



**Davis 49.1 MW Load Interconnection
System Impact Study
PSCo Transmission Planning
April 26, 2012
FINAL**

A. Executive Summary

On November 23, 2011, Public Service Company of Colorado (PSCo) received a request to interconnect a 49.1 MW load near Ft. Lupton, Colorado, to the PSCo transmission system. This load interconnection point is to be located within the Customer's service territory, and will be called the "Davis Substation". The requested in-service date of the Davis Substation is December 1, 2012; however, this date has since been changed by the Customer to January 1, 2013. The interconnected load was requested to be implemented in two stages; initially **19.8 MW** expected during the 2013 summer peak and **49.1 MW** expected by the summer of 2022.

Initially the Customer requested a transmission interconnection to PSCo's Pawnee – Ft. Lupton 230 kV line; however, due to timing constraints the interconnection location was changed by the Customer to PSCo's Ft. Lupton – Ennis 115 kV line (Circuit 9495).

In response to this inquiry, PSCo Transmission Planning conducted a System Impact Study, and developed scoping level planning cost estimates to construct facilities that would be required for the Customer to interconnect as a transmission customer. The System Impact Study indicated it is possible to interconnect the proposed 19.8 MW load by the requested in-service date to the Ft. Lupton – Ennis 115 kV line without any network upgrades other than those required for interconnection (i.e. switches, metering equipment, etc.). Additionally, the System Impact Study indicated the Ft. Lupton – Ennis 115 kV line could reliably support the full build out of 49.1 MW by 2022 provided the breaker current transformers (CT's) are upgraded at Ft. Lupton to increase the rating of the Ft. Lupton – Hudson section of the line a minimum of 74 MVA (372 amps).

On March 26th, 2012, the Customer indicated they will be responsible for the design, permitting and construction of the Davis Substation, associated Substation metering equipment and the radial transmission line connecting the Substation to PSCo's Ft. Lupton – Ennis 115 kV line "Davis Tap." The Customer will also be responsible for maintaining a +/- 0.98 power factor at the point of delivery, and for the installation of variable frequency drives or other soft starting devices in order to prevent significant voltage drop (greater than 2%) for large motor starting conditions.

Since the Customer will own, operate, maintain and fund the transmission line from the Davis Tap to the Davis Substation as well as the Davis Substation, PSCo Substation and Transmission Engineering only developed cost estimates for the line tap switches required to tap the existing Ft. Lupton – Ennis 115 kV line. The time to design, procure and construct this interconnection equipment is approximately 9 – 12 months.

B. Project Description

Figure 1 provides a conceptual one-line of the project to serve the proposed Davis Substation load that would tap PSCo's Ft. Lupton – Ennis 115 kV line.

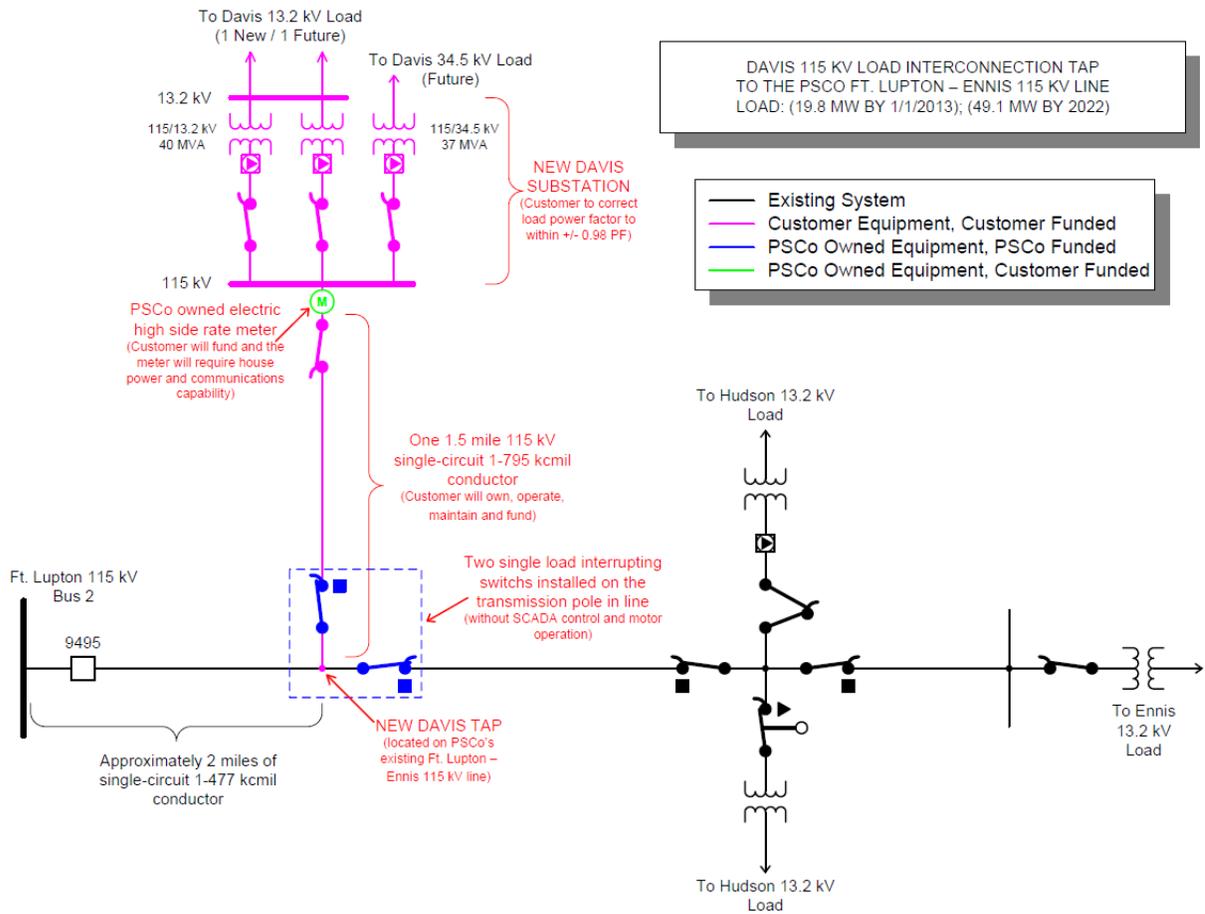


Figure 1: Conceptual One-line for the Proposed Davis Delivery Point Substation

This interconnection will provide transmission service to the Customers Davis Substation. A 1.5 mile, single-circuit, 1-795 kcmil conductor will tap PSCo’s existing Ft. Lupton – Ennis 115 kV line at a distance approximately 2 miles from the Ft. Lupton Substation. Two single load interrupting switches (not capable of remote operation) will be installed at the tap location in or adjacent to PSCo’s right-of-way. PSCo will install a high side remote metering unit at the Davis Substation.

At the Davis Substation the Customer will provide and install a single 115-13.2 kV, 24/32/40 MVA or larger distribution transformer with LTC. A second, same-sized transformer is planned for future growth but will not be installed at this time. Additionally, a 115-34.5 kV, 20/37 MVA autotransformer is planned to be installed in the 2014 – 2015 timeframe.

The Davis Substation will be sited approximately 1.5 miles east of Weld CR 31 and CR 22, Section 14, T2N, R66W, in Weld County, Colorado.

Figure 1 is a conceptual one-line only and does not reflect a detailed description of the Customers facilities.

Figure 2 shows an aerial photograph of the site location along with 3 alternative locations for the proposed 1.5 mile radial tap line.

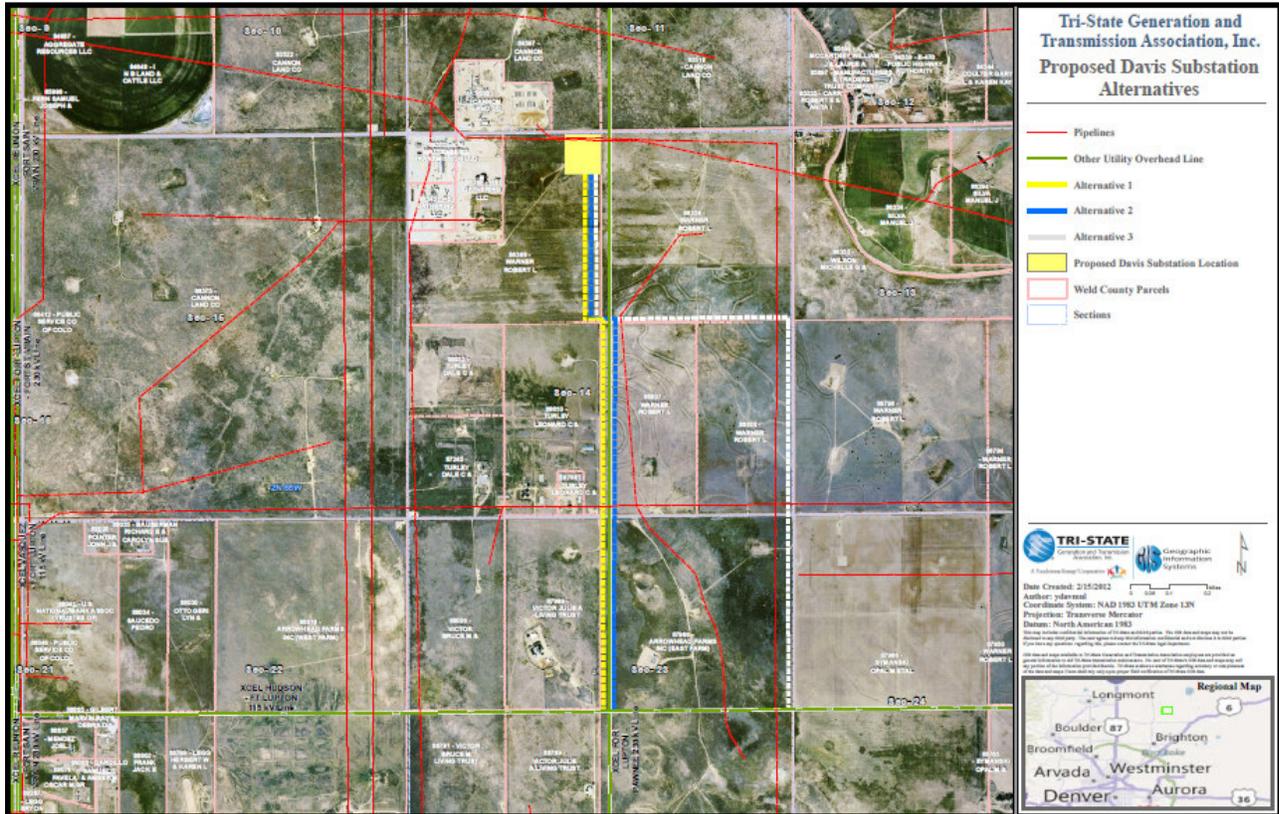


Figure 2: Aerial Photograph of Site Location and Proposed Line Alternatives

C. Background

On November 23, 2011, PSCo received a load interconnection request to acquire transmission service to interconnect a new 49.1 MW load (Davis Substation) near Ft. Lupton, Colorado. The Davis Substation is located within the Customers service territory (sited approximately 1.5 miles east of Weld CR 31 and CR 22, Section 14, T2N, R66W, in Weld County, Colorado), and will be used to serve new industrial oil and gas processing customers. The Customer indicated on December 7, 2011, during the initial project kick-off meeting, that a project site had already been secured adjacent to the Customer's facilities, and proposed an in-service date of December 1, 2012. The interconnected load was requested to be modeled in two stages; initially **19.8 MW** expected during the 2013 summer peak and **49.1 MW** expected by the summer of 2022. For the 2013 summer peak, the load will be approximately 75% new industrial gas compression (two 10,000-hp motors), and 25% existing petroleum refining, residential and irrigation. The Customer has stated they will build the Davis Substation to their design standards, which includes the use of Variable Frequency Drive's (VFD) or other soft starting devices for the large motors during starting conditions to prevent a voltage drop of greater than 2%.

Initially the study was to consider two load interconnection alternatives; a 230 kV interconnection on PSCo's Pawnee – Ft. Lupton transmission line, and a 115 kV interconnection on PSCo's Ft. Lupton – Ennis transmission line. A third alternative, the Ft. Lupton – Vasquez 115 kV line, was also suggested during the project kick-off meeting on December 7, 2011; however, it was eliminated due to timing constraints, its location in relationship to the project area, and the need to run a more detailed study to determine the full impact to the line and surrounding area. On March 5, 2012, during a face-to-face meeting, the Customer requested two changes to the project scope. First, that the in-service date be changed to January 1, 2103, and second that the 230 kV alternative be eliminated due to timing constraints and the immediate need to proceed with the



project. After this meeting PSCo was requested by the Customer to only study the Ft. Lupton – Ennis 115 kV alternative.

The original concept consisted of connecting the Davis Substation to the bulk transmission system using one span of 115kV double-circuit 477 kcmil conductor, providing in-and-out service; however, the Customer requested on March 5, 2012, that the design be changed to a single point tap and radial span of 115kV single circuit 795 kcmil conductor. PSCo Transmission Engineering subsequently revised the concept to reflect a single span of 115kV single circuit transmission. On March 26, 2012, PSCo received a letter from the Customer stating the Customer will design, construct, own, operate and maintain the 115 kV circuit between the Davis Substation and PSCo's Ft. Lupton – Ennis 115 kV line. This change required a new cost estimate to be developed. PSCo Substation and Transmission Engineering developed cost estimates for the design, construction, and ownership of the necessary two-way tap switch necessary to tap the line.

D. Study Scope and Analysis

The study consisted of power flow analysis and short circuit analysis only. Angle stability, voltage stability, and motor starting studies were not performed in this study. Instead it was assumed the Customer would use a VFD or other soft start mechanism during motor starting conditions.

Initially the study was to consider two load interconnection alternatives; a 230 kV interconnection on PSCo's Pawnee – Ft. Lupton transmission line, and a 115 kV interconnection on PSCo's Ft. Lupton – Ennis transmission line. Due to timing constraints and the immediate need to proceed with the project, the 230 kV alternative was eliminated by the Customer. Additionally, the Ft. Lupton – Vasquez 115 kV line was considered as an alternative; however, this line was also eliminated by the Customer due to timing constraints, its location in relationship to the project area, and the need to conduct a more detailed study to determine the total impacts on the transmission line and surrounding transmission system.

A study cases was developed for the year 2013 based on the WECC approved 12HS3SAP case. PSCo loads in the case were adjusted to reflect the most recent (September 2011) PSCo load forecast. Other loads on the Ft. Lupton – Ennis line include the Hudson Substation, owned by Tri-State Generation and Transmission (TSGT). Updates to the Hudson load were based off the latest TSGT load forecast. The case reflected the system under heavy summer conditions and moderate to high north-to-south transfer conditions. Only Category A and Category B disturbances were conducted for this study.

Due to the location of the Davis Substation on the radial Ft. Lupton – Ennis line, the same 2013 case was used to evaluate the 2022 scenario; however, the load addition at the Davis Substation was increased to its full build out, the load at Hudson was changed to slightly more than the 2021 forecasted load in the TSGT 10 year load forecast, and the load at Ennis was scaled by a 1.5% growth factor over a period of 9 years. A summary of the loads modeled on the Ft. Lupton – Ennis 115 kV line in both scenarios can be seen in Section H, Table 1.

E. Study Criteria

PSCo adhered to the following criteria for these load flow studies:

- **Category A – System Normal**
“N-0” System Performance Under Normal (No Contingency) Conditions
NERC Standard TPL-001-0
Voltage: 0.95 to 1.05 per unit



Line Loading:	100 percent of continuous rating
Transformer Loading:	100% of highest 65 °C rating

Manual or automatic system adjustments such as shunt capacitor or reactor switching, generator scheduling, or LTC tap adjustment are allowed. Area interchanges and phase shifter adjustments are allowed.

- **Category B – Loss of generator, line, or transformer (Forced Outage)**

“N-1” System Performance Following Loss of a Single Element
NERC Standard TPL-002-0

Voltage:	0.90 to 1.05 per unit
Line Loading:	100 percent of continuous rating
Transformer Loading:	115% of highest 65 °C rating (for load-serving xfmr’s)

Manual system adjustments such as generation dispatch will not be allowed. Area interchange adjustments will not be allowed. Adjustments of shunt capacitors or reactors, phase shifting transformers and load tap changing (LTC) transformers will not be allowed.

G. Motor-Starting Requirements

PSCo requires customers to adhere to a voltage dip requirement during motor starting that restricts voltage dips to 2% or less at any company transmission bus. The voltage dip percentage (%) is defined as:

$$\% \text{Voltage Dip} = (V_{\text{prestart}} - V_{\text{start}}) / V_{\text{prestart}} * 100$$

where V_{prestart} is the voltage at the bus before the motor is started and V_{start} is the voltage at the bus at the instant of maximum voltage drop during starting.

The study assumes the Customer will use a VFD or other soft starting device with the large motors during starting conditions to prevent a voltage drop greater than 2%.

H. Load Flow Study Results

The proposed load was requested to be modeled in two stages; initially 19.8 MW expected during the 2013 summer peak and 49.1 MW expected by the summer of 2022.

The study was conducted assuming 19.8 MW would be on-line by the summer of 2013; therefore, a 2013 heavy summer case, developed from the WECC approved 12HS3SAP case was used to study the initial load addition. To study the addition of the total proposed Customer load, the same 2013 heavy summer case was used with the load at the Davis Substation increased to 49.1 MW, and the loads at Hudson and Ennis changed to reflect their forecasted 2022 values. A summary of the loads on the Ft. Lupton – Ennis line were obtained from the two cases can be seen in Table 1 below.

Table 1. Loads on the Ft. Lupton – Ennis 115 kV Line (2013, 2022)

Bus No.	Name	ID	2013 HS		2022 HS (Scaled)	
			MW	MVAR	MW	MVAR
70234	HUDSON 115.00	TS	16.6	3.4	19.7	3.5
70169	ENNIS 115.00	P1	2.8	0.7	3.2	0.7
70999	DAVIS TP 115.00	P1	19.8	4.0	49.1	10.0
	TOTAL DEMAND		39.2	8.1	72.0	14.2

1. 2013 Summer On-Peak Conditions

For the 2013 study, results of the load flow analysis indicated no facilities were overloaded as a result of the load addition. In the 2013 case, the section of conductor between Ft. Lupton and Hudson was rated at 60 MVA. According to the latest TSGT and PSCo load forecasts, the total load on the Ft. Lupton – Ennis 115 kV line for 2013, prior to the load addition, was 19.8 MVA. With the addition of the initial 19.8 MW (20.2 MVA) load, the total load was increased to 40 MVA, which is less than the rating of the conductor.

2. 2022 Summer On-Peak Conditions

For the 2022 study, results of the load flow analysis indicated the Ft. Lupton – Hudson section of the Ft. Lupton – Ennis 115 kV line (9495) would be overloaded by 120% as a result of the load addition. Based on the latest TSGT and PSCo 10 year load forecasts, the total load on the Ft. Lupton – Ennis 115 kV line for 2022, prior to the load addition, was 23.3 MVA. With the addition of another 29.3 MW at the Davis Substation, bring the total at that location to 49.1 MW (50.1 MVA), the total load on the line was increased to 73.4 MVA, which is greater than the rating of the conductor. The Ft. Lupton – Hudson section of line is limited by the 300 A breaker current transformer's (CT's) at the Ft. Lupton Substation. In order to connect the total proposed load in 2022, these CT's will need to be replaced to allow for a minimum circuit rating of 74 MVA (372 amps)

I. Short Circuit Analysis

A short circuit breaker duty analysis was conducted to determine the available fault current (single-line-to-ground or three-phase at the Davis Tap. Table 2 below summarizes the results of the short circuit analysis.

Table 2. Short-Circuit Study Results at Davis Tap

System Condition	Three-phase (amps)	Thevenin System Equivalent Impedance (R,X) (ohms)	Single-line-to-ground (amps)	Thevenin System Equivalent Impedance (R,X) (ohms)
Available fault current at the Davis Tap	$I_1=13,337$ $I_2=I_0=0$ $I_A=I_B=I_C=13,337$	$Z_1(\text{pos})=$ 0.60679,4.94115 $Z_2(\text{neg})=$ 0.61095,4.93999 $Z_0(\text{zero})=$ 1.70489,9.04241	$I_1=I_2=3,468$ $I_0=10,403$ $I_A=10,403$ $I_B=I_C=0$	$Z_1(\text{pos})=$ 0.60679,4.94115 $Z_2(\text{neg})=$ 0.61095,4.93999 $Z_0(\text{zero})=$ 1.70489,9.04241

Fault currents at the 115 kV Davis Tap are 13,337 amps and 10,403 amps respectively for a three-phase fault and single-line to ground faults.

J. Costs Estimates and Assumptions



Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Xcel Energy/PSCo Engineering staff. The cost estimates are in 2012 dollars with escalation and contingencies applied (AFUDC is not included) and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, material/equipment procurement and construction of these new PSCo facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

The estimated total cost required for the interconnection tap is **\$395,000**. These estimates do not include costs for any other Customer owned equipment and associated design and engineering. The following tables list the improvements required to accommodate the interconnection and the delivery of the Project generation output.

PSCo Transmission Tap Point (\$185,000)

- Two 115 kV tap switches
- One steel pole
- Conductor (477 Hawk), hardware and insulators
- Associated line relaying, testing and commissioning

Customer's Davis Substation - PSCo equipment (\$110,000)

- Three 115kV CT/PT metering transformers
- Revenue metering cabinet and high side electric rate meter
- Associated foundations and structures
- Associated wiring and conductor
- Associated testing and commissioning

Construct/Remove transmission fly-line for construction duration (\$90,000)

- Wood poles, conductor, hardware and insulators

Siting and Land Rights Activities (\$10,000)

- S&LR's support for the project

Cost Estimate Assumptions:

- All estimates are scoping level cost estimates with a +/- 30% accuracy.
- Estimates are based using 2012 dollars. Appropriate contingency and escalation is applied.
- AFUDC has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Xcel (or it's Contractor) crews will perform all design, material and equipment procurement, construction, wiring, testing and commissioning for transmission substation and tap facilities. It may ultimately be decided to have the Customer (or its Contractors) design, procure and construct the metering equipment and cabinet installation at their Davis Substation



- The estimated time to site, design, procure and construct the transmission substation and line facilities is approximately 9-12 months after authorization to proceed has been obtained.
- No CPUC, Regulatory or CPCN activities required by PSCo
- Typical site development required – no obstructions.
- Siting support by PSCo as required.