and other service providers in the area as crews and employees concentrate themselves in the area of the site [17]. This project will be a benefit to the local economy.

7.1 Sustainability and Upkeep

In research for designing this project, some research was given towards maintenance strategies for the above ground transmission tower. One of the tools the team may look into for future maintenance and increases sustainability is a tower coating. There have been studies conducted which have shown that protective coatings over the steel of the tower extend the useful life of the tower, and avoid structural damage [18]. We will also conduct a vegetation study after installation to monitor the grown of vegetation in the site area. Since we will be installing in the rolling hills, there may be opportunity for localized vegetation to grow upwards towards the tower

8 Health & Safety

This section will consider multiple factors of safety, as safety of the crew, and residence is of the upmost importance. This is true for the installation and construction period as well as the remaining life of the tower.

8.1 Metal Roofs

Since metal is a known conductor, the team has surveyed the area to ensure that there is no metal roofing in or around the installation site. Since potential line sagging is a future possibility, residents and farming community will be advised not to install any sheds, barns, or other buildings with metal roofing. Any unintentional contact with metal roofing may can create a ground for the transmission line, causing an arc or fault in the line.

8.2 Livestock

Considering previous sections on stray voltage, it has been observed in several studies that stray voltage can have adverse effects in livestock behavior [19]. Specifically in cows, as there are dairy farms in the local area of the site, there are several confirmed adverse effects including nervousness during milking, refusing to enter parlors, anxious to leave parlors, increased defecation and urination in parlor, and reluctance to consume feed or water [19]. Because of these adverse effects, and the farming community in and around the area, we will be taking the upmost care to follow safety protocols. We will be cognizant of monitoring and regulating stray voltage.

8.3 Human EMF Exposure

Human health and safety is of the highest concern to the team. We have conducted research in the adverse effects of Electromagnetic Fields (EMF) on humans. The results that we found show some correlation with a risk of developing cancers, neuro-behavioral abnormalities, and infertility in males [20]. We will monitor the residencies of the area, and conduct in person surveys to ensure following our installation, there are no spikes in these symptoms to the area. We will also use an EMF detector to make public acknowledgment of the EMF levels in the area.

8.4 Line Crew Safety

Since there will be an extensive crew required to complete the project, we would like to uphold the highest of standards for safety during installation and construction. We will follow guidelines similar to those found in the Western Area Power Administration Construction Standards book [21] We will ensure that the employees have all of the necessary safety equipment, including hard hats, fall protection, respiratory protection, high visibility clothing, electrical protection and more. We will ensure the site has the proper equipment, that has been calibrate and licensed for the field [21]. There will be safety training sessions, and team meetings to review the expectations to be held when it comes to safety and following procedure. All of the factors will be considered to ensure crew safety.

9 Conclusion

The goal was to find a least-cost solution to connect a new power generation plant based on 100% wind generation in the local WNY area. The final design connection from KWW to PAI69 and PETE69 achieves that while making the overall system better with lower losses. The final design uses two different tower types and Condor-based transmission lines. Although Condor has a higher initial cost, it results in lower system losses which leads to savings over 5 years. Overall, the system costs about $5.3m over 5 years, savings from losses included. Effects on the local area, such as environmental, political, economical and societal, are still under-review.

We think this system can achieve the high standard of reliability and sustainability that KWW is known for around the nation. Given the fact that this addition will reduce system losses over 5 years, accelerate New York's state transition to sustainable energy, and allow KWW to enter the area, we recommend that this is a great opportunity with a reasonable cost for everyone involved.

A Formula's and Givens Used

The following formula and givens were used in the calculation of each design section:

- $\epsilon_o = 8.85 \times 10^{-12} F \cdot m^{-1}$
- Frequency = 60Hz
- $\rho_{Al} = 2.7 \times 10^{-8} \Omega \cdot m$ [1,2]
- $S_{base} = 100MVA$ [1,2]
- $V_{base} = 69kV$ [1,2]
- Therefore,
  - $I_{base} = \frac{100MVA}{69kV} = 1.45kA$
  - $Z_{base} = \frac{69kV}{1.45kA} = 47.61\Omega$
  - $Y_{base} = \frac{1}{Z_{base}} = 0.021 \frac{1}{\Omega}$

	GMR	**a**
Rook	0.0100m	0.01240m
Condor	0.0112m	0.01388m
Crow	0.0106m	0.01315m

Table 1: Conductor Givens [1,2]

$$D_{ab} = \sqrt{X_{ab}^2 + Y_{ab}^2} = ...\ m \tag{1}$$

$$D_{bc} = \sqrt{X_{bc}^2 + Y_{bc}^2} = ...\ m \tag{2}$$

$$D_{ac} = \sqrt{X_{ac}^2 + Y_{ac}^2} = ...\ m \tag{3}$$

Right of Way	**Distance (mi)**	**Distance (m)**
KWW to PAI	6	9656.1
KWW to PETE	7.4	11909.1
KWW to DEMAR	12	19312.1
KWW to GROSS	4.5	7242.0
KWW to HISKY	11.2	18024.7
KWW to TIM	13	20921.5
KWW to RAY	15	24140.2
KWW to ZEB	11	17702.8

Table 2: Right-of-Way Givens [1, 2]

Tower Name – Tangent	X_{ab}	X_{ab}	Y_{ab}	Y_{ab}	X_{ac}	X_{ac}	Y_{ac}	Y_{ac}
Wishbone - Single Arm (TWSA)	1ft	6in	11ft	14in	16ft	20in	6ft	6in
Single Pole Suspension (TSPS)	0ft	0in	7ft	0in	8ft	12in	7ft	0in
Single Pole Suspension With Brackets (TSPSB)	1ft	0in	7ft	0in	11ft	12in	7ft	0in
Double Circuit Suspension (TDCS)	1ft	0in	6ft	0in	0ft	0in	12ft	0in

Table 3: Tower Givens [3]

Therefore, Geometrical Mean Distance (GMD) is given by [22]:

$$GMD = \sqrt[3]{D_{ab} \times D_{bc} \times D_{ac}} = ...\ m \tag{4}$$

$$\textbf{Series Resistance}\ [1,2] = \frac{2 \times \rho_{Al} \times length}{\pi \times a^2} = ...\ \Omega \tag{5}$$

$$\textbf{Series Reactance}\ [22] = X_L = 4\pi f \times \ln\left(\frac{GMD}{GMR}\right) = ...\ \Omega \tag{6}$$

$$\textbf{Susceptance } [22] = B = 2\pi f \left(\frac{2\pi\epsilon_o}{ln\left(\frac{GMD}{GMR}\right)} \right) = ... \ \frac{1}{\Omega} \tag{7}$$

$$R_{pu} = \frac{(\text{Series Resistance})_{actual}}{Z_{base}} = ... \ pu \tag{8}$$

$$X_{l-pu} = \frac{(\text{Series Reactance})_{actual}}{Z_{base}} = ... \ pu \tag{9}$$

$$B_{pu} = \frac{(\text{Suspectance})_{actual}}{Y_{base}} = ... \ pu \tag{10}$$

B Final Design Solution

Transmission Line	Series Resistance	Series Reactance	Shunt Charging
KWW to PAI	0.012 pu	0.082 pu	0.0018 pu
KWW to PETE	0.014 pu	0.101 pu	0.0022 pu

Table 4: Final Design R, L, C Summary

Right of Way	Conductor	Conductor Price/mi
KWW to PAI	Condor	$240,000 [1]
KWW to PETE	Condor	$240,000 [1]

Table 5: Final Design Solution Characteristics Summary

Total Cost = (# of Towers × Price per Tower) + (R-o-W + Conductor Price/mi) + Fixed Cost

Right of Way	Towers/mi	# of Towers	Price/Tower	Fixed Cost	Total Cost
KWW to PAI	9 [5]	55	$20,500 [5]	$125,000 [1]	$2,692,500
KWW to PETE	9 [5]	68	$20,500 [5]	$125,000 [1]	$3,295,000

Table 6: Final Design Solution Cost Evaluation

Base Case	Proposed Case	MWh Saved (Over 5 Years)	$/MWh	Cost Saved
10.71 MW	10.41 MW	13140h	$50 [1]	$657,000

Table 7: Final Design System Losses Evaluation

Line Costs		System Losses Recovered	**Total Cost of Project**
KWW to PAI	KWW to PETE		
$2,692,500	$3,295,000	$657,000	**$5,330,500**

Table 8: Final Design Final Projected cost

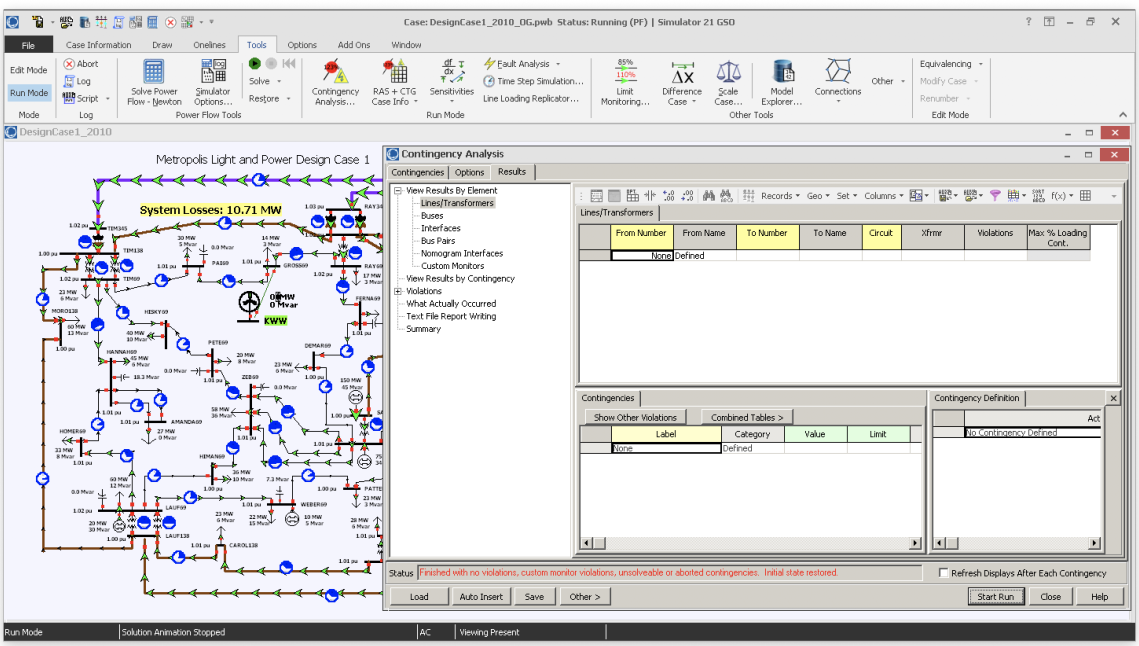

Figure 1: Initial Design without KWW, without contingencies

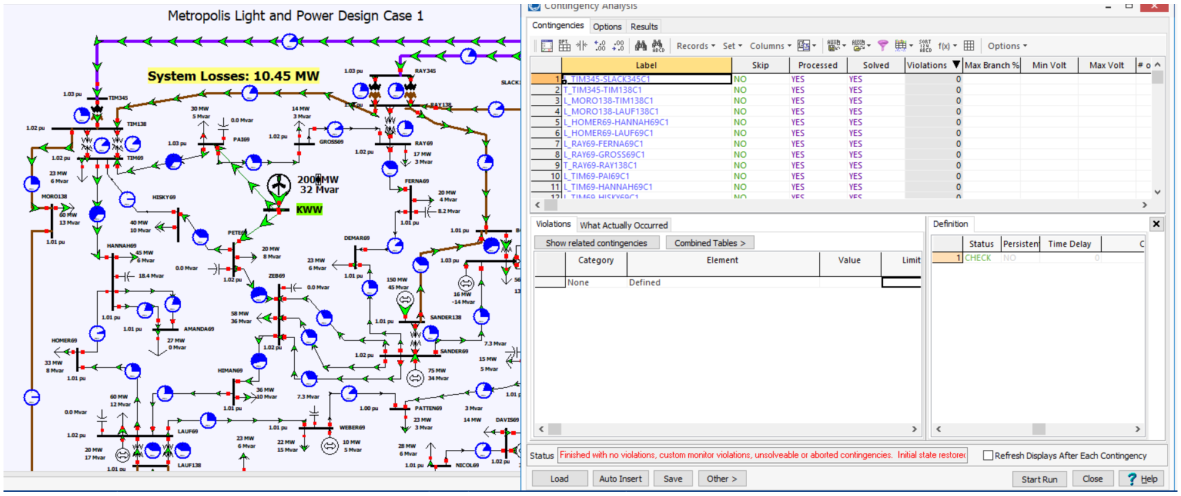

Figure 2: Final Design Solution using Condor to PETE69 and PAI69

Fig. 1 represents the initial design of the grid and the base contingency analysis. Fig. 2 represents the final design solution. For the final design solution, a Tangent Double Circuit Suspension (TDCS) was used to connect KWW to PETE69, and a Tangent Single Pole Suspension (TSPS) was used to connect KWW to PAI69. Both transmission lines use Condor as their conductor type.

We can see that the losses are approximately 10.4MW in the final design, a decrease of almost 0.30MW from the original solution that in Fig. 1. We also see from Fig. **??** that the reactive power is about 32Mvar, within the ± 100Mvar required.

C Other Design Solutions

This appendix contains some of the other designs that were simulated and not used in the final design. These include failed solutions, and working solutions that were considered but did not meet the objectives. These also include the second, third and fourth best (in terms of cost) solutions that were in consideration before the final design was chosen.

C.1 KWW to PAI69 using Rook and Tangent Wishbone Single Arm

$$D_{ab} = \sqrt{X_{ab}^2 + Y_{ab}^2} = \sqrt{0.4572^2 + 3.7084^2} = 3.73m$$

$$D_{bc} = \sqrt{X_{bc}^2 + Y_{bc}^2} = \sqrt{4.9276^2 + 1.7272^2} = 5.22m$$

$$D_{ac} = \sqrt{X_{ac}^2 + Y_{ac}^2} = \sqrt{5.3848^2 + 1.9812^2} = 5.73m$$

$$GMD = \sqrt[3]{D_{ab} \times D_{bc} \times D_{ac}} = \sqrt[3]{3.73 \times 5.22 \times 5.73} = 4.82m$$

$$\textbf{Series Resistance } [1,2] = \frac{2 \times \rho_{Al} \times length}{\pi \times a^2} = \frac{2 \times 2.7 \times 10^{-8} \times 9656.04m}{\pi \times (0.00137795)^2} = 0.686\Omega$$

$$\textbf{Series Reactance } [22] = X_L = 4\pi f \times \ln\left(\frac{GMD}{GMR}\right) = 4\pi 60 \times \ln\left(\frac{4.82}{0.01002}\right) = 4.50\Omega$$

$$\textbf{Susceptance } [22] = B = 2\pi f \left(\frac{2\pi\epsilon_o}{ln\left(\frac{GMD}{GMR}\right)}\right) = 2\pi 60 \left(\frac{2\pi \times 8.85 \times 10^{-12}}{ln\left(\frac{4.82}{0.01002}\right)}\right) = 3.28 \times 10^{-5}\frac{1}{\Omega}$$

$$R_{pu} = \frac{(\text{Series Resistance})_{actual}}{Z_{base}} = \frac{87.41\Omega}{47.61\Omega} = 0.014pu$$

Therefore the final value of R_{pu} is,

$$\boxed{R_{pu} = 0.014pu}$$

Next,

$$X_{l-pu} = \frac{(\text{Series Reactance})_{actual}}{Z_{base}} = \frac{4.50\Omega}{47.61\Omega} = 0.09451pu$$

Therefore the final value of X_{L-pu} is,

$$X_{L-pu} = 0.095pu$$

Next,

$$B_{pu} = \frac{(\text{Suspectance})_{actual}}{Y_{base}} = \frac{3.28 \times 10^{-5} \frac{1}{\Omega}}{0.021 \frac{1}{\Omega}} = 0.0015pu$$

Therefore the final value of B_{pu} is,

$$B_{pu} = 0.0015pu$$

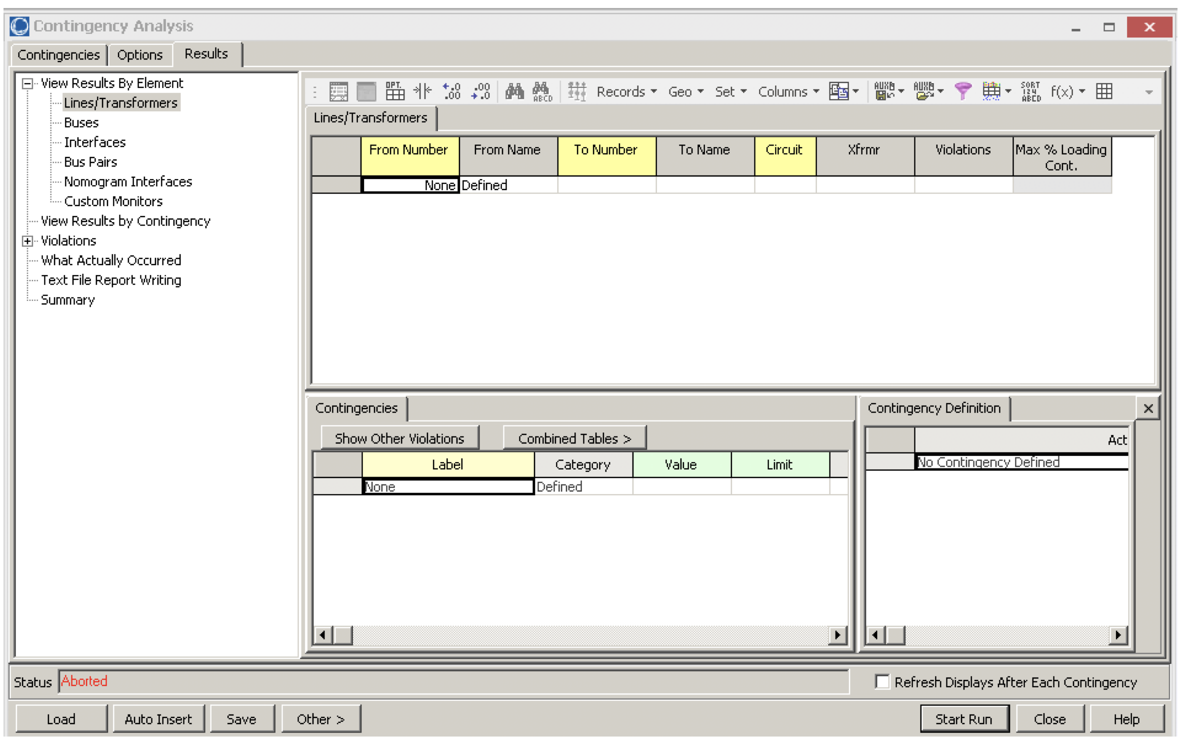

Figure 3: Contingency Analysis reads *Aborted* for KWW to PAI69 using Rook

Conclusion

For this design case, a transmission line was added between KWW and PAI69. From Fig. 3, we can see that this addition made the system worse because the contingency could not successfully run on this system.

C.2 KWW to ZEB69 using Condor and Tangent Wishbone Single Arm

$$\textbf{Series Resistance } [1,2] = R = 1.00\Omega$$

$$\textbf{Series Reactance } [22] = X_L = 8.09\Omega$$

$$\textbf{Susceptance } [22] = B = 6.12 \times 10^{-5} \frac{1}{\Omega}$$

$$\boxed{R_{pu} = 0.021pu}$$

$$\boxed{X_{L-pu} = 0.17pu}$$

$$\boxed{B_{pu} = 0.0029pu}$$

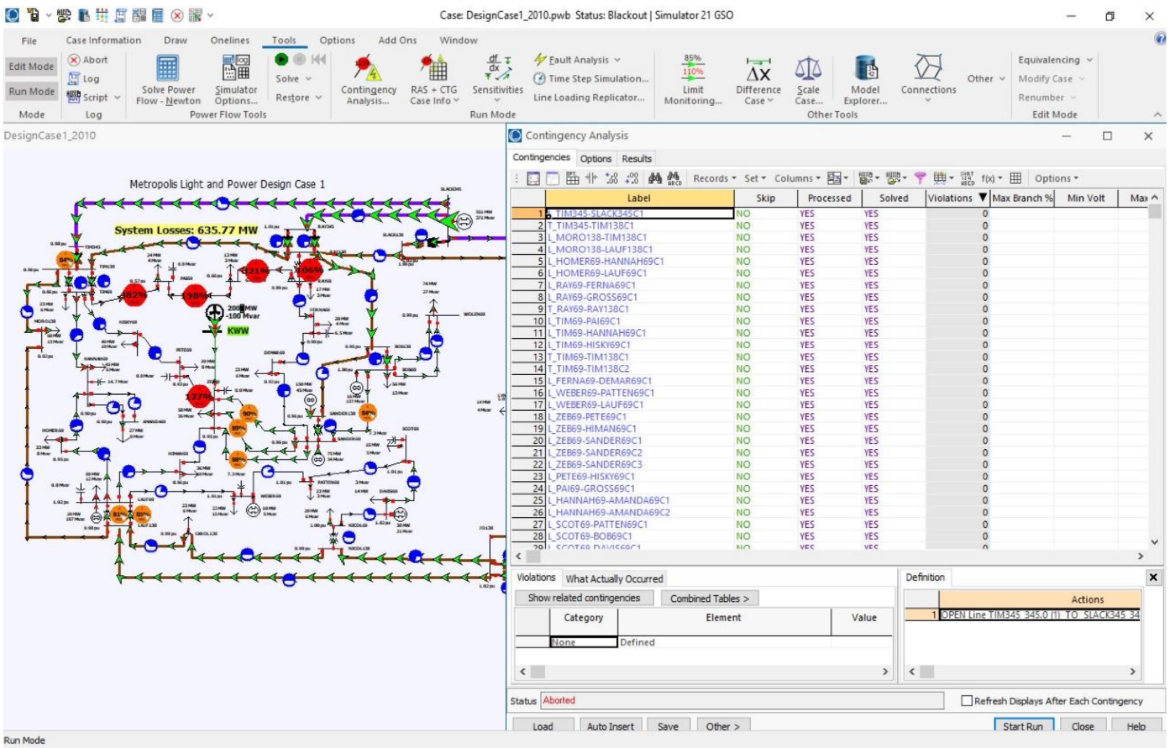

Figure 4: Contingency Analysis reads *Aborted* for KWW to ZEB69 using Condor

Conclusion

For this design case, a transmission line was added from KWW to ZEB69, using a Condor conductor, and a Tangent Wishbone-Single Arm tower. From Fig. 4, we can see that this addition made the system worse because the contingency could not successfully run on this system. A more suitable tower type, Right of Way, and conductor type combination will need to be implemented to reduce losses.

C.3 KWW to PETE69 using Condor and Tangent Double Circuit Suspension & PAI69 using Rook and Tangent Wishbone Single Arm

	Series Resistance	Series Reactance	Susceptance
PETE69 using Condor	0.55 Ω	3.88 Ω	$3.79 \times 10^{-5}\frac{1}{\Omega}$
PAI69 using Rook	0.68 Ω	4.49 Ω	$3.28 \times 10^{-5}\frac{1}{\Omega}$

Table 9: PETE69 using Condor with TDCS Tower and PAI69 using Rook with TWSA R, L, C Solutions

	R_{pu}	X_{L-pu}	B_{pu}
PETE69 using Condor	0.0142 pu	0.106 pu	2.11×10^{-3} pu
PAI69 using Rook	0.0144 pu	0.0944 pu	1.56×10^{-3} pu

Table 10: PETE69 using Condor with TDCS Tower and PAI69 using Rook with TWSA per-unit Solutions

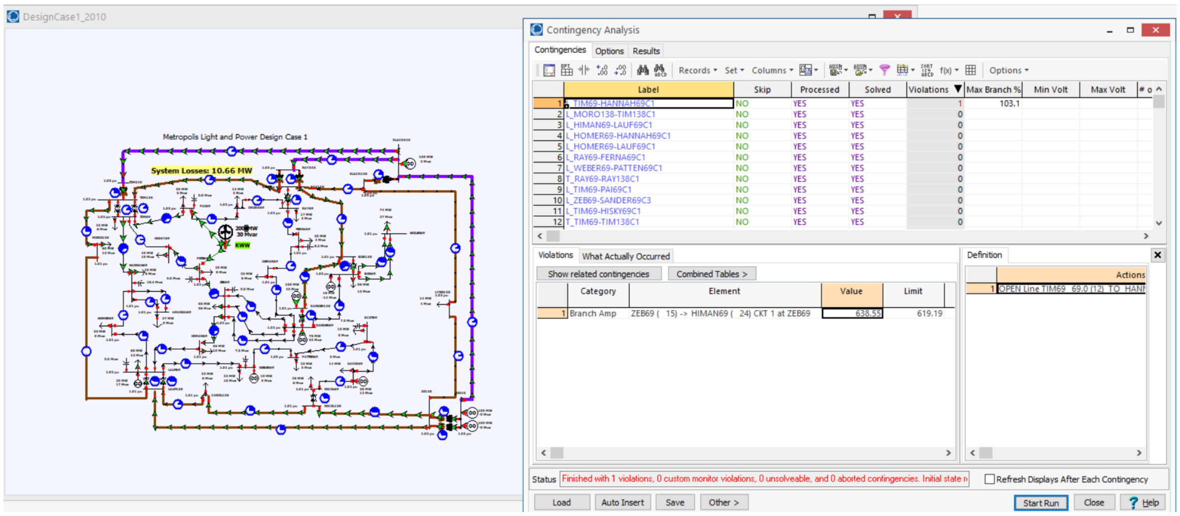

Figure 5: Solution connecting KWW to PETE69 using Condor with TDCS and PAI69 using Rook with TWSA

Conclusion

For this design case, a transmission line was added from KWW to PETE69, using a Condor conductor. A second transmission line was added from KWW to PAI69 using Rook and Tangent Wishbone-Single Arm tower. From Fig. 5, we can see that the system losses decrease to 10.65MW. We can also see that there is one violation in this design; that means it required further enhancements that may or may not increase costs. From Table 18, Sim #24, we can see that this was the second cheapest solution at $5,616,100. It costs $285,600 more than the final design chosen.

C.4 KWW to PETE69 using Condor & PAI69 using Rook both using Tangent Wishbone Single Arm

	Series Resistance	Series Reactance	Susceptance
PETE69 using Condor	0.67 Ω	5.44 Ω	$4.12 \times 10^{-5} \frac{1}{\Omega}$
PAI69 using Rook	0.68 Ω	4.49 Ω	$3.28 \times 10^{-5} \frac{1}{\Omega}$

Table 11: PETE69 using Condor and PAI69 using Rook both with TWSA R, L, C Solutions

	R_{pu}	X_{L-pu}	B_{pu}
PETE69 using Condor	0.0142 pu	0.114 pu	1.96×10^{-3} pu
PAI69 using Rook	0.0144 pu	0.0944 pu	1.56×10^{-3} pu

Table 12: PETE69 using Condor and PAI69 using Rook both with TWSA per-unit Solutions

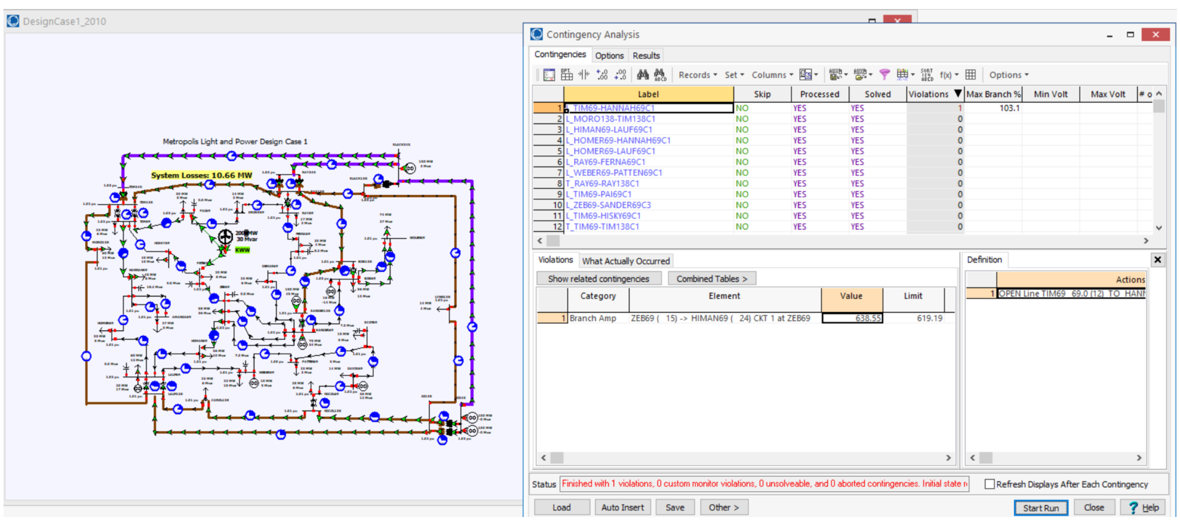

Figure 6: Solution connecting KWW to PETE69 using Condor and PAI69 using Rook with TWSA

Conclusion

For this design case, a transmission line was added from KWW to PETE69, using a Condor conductor. A second transmission line was added from KWW to PAI69 using Rook. Both transmission lines used Tangent Wishbone-Single Arm tower. From Fig. 6, we can see that the system losses decrease to 10.69MW. We can also see that there is one violation in this design; that means it required further enhancements that may or may not increase costs. From Table 18, Sim #23, we can see that this was the third cheapest solution at $5,703,700 It costs $373,200 more than the final design chosen.

C.5 KWW to PAI69 & PETE69 both using Rook and Tangent Wishbone Single Arm

	Series Resistance	Series Reactance	Susceptance
PAI69 using Rook	0.68 Ω	4.49 Ω	$3.28 \times 10^{-5} \frac{1}{\Omega}$
PETE69 using Rook	0.84 Ω	5.54 Ω	$4.04 \times 10^{-5} \frac{1}{\Omega}$

Table 13: PAI69 and PETE69 both using Rook with TWSA R, L, C Solutions

	R_{pu}	X_{L-pu}	B_{pu}
PAI69 using Rook	0.0144 pu	0.0944 pu	1.56×10^{-3} pu
PETE69 using Rook	0.0177 pu	0.116 pu	1.92×10^{-3} pu

Table 14: PAI69 and PETE69 both using Rook with TWSA per-unit Solutions

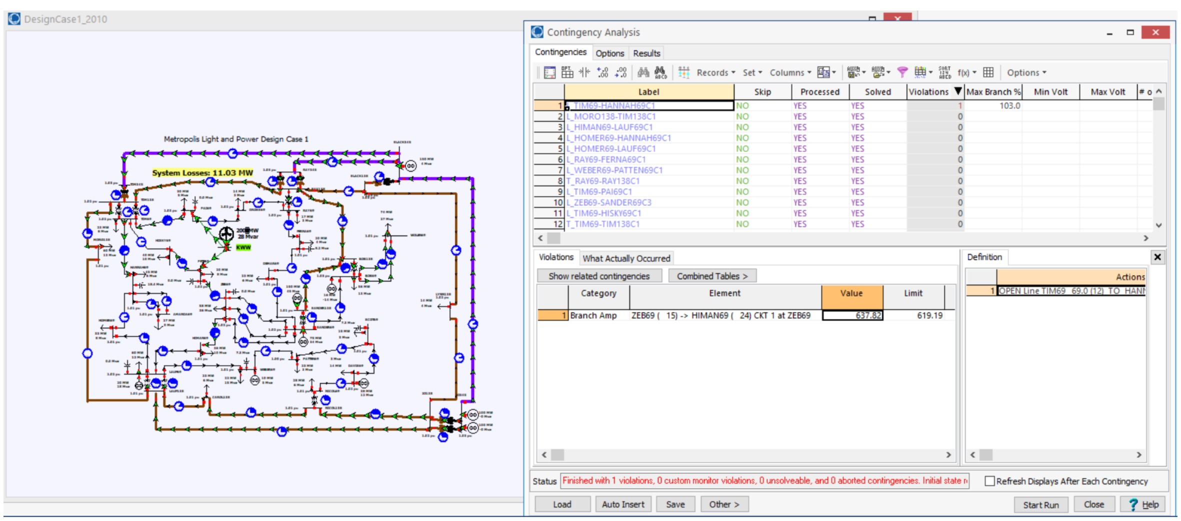

Figure 7: Solution connecting KWW to PAI69 and PETE using Rook with TWSA

Conclusion

For this design case, a transmission line was added from KWW to PAI69, using a Rook conductor. A second transmission line was added from KWW to PETE using Rook conductor as well.

Both transmission lines used Tangent Wishbone-Single Arm tower. From Fig. 7, we can see that the system losses increased to 11.03MW. We can also see that there is one violation in this design; that means it required further enhancements that may or may not increase costs. From Table 18, Sim #16, we can see that solution costs \$6,152,300. It costs \$821,800 more than the final design chosen. This concludes that even though Rook is the cheapest conductor, extra losses over 5 years make using it more expensive.

C.6 KWW to PETE69 using Rook and Tangent Double Circuit Suspension & PAI69 using Rook and Tangent Wishbone Single Arm

	Series Resistance	Series Reactance	Susceptance
PETE69 using Rook	0.85 Ω	4.89 Ω	$4.58 \times 10^{-5} \frac{1}{\Omega}$
PAI69 using Rook	0.68 Ω	4.49 Ω	$3.28 \times 10^{-5} \frac{1}{\Omega}$

Table 15: PETE69 with TDSC and PAI69 with TWSA both using Rook R, L, C Solutions

	R_{pu}	X_{L-pu}	B_{pu}
PETE69 using Rook	0.0.8 pu	0.103 pu	2×10^{-3} pu
PAI69 using Rook	0.014 pu	0.0.94 pu	2×10^{-3} pu

Table 16: PETE69 with TDSC and PAI69 with TWSA both using Rook per-unit Solutions

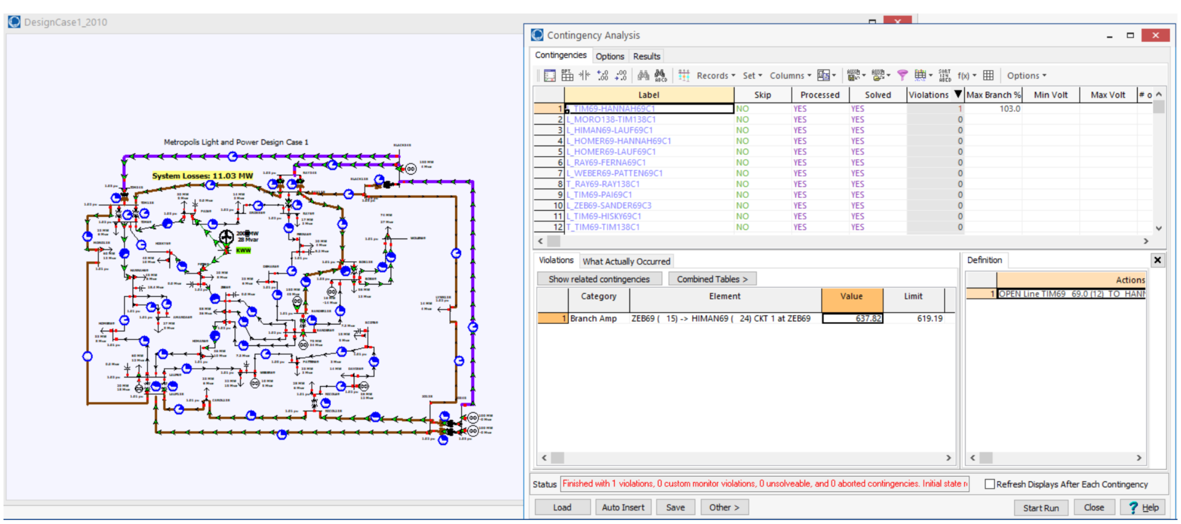

Figure 8: Solution connecting KWW to PAI69 and PETE using Rook with TDSC

Conclusion

For this design case, a transmission line was added from KWW to PETE69, using a Rook conductor using Tangent Double Circuit Suspension tower type. A second transmission line was added from KWW to PAI69 using Rook conductor using Tangent Wishbone-Single Arm tower type. From Fig. 8, we can see that the system losses increased to 11.03MW. We can also see that there is one violation in this design; that means it required further enhancements that may or may not increase costs. From Table 18, Sim #25, we can see that solution costs $6,108,500. It costs $373,200 more than the final design chosen.

D Various Base Cases for Different Tower Types, Conductor Types, and Right-of-Way

Tower Name abbreviations used in Table 17 can be referred to from Table 3.

Table 17: Base case analysis for each combination of Tower, Right-of-Way (R-o-W) and Conductor [1–3]

Case	Tower Name	R-o-W	Conductor	R_{pu}	X_{L-pu}	B_{pu}	Cost
1	TWSA	DEMAR	Crow	0.026	0.187	0.003	$4,999,500
2	TWSA	DEMAR	Rook	0.029	0.189	0.003	$4,759,500
3	TWSA	DEMAR	Condor	0.023	0.185	0.003	$5,239,500
4	TWSA	DEMAR	Cardinal	0.019	0.183	0.003	$5,479,500
5	TWSA	PAI	Crow	0.013	0.094	0.002	$2,572,500
6	TWSA	PAI	Rook	0.014	0.094	0.002	$2,452,500
7	TWSA	PAI	Condor	0.012	0.093	0.002	$2,692,500
8	TWSA	PAI	Cardinal	0.01	0.091	0.002	$2,812,500
9	TWSA	PETE	Crow	0.016	0.115	0.002	$3,138,800
10	TWSA	PETE	Rook	0.018	0.116	0.002	$2,990,800
11	TWSA	PETE	Condor	0.014	0.114	0.002	$3,286,800
12	TWSA	PETE	Cardinal	0.012	0.113	0.002	$3,434,800
13	TWSA	GROSS	Crow	0.01	0.07	0.001	$1,965,750
14	TWSA	GROSS	Rook	0.011	0.071	0.001	$1,875,750
15	TWSA	GROSS	Condor	0.009	0.07	0.001	$2,055,750

Continued on next page

Table 17 – continued from previous page

Case	Tower Name	R-o-W	Conductor	R_{pu}	X_{L-pu}	B_{pu}	Cost
16	TWSA	GROSS	Cardinal	0.007	0.068	0.001	$2,145,750
17	TWSA	HISKY	Crow	0.024	0.175	0.003	$4,675,900
18	TWSA	HISKY	Rook	0.027	0.176	0.003	$4,451,900
19	TWSA	HISKY	Condor	0.022	0.173	0.003	$4,899,900
20	TWSA	HISKY	Cardinal	0.018	0.17	0.003	$5,123,900
21	TWSA	TIM	Crow	0.028	0.203	0.003	$5,404,000
22	TWSA	TIM	Rook	0.031	0.205	0.003	$5,144,000
23	TWSA	TIM	Condor	0.025	0.201	0.003	$5,664,000
24	TWSA	TIM	Cardinal	0.021	0.198	0.003	$5,924,000
25	TWSA	RAY	Crow	0.032	0.234	0.004	$6,213,000
26	TWSA	RAY	Rook	0.036	0.236	0.004	$5,913,000
27	TWSA	RAY	Condor	0.029	0.232	0.004	$6,513,000
28	TWSA	RAY	Cardinal	0.024	0.228	0.004	$6,813,000
29	TWSA	ZEB	Crow	0.024	0.171	0.003	$4,595,000
30	TWSA	ZEB	Rook	0.026	0.173	0.003	$4,375,000
31	TWSA	ZEB	Condor	0.021	0.17	0.003	$4,815,000
32	TWSA	ZEB	Cardinal	0.018	0.167	0.003	$5,035,000
33	TSPS	DEMAR	Crow	0.026	0.17	0.003	$4,999,500
34	TSPS	DEMAR	Rook	0.029	0.171	0.003	$4,759,500
35	TSPS	DEMAR	Condor	0.023	0.168	0.004	$5,239,500
36	TSPS	DEMAR	Cardinal	0.019	0.165	0.004	$5,479,500
37	TSPS	PAI	Crow	0.013	0.085	0.002	$2,572,500
38	TSPS	PAI	Rook	0.014	0.086	0.002	$2,452,500
39	TSPS	PAI	Condor	0.012	0.084	0.002	$2,692,500
40	TSPS	PAI	Cardinal	0.01	0.083	0.002	$2,812,500
41	TSPS	PETE	Crow	0.016	0.105	0.002	$3,138,800

Continued on next page

Table 17 – continued from previous page

Case	Tower Name	R-o-W	Conductor	R_{pu}	X_{L-pu}	B_{pu}	Cost
42	TSPS	PETE	Rook	0.018	0.106	0.002	$2,990,800
43	TSPS	PETE	Condor	0.014	0.104	0.002	$3,286,800
44	TSPS	PETE	Cardinal	0.012	0.102	0.002	$3,434,800
45	TSPS	GROSS	Crow	0.01	0.064	0.001	$1,965,750
46	TSPS	GROSS	Rook	0.011	0.064	0.001	$1,875,750
47	TSPS	GROSS	Condor	0.009	0.063	0.001	$2,055,750
48	TSPS	GROSS	Cardinal	0.007	0.062	0.001	$2,145,750
49	TSPS	HISKY	Crow	0.024	0.158	0.003	$4,675,900
50	TSPS	HISKY	Rook	0.027	0.16	0.003	$4,451,900
51	TSPS	HISKY	Condor	0.022	0.157	0.003	$4,899,900
52	TSPS	HISKY	Cardinal	0.018	0.154	0.003	$5,123,900
53	TSPS	TIM	Crow	0.028	0.184	0.004	$5,404,000
54	TSPS	TIM	Rook	0.031	0.186	0.004	$5,144,000
55	TSPS	TIM	Condor	0.025	0.182	0.004	$5,664,000
56	TSPS	TIM	Cardinal	0.021	0.179	0.004	$5,924,000
57	TSPS	RAY	Crow	0.032	0.212	0.004	$6,213,000
58	TSPS	RAY	Rook	0.036	0.214	0.004	$5,913,000
59	TSPS	RAY	Condor	0.029	0.21	0.004	$6,513,000
60	TSPS	RAY	Cardinal	0.024	0.207	0.004	$6,813,000
61	TSPS	ZEB	Crow	0.024	0.156	0.003	$4,595,000
62	TSPS	ZEB	Rook	0.026	0.157	0.003	$4,375,000
63	TSPS	ZEB	Condor	0.021	0.154	0.003	$4,815,000
64	TSPS	ZEB	Cardinal	0.018	0.151	0.003	$5,035,000
65	TSPS w/ Brackets	DEMAR	Crow	0.026	0.174	0.003	$4,999,500
66	TSPS w/ Brackets	DEMAR	Rook	0.029	0.176	0.003	$4,759,500
67	TSPS w/ Brackets	DEMAR	Condor	0.023	0.172	0.003	$5,239,500

Continued on next page

Table 17 – continued from previous page

Case	Tower Name	R-o-W	Conductor	R_{pu}	X_{L-pu}	B_{pu}	Cost
68	TSPS w/ Brackets	DEMAR	Cardinal	0.019	0.169	0.003	$5,479,500
69	TSPS w/ Brackets	PAI	Crow	0.013	0.087	0.002	$2,572,500
70	TSPS w/ Brackets	PAI	Rook	0.014	0.088	0.002	$2,452,500
71	TSPS w/ Brackets	PAI	Condor	0.012	0.086	0.002	$2,692,500
72	TSPS w/ Brackets	PAI	Cardinal	0.01	0.085	0.002	$2,812,500
73	TSPS w/ Brackets	PETE	Crow	0.016	0.107	0.002	$3,138,800
74	TSPS w/ Brackets	PETE	Rook	0.018	0.108	0.002	$2,990,800
75	TSPS w/ Brackets	PETE	Condor	0.014	0.106	0.002	$3,286,800
76	TSPS w/ Brackets	PETE	Cardinal	0.012	0.104	0.002	$3,434,800
77	TSPS w/ Brackets	GROSS	Crow	0.01	0.065	0.001	$1,965,750
78	TSPS w/ Brackets	GROSS	Rook	0.011	0.066	0.001	$1,875,750
79	TSPS w/ Brackets	GROSS	Condor	0.009	0.065	0.001	$2,055,750
80	TSPS w/ Brackets	GROSS	Cardinal	0.007	0.064	0.001	$2,145,750
81	TSPS w/ Brackets	HISKY	Crow	0.024	0.162	0.003	$4,675,900
82	TSPS w/ Brackets	HISKY	Rook	0.027	0.164	0.003	$4,451,900
83	TSPS w/ Brackets	HISKY	Condor	0.022	0.161	0.003	$4,899,900
84	TSPS w/ Brackets	HISKY	Cardinal	0.018	0.158	0.003	$5,123,900
85	TSPS w/ Brackets	TIM	Crow	0.028	0.188	0.004	$5,404,000
86	TSPS w/ Brackets	TIM	Rook	0.031	0.19	0.004	$5,144,000
87	TSPS w/ Brackets	TIM	Condor	0.025	0.187	0.004	$5,664,000
88	TSPS w/ Brackets	TIM	Cardinal	0.021	0.184	0.004	$5,924,000
89	TSPS w/ Brackets	RAY	Crow	0.032	0.217	0.004	$6,213,000
90	TSPS w/ Brackets	RAY	Rook	0.036	0.22	0.004	$5,913,000
91	TSPS w/ Brackets	RAY	Condor	0.029	0.215	0.004	$6,513,000
92	TSPS w/ Brackets	RAY	Cardinal	0.024	0.212	0.004	$6,813,000
93	TSPS w/ Brackets	ZEB	Crow	0.024	0.159	0.003	$4,595,000

Continued on next page

Table 17 – continued from previous page

Case	Tower Name	R-o-W	Conductor	R_{pu}	X_{L-pu}	B_{pu}	Cost
94	TSPS w/ Brackets	ZEB	Rook	0.026	0.161	0.003	$4,375,000
95	TSPS w/ Brackets	ZEB	Condor	0.021	0.158	0.003	$4,815,000
96	TSPS w/ Brackets	ZEB	Cardinal	0.018	0.155	0.003	$5,035,000
97	TDSC	DEMAR	Crow	0.026	0.165	0.004	$4,999,500
98	TDSC	DEMAR	Rook	0.029	0.167	0.004	$4,759,500
99	TDSC	DEMAR	Condor	0.023	0.163	0.004	$5,239,500
100	TDSC	DEMAR	Cardinal	0.019	0.16	0.004	$5,479,500
101	TDSC	PAI	Crow	0.013	0.082	0.002	$2,572,500
102	TDSC	PAI	Rook	0.014	0.083	0.002	$2,452,500
103	TDSC	PAI	Condor	0.012	0.082	0.002	$2,692,500
104	TDSC	PAI	Cardinal	0.01	0.08	0.002	$2,812,500
105	TDSC	PETE	Crow	0.016	0.102	0.002	$3,138,800
106	TDSC	PETE	Rook	0.018	0.103	0.002	$2,990,800
107	TDSC	PETE	Condor	0.014	0.101	0.002	$3,286,800
108	TDSC	PETE	Cardinal	0.012	0.099	0.002	$3,434,800
109	TDSC	GROSS	Crow	0.01	0.062	0.001	$1,965,750
110	TDSC	GROSS	Rook	0.011	0.062	0.001	$1,875,750
111	TDSC	GROSS	Condor	0.009	0.061	0.001	$2,055,750
112	TDSC	GROSS	Cardinal	0.007	0.06	0.001	$2,145,750
113	TDSC	HISKY	Crow	0.024	0.154	0.003	$4,675,900
114	TDSC	HISKY	Rook	0.027	0.155	0.003	$4,451,900
115	TDSC	HISKY	Condor	0.022	0.152	0.003	$4,899,900
116	TDSC	HISKY	Cardinal	0.018	0.15	0.003	$5,123,900
117	TDSC	TIM	Crow	0.028	0.178	0.004	$5,404,000
118	TDSC	TIM	Rook	0.031	0.18	0.004	$5,144,000
119	TDSC	TIM	Condor	0.025	0.177	0.004	$5,664,000

Continued on next page

Table 17 – continued from previous page

Case	Tower Name	R-o-W	Conductor	R_{pu}	X_{L-pu}	B_{pu}	Cost
120	TDSC	TIM	Cardinal	0.021	0.174	0.004	$5,924,000
121	TDSC	RAY	Crow	0.032	0.206	0.004	$6,213,000
122	TDSC	RAY	Rook	0.036	0.208	0.004	$5,913,000
123	TDSC	RAY	Condor	0.029	0.204	0.005	$6,513,000
124	TDSC	RAY	Cardinal	0.024	0.2	0.005	$6,813,000
125	TDSC	ZEB	Crow	0.024	0.151	0.003	$4,595,000
126	TDSC	ZEB	Rook	0.026	0.153	0.003	$4,375,000
127	TDSC	ZEB	Condor	0.021	0.15	0.003	$4,815,000
128	TDSC	ZEB	Cardinal	0.018	0.147	0.003	$5,035,000

E Simulation of Losses Using 2 or More Base Cases for Interconnections

Sim # in Table 18 is the Simulation number that helps keep track of various simulations. Case #1, Case #2 and Case #3 refer to the design case used (Tower, Right-of-Way and Conductor) from Table 17 to perform the simulation.

Table 18: Combined Case analysis of at least 2 or more interconnections in PowerWorld.

Sim #	Case #1	Case #2	Case #3	Additional Losses	Total Cost Over 5 Years
1	44	56	40	-1.42MW	$9,069,700
2	44	56	0	-0.08MW	$9,191,800
3	44	40	0	-0.69MW	$4,744,400
4	40	56	0	0.94MW	$10,795,100
5	12	24	0	-0.04MW	$9,279,400
6	12	24	8	-1.45MW	$9,279,400
7	12	24	4	-0.81MW	$13,072,600
8	12	4	0	0.99MW	$11,090,600
9	24	4	0	2.54MW	$16,966,100
10	6	14	0	3.45MW	$11,884,000

Continued on next page

Table 18 – continued from previous page

Sim #	**Case 1**	**Case w**	**Case 3**	**Additional Losses**	**Total Cost**
11	6	14	1	0.63MW	$10,717,700
12	10	14	0	1.05MW	$7,184,500
13	42	46	0	0.98MW	$7,031,200
14	6	14	18	-0.21MW	$8,334,600
16	6	10	0	0.32MW	$6,152,300
17	30	10	0	-0.39MW	$6,519,900
18	32	10	0	-0.91MW	$6,041,100
19	44	46	0	0.35MW	$6,095,500
20	44	48	0	0.11MW	$5,839,900
21	2	10	0	-0.5MW	$6,663,500
22	10	26	0	-0.63MW	$7,532,300
23	11	6	0	-0.02MW	$5,703,700
24	75	6	0	-0.06MW	$5,616,100
25	106	6	0	0.3MW	$6,108,500
26	103	42	0	0.05MW	$5,801,000
27	103	43	0	-0.3MW	$5,339,500

F Tower Configurations

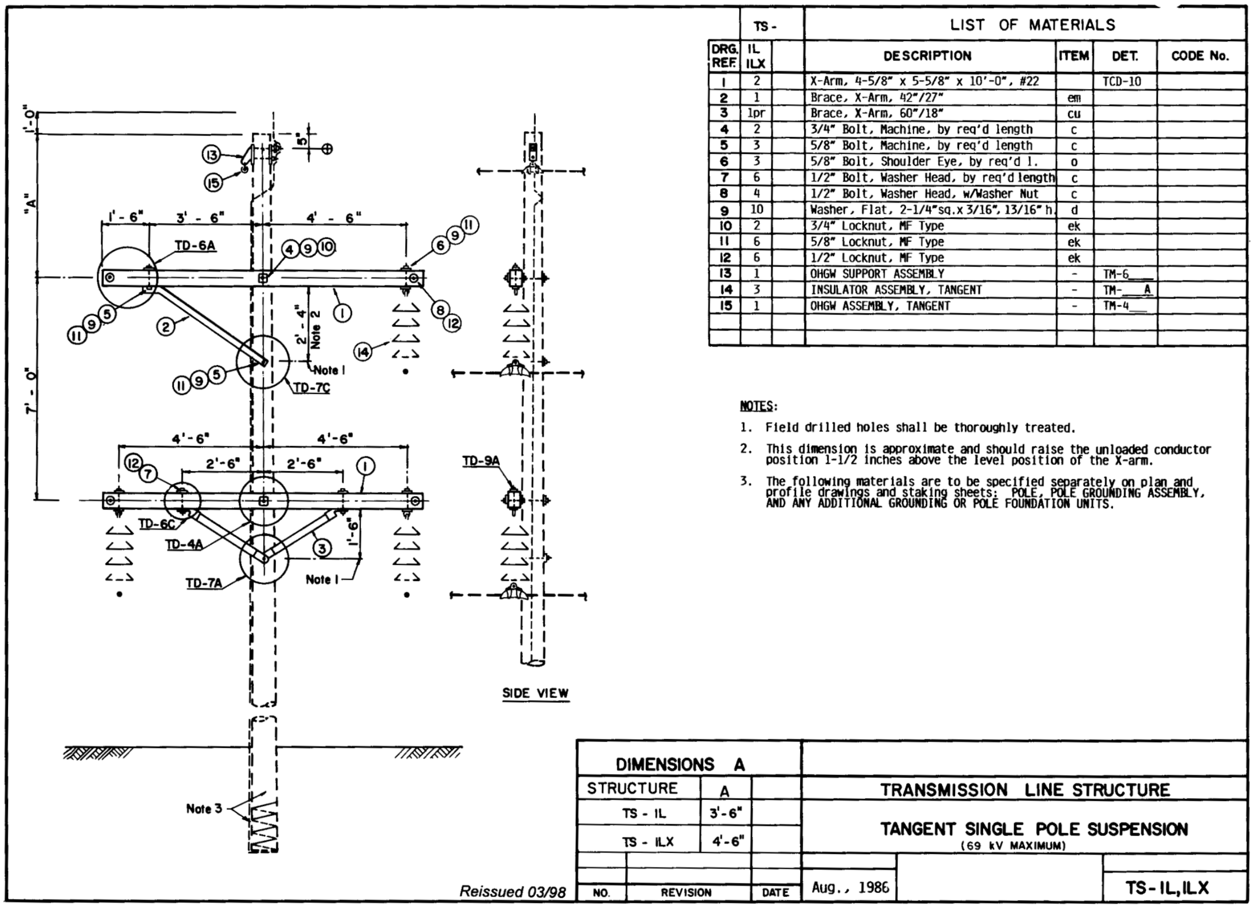

Figure 9: Tangent Single Pole Suspension Tower Used to Connect KWW to PETE69

In Fig. 9 and 10, we can see the transmission towers that were used in the design. Both towers support up to a maximum of 69kV. The design also used 69kV transmission lines. The estimated cost for each tower is approximately $20,500, which includes construction [5].

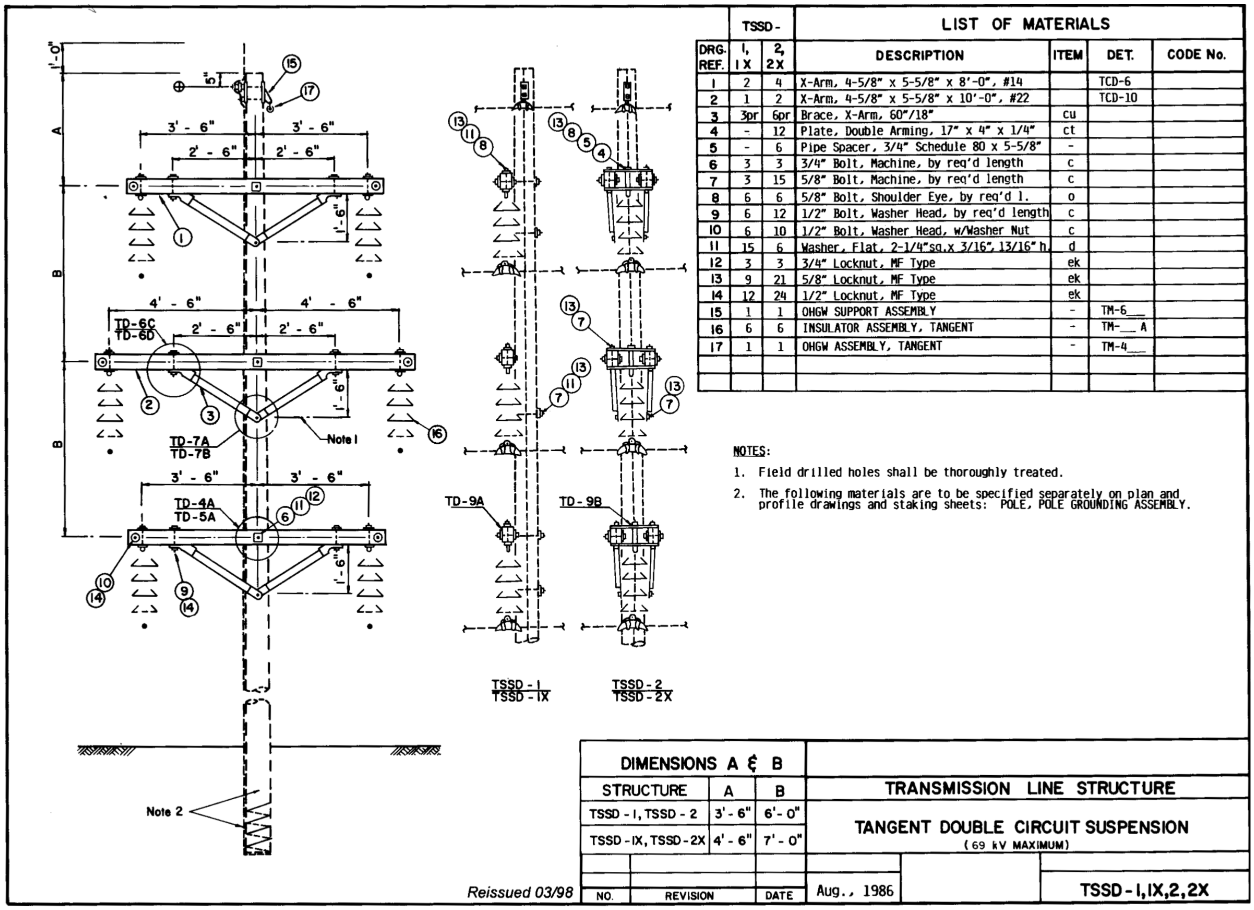

Figure 10: Tangent Double Circuit Suspension Tower Used to Connect KWW to PAI69

References

[1] J. Zirnheld, "Final Project Description and Class Handouts, Power Systems Engineering 1," *The State University of New York, University at Buffalo*, Fall 2019. [Online]. Available: https://www.ublearns.buffalo.edu

[2] J. D. Glover, T. J. Overbye, and M. S. Sarma, *Power System Analysis and Design, 6th ed.* Cengage Learning, 2017.

[3] *Electric Transmission Specifications and Drawings, 34.5kV Through 69kV*, 1998. [Online]. Available: https://www.rd.usda.gov/files/UEP_Bulletin_1728F-811.pdf

[4] S. DiSavino, "New York adopts rules to phase out coal power plants by 2020," May 2019. [Online]. Available: https://www.reuters.com/article/us-new-york-coal/new-york-adopts-rules-to-phase-out-coal-power-plants-by-2020-idUSKCN1SG24U

[5] "Transmission Cost Estimation Guide — MTEP 2019," 2019. [Online]. Available: https://cdn.misoenergy.org/20190212%20PSC%20Item%2005a%20Transmission%20Cost%20Estimation%20Guide%20for%20MTEP%202019_for%20review317692.pdf

[6] "Condor, ACSR Aluminum Conductor Steel Reinforced," 2010. [Online]. Available: http://wire.buyawg.com/item/bare-aluminum-acsr/acsr-aluminum-conductor-steel-reinforced/condor

[7] "Rook, ACSR Aluminum Conductor Steel Reinforced," 2010. [Online]. Available: http://wire.buyawg.com/item/bare-aluminum-acsr/acsr-aluminum-conductor-steel-reinforced/rook

[8] E. Electrical Engineering Portal, "The basics of underground power transmission lines," Aug 2017. [Online]. Available: https://electrical-engineering-portal.com/download-center/books-and-guides/power-substations/underground-power-transmission-lines

[9] A. T. Company, "Stray voltage," 2017. [Online]. Available: https://www.atc-projects.com/learning-center/stray-voltage/

[10] P. Service, "04-m-0159: Electric safety standards," 2015. [Online]. Available: https://www3.dps.ny.gov/W/PSCWeb.nsf/All/400E5FF8A07FEFC185257687006F38C8?OpenDocument

[11] "OSHA: Transmission Lines." [Online]. Available: https://www.osha.gov/SLTC/etools/electric_power/illustrated_glossary/transmission_lines.html

[12] "Make a Safety Boundary." [Online]. Available: http://firstenergy.e-smartonline.net/worker/69140_safe_practices/69142_look_up/boundary.html

[13] N. .Gov, "Jedi line model," 2014. [Online]. Available: https://www.nrel.gov/analysis/jedi/transmission.html

[14] "Greenhouse gases equivalencies calculator - calculations and references," Dec 2018. [Online]. Available: https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

[15] "America's top ten most endangered birds," Mar 2006. [Online]. Available: https://www.audubon.org/sites/default/files/documents/Top10_Endangered_Species.pdf

[16] N. .Gov, "Jedi transmission line model," 2012. [Online]. Available: https://www.nrel.gov/analysis/jedi/transmission-line.html

[17] M. Goldberg and D. Keyser, "Transmission line jobs and economic development impact (jedi) model user reference guide," Oct 2013. [Online]. Available: https://www.nrel.gov/docs/fy14osti/60250.pdf

[18] F. Rimmer, "Transmission line operations and maintenance," Apr 2005. [Online]. Available: https://electricenergyonline.com/energy/magazine/200/article/Transmission-Line-Operations-and-Maintenance.htm

[19] O. .gov, "Ministry of agriculture, food and rural affairs," 2019. [Online]. Available: www.omafra.gov.on.ca/english/livestock/dairy/facts/strayvol.htm

[20] D. O. Carpenter, "Human disease resulting from exposure to electromagnetic fields," *Reviews on Environmental Health*, vol. 28, no. 4, 2013.

[21] "Constructions standards, general requirements," Sep 2016. [Online]. Available: https://www.wapa.gov/DoingBusiness/SellingToWestern/Documents/ConstructionStandard2016.pdf

[22] P. W. Corporation, "PowerWorld Transmission Line Parameter Calculator Version 2," Apr 2013. [Online]. Available: https://www.powerworld.com/files/TransLineCalcHelp2.pdf

20, 22, 24, 32	GROUP	Timesheet
SEAT NUMBER	**LAST NAME** (ALL Printed Capitals)	**First Name** (Upper & Lower case)

(Use the above format of seat number and names on every page of all submitted materials)

/ Do NOT write in space below/ / / / / / / / / / / / / / / / / / /

TIME SCHEDULE:
(Decimal Hours)
Travel: 8.0
Reading: 23.0
Typing: 31.0
Consultation: 16.5
Other: 66.0
Measurement: 0.0
Library: 0.0
Looking: 0.0
Photocopy: 0.0
Total: 144.5

Seat Number	Name	Email
24	Siddhant Khera	skhera2@buffalo.edu
22	Eric Johnson	ej37@buffalo.edu
20	Daniel Giovino	dcgiovin@buffalo.edu
32	Catherine Rogers	crrogers@buffalo.edu

Circle Correct Code in Left Margin

Circle **CT-N** if you plan to give a presentation. Circle **CT-TC** if you plan on coordinating a tour with up to three other group members, in which case you will **not** present your presentation in front of the class.

CT-N: Chosen Topic for Non Tour Coordinator: ______________________________
List the topic you propose to do your DP and presentation on.

CT-TC: Chosen **T**opic for **T**our **C**oordinator. The Tour Coordinator Leader will do only ONE **CT-TC** cover sheet per Tour Coordinating Group "Tour Letter and Name: ?______________________________", Place Team Leader seat number, name at the top of the page. In the empty space above give team member's: seat number, names and telephone numbers, including yours. Attach a communication Letter of Intent to or from your contact initiating tour coordination.

Circle **DP** if today is the day you are turning in your presentation. EVERYONE is required to turn in Draft Presentation, but not everyone is required to present them.

DP: Draft Presentation: Competitively and independently graded copies (which I keep) of the material you are proposing to use as your presentation, maximum of three (3) pages for undergraduates and five (5) pages for graduates, (DP's must have words, figures, numbers and a prime reference). Also, turn in one loose cover sheet with the copy of your presentation. **Fill out the time schedule above if DP is circled.**

Circle **FP** if you are turning in the final project today. Make sure you fill in the title of your final project on the line below, and make sure your report adheres to the guidelines given below or else it will not be accepted. Attach this coversheet to the FP with all group members seat number's, names and university email addresses in the blank space above. Also turn in a loose coversheet for each group member with only their information filled in, including the hours they worked on the project.

Final Project Title: Preliminary Analysis for Transmission System To Connect KWW Generation Substation

FP: Final Project: Competitively and independently graded, instructor keeps the original (you keep a copy), maximum of 100 pages five staples evenly spaced along the left edge. Report is double-spaced TYPED on 8-1/2" x 11" paper, with 1" margins, single-sided, no legal paper, IEEE Reference format: See Ublearns. Also, turn in one loose, FP cover sheet for each team member with their name and seat number at the top and completed time schedule. **PLEASE NO FOLDERS OR BINDING.** Instructor has a stapler that can do the job. **Fill out the time schedule above if FP is circled.**

24		KHERA	Siddhant
SEAT NUMBER		**LAST NAME** (ALL Printed Capitals)	**First Name** (Upper & Lower case)

(Use the above format of seat number and names on every page of all submitted materials)

/ Do NOT write in space below/ / / / / / / / / / / / / / / / / / /

TIME SCHEDULE:
(Decimal Hours)
Travel: 2.0
Reading: 7.0
Typing: 20.0
Consultation: 7.0
Other: 20.5
Measurement: 0.0
Library: 0.0
Looking: 0.0
Photocopy: 0.0
Total: 56.5

Seat Number	Name	Email
24	**Siddhant Khera**	**skhera2@buffalo.edu**
22	Eric Johnson	ej37@buffalo.edu
20	Daniel Giovino	dcgiovin@buffalo.edu
32	Catherine Rogers	crrogers@buffalo.edu

Circle Correct Code in Left Margin

Circle **CT-N** if you plan to give a presentation. Circle **CT-TC** if you plan on coordinating a tour with up to three other group members, in which case you will **not** present your presentation in front of the class.

CT-N: Chosen Topic for Non Tour Coordinator: ______________________________
List the topic you propose to do your DP and presentation on.

CT-TC: Chosen **T**opic for **T**our **C**oordinator. The Tour Coordinator Leader will do only ONE **CT-TC** cover sheet per Tour Coordinating Group "Tour Letter and Name: ?______________________", Place Team Leader seat number, name at the top of the page. In the empty space above give team member's: seat number, names and telephone numbers, including yours. Attach a communication Letter of Intent to or from your contact initiating tour coordination.

Circle **DP** if today is the day you are turning in your presentation. EVERYONE is required to turn in Draft Presentation, but not everyone is required to present them.

DP: Draft Presentation: Competitively and independently graded copies (which I keep) of the material you are proposing to use as your presentation, maximum of three (3) pages for undergraduates and five (5) pages for graduates, (DP's must have words, figures, numbers and a prime reference). Also, turn in one loose cover sheet with the copy of your presentation. **Fill out the time schedule above if DP is circled.**

Circle **FP** if you are turning in the final project today. Make sure you fill in the title of your final project on the line below, and make sure your report adheres to the guidelines given below or else it will not be accepted. Attach this coversheet to the FP with all group members seat number's, names and university email addresses in the blank space above. Also turn in a loose coversheet for each group member with only their information filled in, including the hours they worked on the project.

Final Project Title: Preliminary Analysis for Transmission System To Connect KWW Generation Substation

FP: Final Project: Competitively and independently graded, instructor keeps the original (you keep a copy), maximum of 100 pages five staples evenly spaced along the left edge. Report is double-spaced TYPED on 8-1/2" x 11" paper, with 1" margins, single-sided, no legal paper, IEEE Reference format: See Ublearns. Also, turn in one loose, FP cover sheet for each team member with their name and seat number at the top and completed time schedule. **PLEASE NO FOLDERS OR BINDING.** Instructor has a stapler that can do the job. **Fill out the time schedule above if FP is circled.**

22		JOHNSON	Eric
SEAT NUMBER		**LAST NAME** (ALL Printed Capitals)	**First Name** (Upper & Lower case)

(Use the above format of seat number and names on every page of all submitted materials)

/ Do NOT write in space below/ / / / / / / / / / / / / / / / / / /

TIME SCHEDULE:
(Decimal Hours)
Travel: 4.0
Reading: 10.0
Typing: 6.0
Consultation: 8.0
Other: 10.0
Measurement: 0.0
Library: 0.0
Looking: 0.0
Photocopy: 0.0
Total: 38.0

Seat Number	Name	Email
24	Siddhant Khera	skhera2@buffalo.edu
22	**Eric Johnson**	**ej37@buffalo.edu**
20	Daniel Giovino	dcgiovin@buffalo.edu
32	Catherine Rogers	crrogers@buffalo.edu

Circle Correct Code in Left Margin

Circle **CT-N** if you plan to give a presentation. Circle **CT-TC** if you plan on coordinating a tour with up to three other group members, in which case you will **not** present your presentation in front of the class.

CT-N: Chosen Topic for Non Tour Coordinator: ______________________________
List the topic you propose to do your DP and presentation on.

CT-TC: Chosen **T**opic for **T**our **C**oordinator. The Tour Coordinator Leader will do only ONE **CT-TC** cover sheet per Tour Coordinating Group "Tour Letter and Name: ?______________________", Place Team Leader seat number, name at the top of the page. In the empty space above give team member's: seat number, names and telephone numbers, including yours. Attach a communication Letter of Intent to or from your contact initiating tour coordination.

Circle **DP** if today is the day you are turning in your presentation. EVERYONE is required to turn in Draft Presentation, but not everyone is required to present them.

DP: Draft Presentation: Competitively and independently graded copies (which I keep) of the material you are proposing to use as your presentation, maximum of three (3) pages for undergraduates and five (5) pages for graduates, (DP's must have words, figures, numbers and a prime reference). Also, turn in one loose cover sheet with the copy of your presentation. **Fill out the time schedule above if DP is circled.**

Circle **FP** if you are turning in the final project today. Make sure you fill in the title of your final project on the line below, and make sure your report adheres to the guidelines given below or else it will not be accepted. Attach this coversheet to the FP with all group members seat number's, names and university email addresses in the blank space above. Also turn in a loose coversheet for each group member with only their information filled in, including the hours they worked on the project.

Final Project Title: Preliminary Analysis for Transmission System To Connect KWW Generation Substation

FP: Final Project: Competitively and independently graded, instructor keeps the original (you keep a copy), maximum of 100 pages five staples evenly spaced along the left edge. Report is double-spaced TYPED on 8-1/2" x 11" paper, with 1" margins, single-sided, no legal paper, IEEE Reference format: See Ublearns. Also, turn in one loose, FP cover sheet for each team member with their name and seat number at the top and completed time schedule. **PLEASE NO FOLDERS OR BINDING.** Instructor has a stapler that can do the job. **Fill out the time schedule above if FP is circled.**

20		GIOVINO	Daniel
SEAT NUMBER		**LAST NAME** (ALL Printed Capitals)	**First Name** (Upper & Lower case)

(Use the above format of seat number and names on every page of all submitted materials)

/ Do NOT write in space below/ / / / / / / / / / / / / / / / / / /

TIME SCHEDULE:
(Decimal Hours)
Travel: 1.5
Reading: 2.0
Typing: 5.0
Consultation: 0.0
Other: 25.5
Measurement: 0.0
Library: 0.0
Looking: 0.0
Photocopy: 0.0
Total: 34.0

Seat Number	Name	Email
24	Siddhant Khera	skhera2@buffalo.edu
22	Eric Johnson	ej37@buffalo.edu
20	**Daniel Giovino**	**dcgiovin@buffalo.edu**
32	Catherine Rogers	crrogers@buffalo.edu

Circle Correct Code in Left Margin

Circle **CT-N** if you plan to give a presentation. Circle **CT-TC** if you plan on coordinating a tour with up to three other group members, in which case you will **not** present your presentation in front of the class.

CT-N: Chosen Topic for Non Tour Coordinator: ______________________________
List the topic you propose to do your DP and presentation on.

CT-TC: Chosen **T**opic for **T**our **C**oordinator. The Tour Coordinator Leader will do only ONE **CT-TC** cover sheet per Tour Coordinating Group "Tour Letter and Name: ?______________________", Place Team Leader seat number, name at the top of the page. In the empty space above give team member's: seat number, names and telephone numbers, including yours. Attach a communication Letter of Intent to or from your contact initiating tour coordination.

Circle **DP** if today is the day you are turning in your presentation. EVERYONE is required to turn in Draft Presentation, but not everyone is required to present them.

DP: **D**raft **P**resentation: Competitively and independently graded copies (which I keep) of the material you are proposing to use as your presentation, maximum of three (3) pages for undergraduates and five (5) pages for graduates, (DP's must have words, figures, numbers and a prime reference). Also, turn in one loose cover sheet with the copy of your presentation. **Fill out the time schedule above if DP is circled.**

Circle **FP** if you are turning in the final project today. Make sure you fill in the title of your final project on the line below, and make sure your report adheres to the guidelines given below or else it will not be accepted. Attach this coversheet to the FP with all group members seat number's, names and university email addresses in the blank space above. Also turn in a loose coversheet for each group member with only their information filled in, including the hours they worked on the project.

Final Project Title: Preliminary Analysis for Transmission System To Connect KWW Generation Substation

FP: Final Project: Competitively and independently graded, instructor keeps the original (you keep a copy), maximum of 100 pages five staples evenly spaced along the left edge. Report is double-spaced TYPED on 8-1/2" x 11" paper, with 1" margins, single-sided, no legal paper, IEEE Reference format: See Ublearns. Also, turn in one loose, FP cover sheet for each team member with their name and seat number at the top and completed time schedule. **PLEASE NO FOLDERS OR BINDING.** Instructor has a stapler that can do the job. **Fill out the time schedule above if FP is circled.**

32	ROGERS	Catherine
SEAT NUMBER	**LAST NAME** (ALL Printed Capitals)	**First Name** (Upper & Lower case)

(Use the above format of seat number and names on every page of all submitted materials)

/ Do NOT write in space below/ / / / / / / / / / / / / / / / / / / /

TIME SCHEDULE:
(Decimal Hours)
Travel: 0.5
Reading: 4.0
Typing: 0.0
Consultation: 1.5
Other: 10.0
Measurement: 0.0
Library: 0.0
Looking: 0.0
Photocopy: 0.0
Total: 16.0

Seat Number	Name	Email
24	Siddhant Khera	skhera2@buffalo.edu
22	Eric Johnson	ej37@buffalo.edu
20	Daniel Giovino	dcgiovin@buffalo.edu
32	**Catherine Rogers**	**crrogers@buffalo.edu**

Circle Correct Code in Left Margin

Circle **CT-N** if you plan to give a presentation. Circle **CT-TC** if you plan on coordinating a tour with up to three other group members, in which case you will **not** present your presentation in front of the class.

CT-N: Chosen Topic for Non Tour Coordinator: ______________________
List the topic you propose to do your DP and presentation on.

CT-TC: Chosen **T**opic for **T**our **C**oordinator. The Tour Coordinator Leader will do only ONE **CT-TC** cover sheet per Tour Coordinating Group "Tour Letter and Name: ?______________________", Place Team Leader seat number, name at the top of the page. In the empty space above give team member's: seat number, names and telephone numbers, including yours. Attach a communication Letter of Intent to or from your contact initiating tour coordination.

Circle **DP** if today is the day you are turning in your presentation. EVERYONE is required to turn in Draft Presentation, but not everyone is required to present them.

DP: Draft Presentation: Competitively and independently graded copies (which I keep) of the material you are proposing to use as your presentation, maximum of three (3) pages for undergraduates and five (5) pages for graduates, (DP's must have words, figures, numbers and a prime reference). Also, turn in one loose cover sheet with the copy of your presentation. **Fill out the time schedule above if DP is circled.**

Circle **FP** if you are turning in the final project today. Make sure you fill in the title of your final project on the line below, and make sure your report adheres to the guidelines given below or else it will not be accepted. Attach this coversheet to the FP with all group members seat number's, names and university email addresses in the blank space above. Also turn in a loose coversheet for each group member with only their information filled in, including the hours they worked on the project.

Final Project Title: Preliminary Analysis for Transmission System To Connect KWW Generation Substation

FP: Final Project: Competitively and independently graded, instructor keeps the original (you keep a copy), maximum of 100 pages five staples evenly spaced along the left edge. Report is double-spaced TYPED on 8-1/2" x 11" paper, with 1" margins, single-sided, no legal paper, IEEE Reference format: See Ublearns. Also, turn in one loose, FP cover sheet for each team member with their name and seat number at the top and completed time schedule. **PLEASE NO FOLDERS OR BINDING.** Instructor has a stapler that can do the job. **Fill out the time schedule above if FP is circled.**