



# **Interconnection Facilities Study Report**

## **Request # GI-2004-2**

**238 MW Wind Facility Located Near Lamar, Colorado  
Interconnecting at the Lamar Switching Station**

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Xcel Energy Services, Inc.  
Transmission Planning – Denver, CO

## I. Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo) to specify and estimate the cost of the equipment, engineering, procurement, and construction needed to interconnect the 238 MW of new generation from the existing Colorado Green Wind Farm at the Lamar Switching Station in Prowers County, Colorado. The expansion would be located just South of the Colorado Green Wind Farm and would interconnect at the existing Colorado Green Substation via the Customer's 7-mile 230 kV transmission line. The requested commercial in-service date is 12/31/05. However, the results of this study indicate that it is not feasible to implement the upgrades required to accommodate the project on a firm basis by the requested date.

The recommended Network Upgrades for Interconnection at Lamar Switching Station include replacement of the existing metering, and the installation of 40 MVAR of Capacitors with an estimated cost of \$1.78 million<sup>1</sup>. The time frame to get the interconnection constructed for the generation addition would be at least 12 months. The total estimated cost for the facilities required for interconnection is approximately \$1.78 million<sup>2</sup> including:

- \$1.78 million for Customer-funded Interconnection Facilities (Table 1)
- \$0 for PSCo Network Upgrades for Interconnection (Table 2)

The estimated time required to engineer, permit, and construct the facilities described above is at least **12 months**.

The Network Upgrades recommended for full delivery of the generation consist of the following:

- Construct a new 99 mile double-circuit 230 kV line (345 kV capable) from Lamar to Boone;
- Construct a new 43 mile single circuit 230 kV (345 kV, double circuit capable) line from Boone to Midway;
- Install 345/230 kV auto transformers at Midway and Daniels Park Substations
- Operate the two Midway to Daniels Park 230 kV transmission lines at 345 kV.

The System Impact Study Report estimated the cost of these additional upgrades to be **\$122.87 million**<sup>3</sup> (Table 3). The estimated time required to engineer, permit, and construct the facilities for delivery is a at least **54 months** from the date a Transmission Service Agreement is executed. Therefore, it is not feasible to implement the facilities required to accommodate the project on a firm basis by the proposed in-service date.

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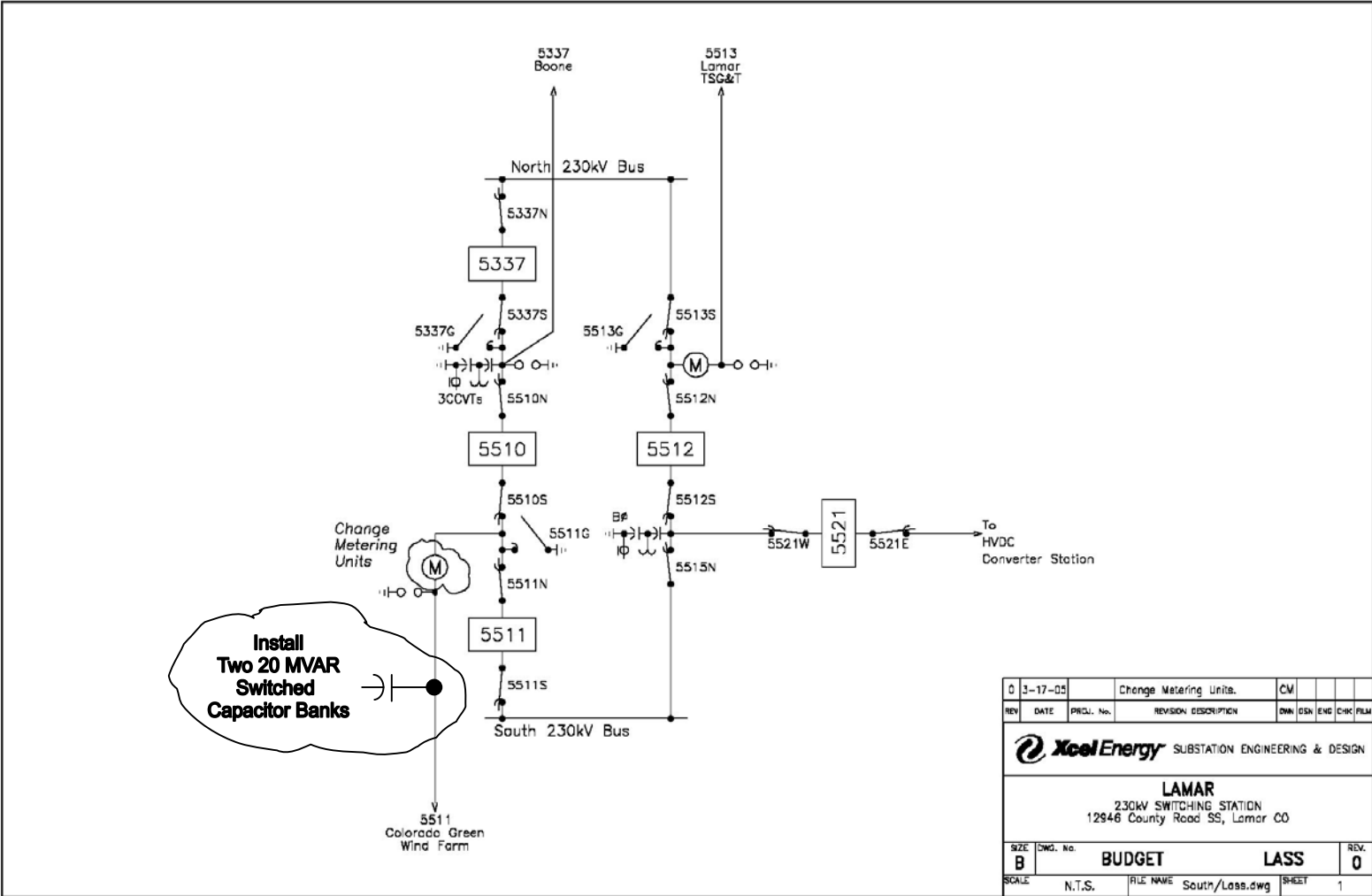
<sup>1</sup> The System Impact Study indicated a Customer cost of \$40,000. The cost in this report includes an additional \$64,000 for revenue metering and \$1.679 million for the capacitors identified to be necessary for interconnection.

<sup>2</sup> Appropriation estimate considered to have an accuracy of +/- 20%.

<sup>3</sup> Scoping, or planning level estimate considered to have an accuracy of +/- 30%.

The total estimated project cost for the PSCo facilities required for interconnection and delivery is approximately **\$124.65 million**. A proposed Station One-Line diagram for the Lamar Switching Station is shown in Figure 1. Figure 2 shows the proposed Network Upgrades associated with Delivery for this transmission project.

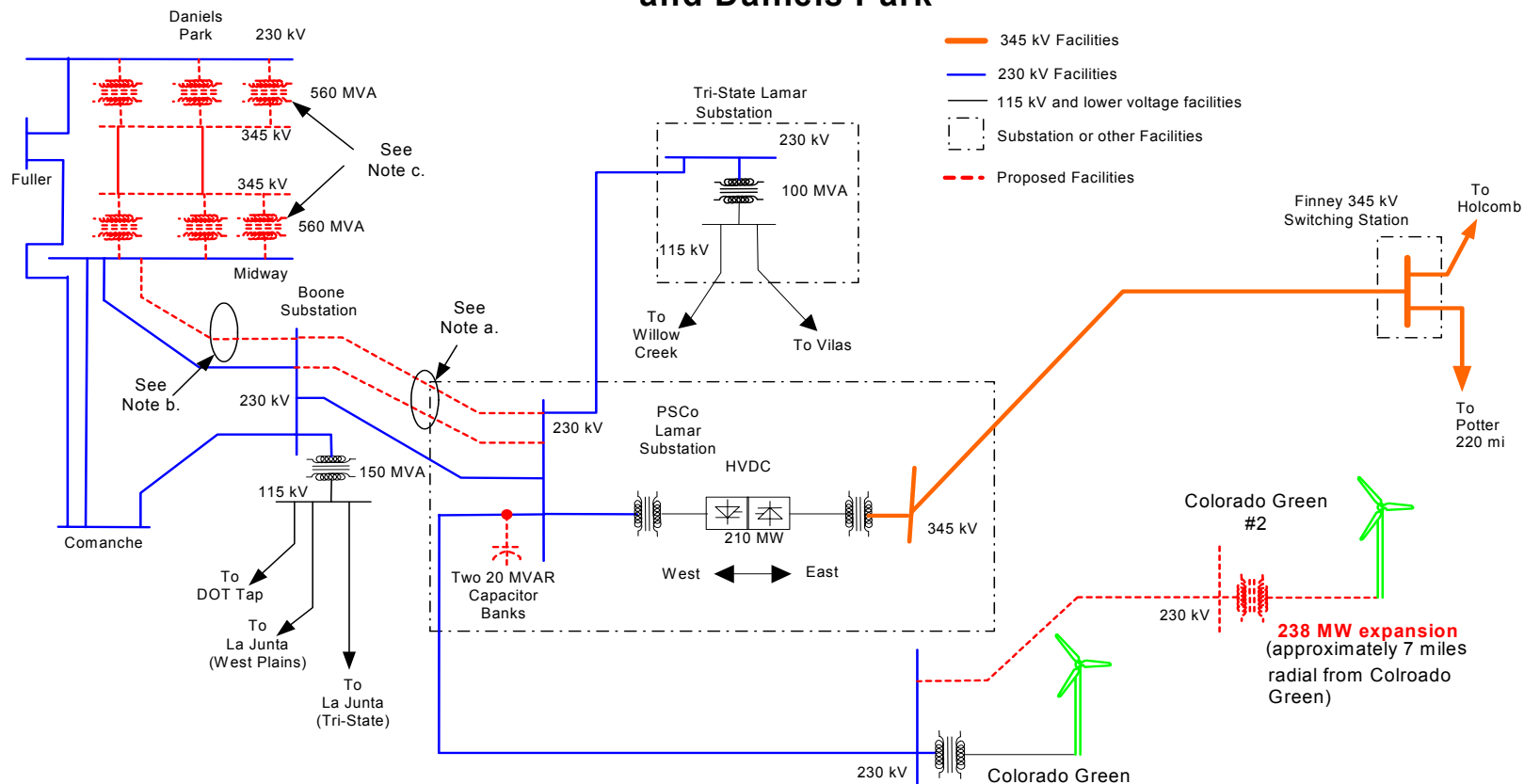
Figure 1 Lamar Switching Station: Proposed Substation One-Line Diagram



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**Figure 2**  
Regional Transmission System with GI-2004-2 Network Upgrades for Delivery

**Regional Transmission System Between Finney and Daniels Park**



- A new 99 mile 230 kV double circuit line from Lamar to Boone built to 345 kV specifications and requires additional ROW from Lamar to Boone
- Build a new single circuit 230 kV line double circuit capable with 345 kV specifications adjacent to the existing line providing ROW is attainable.
- Add three 230/345 kV 560 MVA autotransformers at Midway and Daniels Park and operate the two existing Midway-Daniels Park 230 kV lines at 345 kV.
- Substation expansion at Boone, Midway, Daniels Park, and Lamar.

**162 MW existing**  
 (approximately 44 miles radial from Lamar)

**238 MW expansion**  
 (approximately 7 miles radial from Colorado Green)

## II. Introduction

On February 9, 2004 Xcel Energy Transmission received a request to conduct a feasibility study that would evaluate a 238 MW expansion of the Colorado Green Wind power generating facility in Prowers County, Colorado. The Feasibility Study report was issued and posted on the Rocky Mountain Area OASIS (RMAO) web site<sup>4</sup> in May 2004. An Interconnection System Impact Study (SIS) Agreement was executed with the Customer on or around June 29, 2004, with the SIS Final report posted on RMAO and issued to the Customer on December 3, 2004. An Interconnection Facilities Study Agreement was executed with the Customer on January 17, 2005.

## III. General Description (Project Design Guide)

### Project Purpose & Scope

The purpose of this project is to interconnect an existing customer's wind generation expansion of approximately 238 MW bringing the total of 400 MW into PSCo's existing Lamar 230 kV Switching Station (Lamar). The customer has an existing 44-mile 230 kV transmission line from their site to Lamar. The customer's site is due South of Lamar Switching Station. See the attached Preliminary One-line drawing and general arrangement for the substation additions.

### Background

Lamar Switching Station is a four-breaker ring bus set up in a two bay breaker and half transmission switching station. Presently the Lamar HVDC Tie injects approximately 210 MW into Lamar and Colorado Green Wind Farm injects 162 MW. The additional injection of 238 MW into Lamar from the customer's expansion of their wind site requires upgrading and/or replacing various facilities throughout Xcel Energy's transmission System.

### Other Considerations

The desired back feed date for the customer is October of 2005. However equipment lead times are 5 months. Special agreements should be made to meet this fourth quarter 2005 back feed date.

**The System Impact Study identified the potential for unacceptable voltage deviations between the Colorado Green collector substation and the Lamar substation due to heavy power flow on the single-circuit 230kV line between the substations. It is recommended that the Customer install a 40 MVAR of capacitors switched in 20 MVAR sections near the Lamar end of their line. This installation can take place within the joint owned PSCo and Tri-state property**

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<sup>4</sup> www.rmao.com

where Colorado Green line enters the area. The additional cost to the Customer for this is estimated at \$1.679 million<sup>2</sup>. The time frame for installation of these capacitors is at least 12 months.

#### **A. Interconnection & Network Upgrades for Interconnection**

##### **Fault Current**

Existing 3 phase and SLG fault currents are 1450 Amps and 2700 A respectively at the Lamar 230 kV bus.

##### **Physical – Electrical Installations**

The installation at Lamar will consist of replacing the three existing 230 kV combo CT/PT metering units to accommodate the customer's expansion of their existing interconnection.

The customer's step-up transformers shall be designed to meet PSCo's interconnection guidelines. The configuration shall be GROUNDED – WYE on the 230 kV side, WYE on the 34.5 kV side, and DELTA on the tertiary. This will ensure that the customer meets PSCo's requirements for an effectively grounded system.

##### **AC & DC Systems**

Existing AC and DC panels are adequate for new substation equipment.

##### **Control Building**

New equipment will not be required.

##### **Grounding**

All equipment and associated structures will be connected to the ground mat.

##### **Lightning Protection**

The static wires on the transmission lines will be connected to the dead-end structures within the substation to provide overhead direct stroke protection.

##### **Grading & Fencing**

No grading or fencing is required as all new equipment is going into existing bays.

## **Foundations & Structural**

Existing structures are will be used.

## **Removals & Relocations**

The existing 230 kV metering for the Customer will be removed.

## **Control & Protection – Electrical Installations**

Existing relays and controls at Lamar are adequate: however, ***review of the Customer's relay and control changes at Colorado Green and the expansion need to be periodically reviewed and coordinated with the existing relays and controls at Lamar and the Lamar HVDC Tie. Updated and detailed control models of the existing Colorado Green facility and its expansion need to be provided by the Customer to determine if any control interactions occur between the Lamar HVDC Tie and the Colorado Green Facilities before the expansion goes into service.***

The existing RTU at Lamar will handle the additional SCADA information for the new transmission line and generating facility.

## **Outages**

The existing Lamar to Colorado Green 230 kV line will be out of service during the metering unit replacement period. This cutover period shall be minimized as much as possible.

## **Project and Operating Concerns**

Work will be performed inside an energized 230 kV substation.

## **Related Substation & Transmission Projects**

See Network Upgrades for Delivery.

## **Assumptions for Colorado Green Wind**

Customer will provide power factor correction equipment to meet voltage tolerances at point of interconnection, if needed.

Customer will engineer, procure, and construct all equipment up to the Lamar 230 kV dead-end structure. This includes transmission line relay equipment at customer's site.

The customer will need to arrange for station service power through the local utility/service provider, as customer's site may not be in PSCo service territory.



Customer has built transmission line with fiber optic ground wire built into the static wire for relay communication.

PSCo needs at least 2-4 weeks to test requirements of Interconnection Guidelines For Transmission Interconnected Producer-Owned Generation Greater Than 20 MW. Much of the testing can be performed in parallel with the construction schedule.

### **Assumptions for Lamar**

PSCo meters will be 4 quadrant, bi-directional meters with recorders. Meters/recorders will be equipped such that they can be accessed remotely through a phone circuit.

PSCo will engineer, procure, construct, own, and maintain all 230 kV facilities associated with the metering replacement.

Equipment lead times will dictate the time needed to build facilities. Current lead times are 4 to 5 months.

### **B. Network Upgrades for Delivery**

In general the network upgrades for delivery shall mean the additions, modifications, and upgrades to the transmission provider's transmission system (PSCo) required at or beyond the point at which the interconnection facilities connect to the transmission provider's transmission system to accommodate the interconnection of the large generating facility (customer) to the transmission provider's transmission system. See FERC 2003-A definitions for further explanation.

The following network upgrades required for delivery are:

- Construct a new 99 mile double-circuit 230 kV line (345 kV capable) from Lamar to Boone;
- Construct a new 43 mile single circuit 230 kV (345 kV, double circuit capable) line from Boone to Midway;
- Install 345/230 kV auto transformers at Midway and Daniels Park Substations
- Operate the two Midway to Daniels Park 230 kV transmission lines at 345 kV.

### **Assumptions**

Contract for interconnection with customer has been executed and project is underway.

Timeframe to complete all of the necessary network upgrades for delivery is **substantially longer** than customer's requested in service date.

The construction of the network upgrades for delivery will have to be carefully planned. Not all of the work can be performed at the same time due to transmission capacity restraints.

Enough space will be available at Boone, Midway, and Daniels Parks substations to accommodate substation expansion. If other projects planned for this location are constructed ahead of this project, then this assumption may no longer be valid.

PSCo will engineer, procure, construct, own, and maintain all facilities associated with the network upgrades for delivery.

#### **IV. Costs Estimates and Assumptions:**

##### **A. Interconnection**

The estimated non-binding good faith total cost for the PSCo Interconnection Facilities and Network Upgrades to provide an Interconnection for the Customer requested generation is:

- **\$ 1.78 million for Customer Interconnection Facilities at Lamar Station (Customer funded).**
- **\$0 million for PSCo Network Upgrades for Interconnection.**
- **Total Estimated cost of Interconnection = \$1.78 million**

The estimated costs shown above are “appropriation estimates” with an accuracy of  $\pm$  20%. These estimates do not include any costs for any Customer-owned, supplied, and installed equipment and associated design and engineering for the Customer’s facilities. Detailed appropriation level estimates were not performed for estimating the Network Upgrades for Delivery; these upgrades are discussed later, with only scoping level estimates repeated here as performed for the earlier System Impact Study.

##### **B. Stand-Alone**

“Stand Alone Network Upgrades” are defined by the FERC LGIP as Network Upgrades that the Interconnection Customer may construct without affecting the day-to-day operations of the Transmission System during their construction. The Transmission Provider and Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify them in Appendix A to the Standard Large Generator Interconnection Agreement.

For this generation interconnection request, there are not any Stand Alone Network Upgrades.

##### **C. Delivery**

The additional costs for PSCo Transmission Network Upgrades for Delivery of the full new generation output to PSCo native loads were estimated during the System Impact Study at:

- **\$ 122.87 million<sup>5</sup> for additional PSCo Transmission Network Upgrades for Delivery**

Therefore, the total estimated project cost for the PSCo facilities required for interconnection and delivery is approximately **\$124.65 million**.

The Project Design Guide included in Part III of this report describes the assumptions and additional details associated with this project. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines.

**D. Interconnection Facilities Component Costs Estimates and Assumptions:**

Table 1 describes the improvements assumed necessary to be performed by PSCo Transmission, as dedicated “sole-use” facilities at PSCo Lamar Switching Station for the expanded Customer interconnection. It does not include all of the costs associated with Network Upgrades, required at or beyond the Point of Interconnection (POI) to the PSCo transmission system, and firm delivery (NR) of the generation. Those costs are identified in Tables 2 and 3. It is assumed that all of the Customer owned, supplied, and operated equipment, both installed at PSCo Lamar Switching Station, and equipment installed between and at the Customer generation site, will be designed, and installed by the Customer, or its contractors. (Such as the Customer’s 230 kV transmission line from their site to Lamar and other associated Customer–owned substation / plant equipment). The costs of these Customer owned / operated facilities have not been estimated for by PSCo Transmission. The General Arrangement drawing for the Lamar switchyard is shown in Figure 5.

**Table 1: PSCo Transmission Interconnection Facilities (Customer funded):**

| <b>Element</b>               | <b>Description</b>  | <b>Cost (\$Million)</b> |
|------------------------------|---|-------------------------|
| PSCo Lamar Switching Station | 1. Replace the PSCo 230kV bi-directional revenue metering and associated control and relaying changes, and testing  | \$ .104                 |
|                              | 2. Install two 20 MVAR switched capacitors (40 MVAR total) including zero voltage closing circuit breakers associated control and relaying changes, and testing | \$1.679                 |
|                              | <b>Total Cost Estimate for Interconnection Facilities</b>   | <b>\$1.783</b>          |
| <b>Time Frame</b>            |   | <b>12 Months</b>        |

<sup>5</sup> Scoping, or planning level estimate considered to have an accuracy of +/- 30%.

Table 2 describes the costs associated with providing an interconnection to PSCo Transmission’s system. It does not include all of the costs required for full delivery of the generation. Those costs are included in Table 3.

**Table 2 PSCo Transmission Network Upgrades Required for Interconnection:**

| Element | Description          | Cost (millions) |
|---------|----------------------|-----------------|
|         | <b>None Required</b> |                 |

**E. Delivery Component Costs Estimates and Assumptions**

Table 3 describes the estimated “scoping level” (+/- 30%) costs of PSCo Network Upgrades for Delivery, those associated with firm delivery of the 238 MW generation expansion total ling 400 MW to PSCo Transmission native load. These costs were first determined during the System Impact Study, and have not been refined for this Facilities Study. More detailed, and higher accuracy estimates will need to be performed at later stages in this project, due to the high level of uncertainty regarding specific line routes, permitting, and other details typical for transmission line design and construction of this nature. Many of these details will be determined during the Certificate of Public Convenience and Necessity (CPCN) to be filed with the Colorado PUC for this project.

**Table 3 PSCo Transmission Network Upgrades Required for Delivery**

| Element                      | Description   | Cost (millions) |
|------------------------------|---|-----------------|
| PSCo Lamar Switching Station | Two new 230 kV Line terminals to Boone requiring the following equipment: <ul style="list-style-type: none"> <li>• six 2000 Amp, 40 kA circuit breakers</li> <li>• ten 230 kV switches</li> <li>• Associated steel</li> </ul> Electrical bus work   | \$2.54          |
| Boone Substation             | Three new 230 kV 2000 Amp Line Terminals; two to Lamar and one to Midway. The following equipment will be required: <ul style="list-style-type: none"> <li>• five 2000 Amp, 40 kA circuit breakers</li> <li>• eight 230 kV switches</li> <li>• Misc. supporting steel</li> <li>• Electrical bus work</li> <li>• Associated metering control and relaying</li> </ul> | \$ 2.67         |

| Element                 | Description  | Cost (millions)  |
|-------------------------|--|------------------|
| Midway Substation       | Expand the 230kV station to allow one line and three transformer terminations. Construct a new 345kV station with allowance for two line and three transformer terminations.<br>The following equipment is included: <ul style="list-style-type: none"> <li>• three 345/230 kV 560 MVA autotransformers</li> <li>• six 2000 Amp, 40 kA, 230 kV circuit breakers</li> <li>• ten 230 kV switches</li> <li>• Twelve 3000 Amp, 50 kA, 345 kV circuit breakers</li> <li>• sixteen 345 kV switches</li> <li>• Misc. supporting steel</li> <li>• Electrical bus work</li> <li>• Associated metering, control, and relaying</li> </ul> | \$17.61          |
| Daniels Park Substation | Three 345/230 kV 560 MVA autotransformers, two 345 kV line terminations all of which includes the following: <ul style="list-style-type: none"> <li>• six 2000 Amp, 40 kA, 230 kV circuit breakers</li> <li>• ten 230 kV switches</li> <li>• eight 3000 Amp, 50 kA, 345 kV circuit breakers</li> <li>• sixteen 345 kV switches</li> <li>• Misc. supporting steel</li> <li>• Electrical bus work</li> <li>• Associated metering, control, and relaying</li> </ul>   | \$21.05          |
| Transmission            | Construct a new double circuit 230 kV line, 345 kV capable from Lamar to Boone requiring new ROW   | \$55.95          |
|                         | One new 230 kV line from Boone to Midway requiring new ROW.  | \$23.05          |
|                         | <b>Total PSCo Network Upgrades Required for Interconnection</b>  | <b>\$122.87</b>  |
| <b>Time Frame</b>       |  | <b>54 Months</b> |

Total costs for Network Upgrades for Interconnection and Delivery Costs = **\$124,653,000**

**Assumptions:**

1. The estimated costs provided for Interconnection costs are “Appropriation Estimates” with an accuracy of  $\pm 20\%$ . The estimated costs provided for Delivery/Infrastructure upgrade costs are “Scoping Estimates” with an accuracy of  $\pm 30\%$ .
2. All applicable overheads are included. AFUDC has been removed.
3. Estimates were escalated at 3% per year through 2005.
4. PSCo (or its contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.
5. A Certificate for Convenience and Public Necessity (CCPN) will be required for the transmission line.
6. Any NEPA requirements imposed on transmission because of the generation addition will most likely have adverse effects on schedule and deliverables.
7. No screening has been estimated at any of the substations. If this is required the cost will be significant at each location.
8. Detailed field investigations (surveys, etc.) have not been conducted and could increase these estimates.
9. New transmission line ROW acquisition is assumed for Network Delivery related facilities, since existing ROW will be utilized.
10. These estimates do not include any cost for legal fees.
11. All necessary transmission line outages can be obtained. If not, construction duration times will be longer.
12. All cost estimates have been escalated to reflect the appropriate year of project activity.

The overall timeline to complete all required transmission and substation facilities is expected to require a minimum of 54 months. If there are problems with local and state approvals, this could require an additional year.

**V. Engineering, Procurement & Construction Schedule**

It will take approximately 5 months from the authorization to proceed to procure and install the new 230 kV metering units at Lamar and 12 months to procure and install the new 230 kV 20 MVAR capacitor banks.

**Figure 4: Engineering, Procurement & Construction Schedule**

