Southern New Mexico Transmission Expansion Study

Prepared by
Public Service Company of New Mexico
Transmission Operations

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Electric Services
Transmission Operations

Foreword

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1 – Introduction

This study was conducted to evaluate a specific set of options for transmission system expansion in southern New Mexico to enhance Path 47 and Path 48 transmission capability. The primary focus of the study was on Path 48 impacts. Figure 1 shows the high voltage transmission system in New Mexico, as well as Path 47and Path 48 cutsets. The study was conducted largely in accordance to a Study Scope document[1] that was circulated among New Mexico transmission owners as well as SWAT.

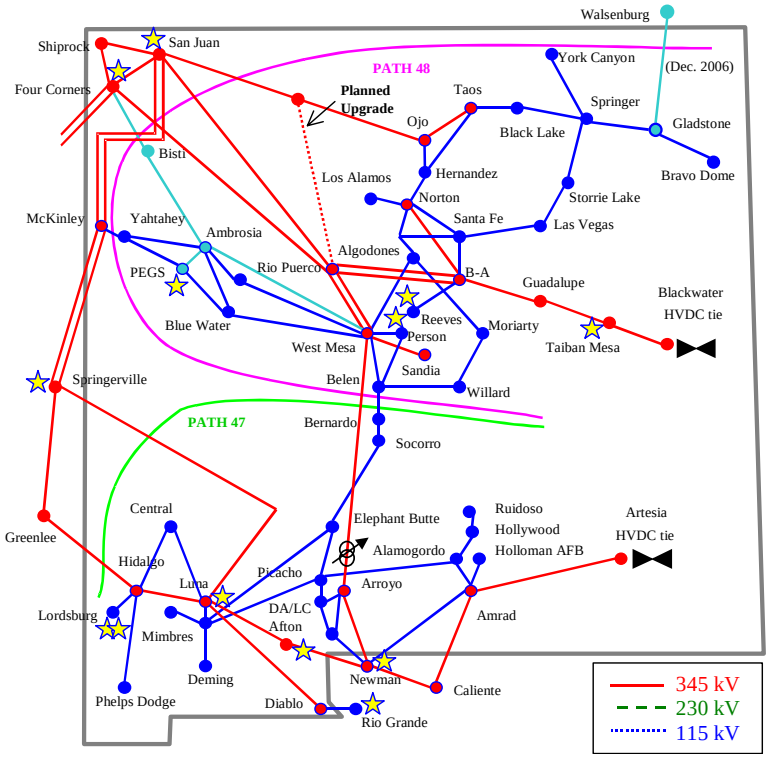


Figure 1 –New Mexico Transmission System

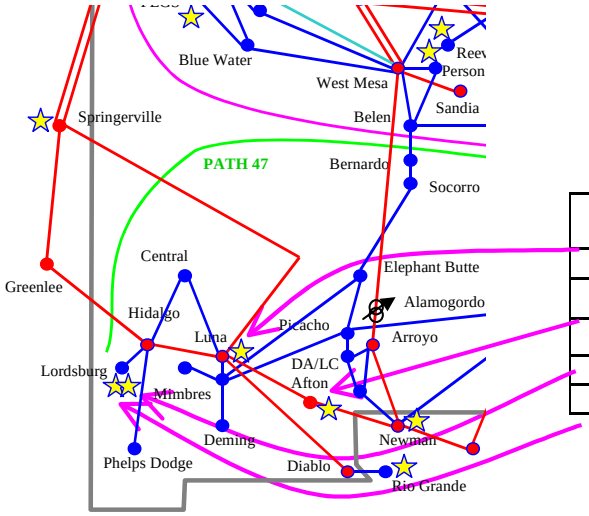
Presently, the WECC-accepted non-simultaneous Path 47 rating is 1048 MW. Path 47 rating is contractually limited to 925 MW. The WECC-accepted non-simultaneous Path 48 rating is 1970 MW with the Arroyo phase shifting transformer (PST) at 0 MW. Neither path has been rated in the export direction. However, a southern NM export study[2] conducted by PNM in 2004 estimated the export capability of Path 47 is approximately 900 MW with the Arroyo PST in service, and approximately 1130 MW with the Arroyo PST bypassed. Path 48 is thermally constrained by the transmission lines from the San Juan/Four Corners area. The Arroyo PST is in service to control interaction between the two paths. Historically, net flow across both paths is in the import direction, while flows between the two paths have from north to south.

The study scope contemplated a new 345 kV line from the Ojo area to the Albuquerque area (OJ East line) as a sensitivity. Figure 1 shows the location of the line. This upgrade would significantly increase transmission capability from the San Juan / Four Corners area to central

[1] New Mexico Transmission Expansion Alternatives, Study Scope, December 2006.
[2] Path 47 Export Study, PNM Report, April 2004.

New Mexico. However, pursuant to the recent New Mexico Integrated Resource Planning legislation and corresponding NMPRC rulings, expansion of load side resources is also being considered to meet the needs of the bundled retail native load customers in northern New Mexico, as well as the need of PNM's transmission customers.

In the last few years, over 1000 MW of gas-fired generators have been added in southern New Mexico, and additional generation development has been proposed. Figure 2 shows the most recent generation additions. The steam portion of the Afton combined cycle plant is expected to be in service in August 2007. Note that the additions include combined cycle facilities that would tend to run at a high capacity factor during the year.



Plant	Capacity (summer)
Luna	570 MW (2x1 CC)
Afton	232 MW (1x1 CC)
Lordsburg	80 MW (2 CT)
Pyramid	160 MW (4 CT)
Total	1080 MW

Figure 2 – Recent generation additions in southern New Mexico

The study focused on a specific set of transmission reinforcements in Southern New Mexico listed in the Study Scope. Path 48 impacts were explored taking into account increased generation levels in that area. The transmission upgrades that were considered are described in Section 2. A brief review of recent operating history is included in Section 3. Section 4 summarizes the study results. The methodology and criteria outlined in the Study Scope document were applied, with some adjustments. Part of this information is recounted in Appendix A.

2 – Transmission Expansion Alternatives

The study considered the transmission expansion alternatives listed below.

- **Option 1 – Bypass existing Arroyo PST**
- **Option 2 – Increase controlled flow from south to North on the EP line.** Angle limitations on the existing Arroyo PST were relaxed as needed. PST settings of 200 MW, and 400 MW northbound were considered. The benchmark case for this option had a PST setting of 64 MW southbound.
- **Option 3 - Tie the existing Springerville – Luna and West Mesa – Arroyo 345 kV lines together at a new station south of Socorro (Ft Craig).** The Arroyo PST was

assumed bypassed. Sensitivity studies were conducted with and without series compensation. The tie was achieved with a single 345 kV, 45-mile terminated at two new 345 kV stations (Ft Craig and VL Tap), as shown in Figure 5. Preliminary studies show that other options to achieve this configuration did not result in significantly different performance.[3]

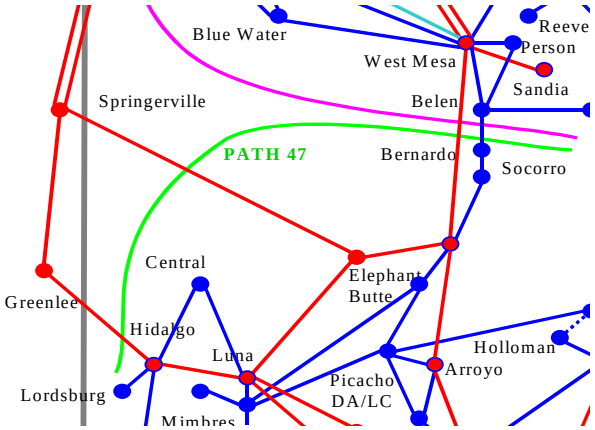


Figure 5 – Transmission expansion assumed for Option 3

- **Option 4 – Starting from Option 3, install a new phase shifting transformer on the Ft Craig – West Mesa line at Ft Craig.** This option explored the impact of controlling flows between Path 47 and Path 48 in the northbound direction, with the 345 kV lines connected as discussed in Option 3. PST settings of 200 MW and 400 MW northbound were considered.

For each of the cases described above, Path 48 voltage stability and thermal limits were calculated using a WECC 2011 heavy summer base case. Sensitivity studies were conducted with and without the planned OJ East – Rio Puerco 345 kV line. Path 48 voltage stability and thermal limits were found by increasing load in the Albuquerque and Santa Fe areas. The results are summarized in the next section.

3 – Analysis of Recent Operating History

Northern New Mexico load is concentrated in the Albuquerque metropolitan and Santa Fe areas, and southern New Mexico load is concentrated in the El Paso area. The aggregated load within the Path 47 and Path 48 cutsets are summer peaking. Path 48 operates near its import limit during the summer season. Presently, load side generation resources in central New Mexico are simple-cycle gas, typically operated only during few summer hours as required to maintain a positive operating margin on Path 48 and to maintain adequate generation spinning reserves. Comparatively, a higher amount of generation in southern New Mexico is likely to be in service during the summer season. A portion of the Afton generation is dispatched to serve PNM load within the Path 48 cutset. As a result, Path 47 imports tend to be appreciably below the import limit during the summer season.

[3] This configuration was considered more cost-effective compared to a double-circuit line with two stations.

Figure 3 shows Path 47 imports as a function of generation output at Luna, Lordsburg Afton and Pyramid, for a two-year period starting April 2005. Note that after the Luna Energy Facility was added in 2006, Path 47 flow patterns have changed significantly. In actual operation, average Path 47 import has decreased, and can occasionally flow in the outbound direction. It should also be noted that the data operating history shown in Figure 3 is prior to commissioning of the Afton steam unit.

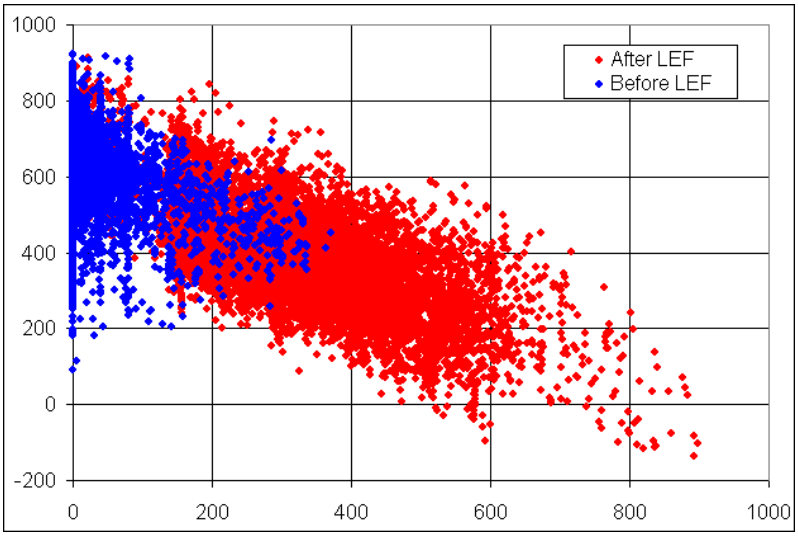


Figure 3: Path 47 import (y axis) as a function of Luna, Afton, Lordsburg, and Pyramid total generation (x axis), April 2005 – April 2007.

Due to the configuration of the 345 kV system, incremental generation in southern New Mexico tends to flow primarily westward toward Greenlee and Springerville, and not toward northern New Mexico across the West mesa – Arroyo line. This is due to the relatively high impedance between the northern and southern systems, as well as the effect of the Arroyo PST. With the present system configuration, additional generation in southern New Mexico provides relief to Path 48 only to the extent that flows across the Arroyo PST can be increased in the northbound direction. As discussed below, some benefit is derived from bypassing the PST, but only during periods of low Path 47 imports.

4 – Study Results

4.1 – Voltage Stability Limits

Tables 1 and 2 show Path 48 voltage stability limits for the various options that were considered. No additional system reinforcements were assumed beyond those discussed in Section 2. The tables clearly show that, for each option, the benefit to Path 48 increases as Path 47 import decreases. In some cases with higher Path 47 imports, the transmission upgrades resulted in a lower Path 48 voltage stability limit, as indicated by a negative delta in the tables.

Path 48 voltage stability limits for Option 2 were not evaluated for the 300 and 600 MW Path 47 import scenarios because they require elevated flows through the El Paso area. Transmission contingencies in the El Paso area (Afton – Newman 345 kV line, for instance) are likely to be

constraining. Evaluation of those contingencies would require direct involvement from El Paso Electric.

Table 1 – Path 48 voltage stability limit and increment without OJ East line

	Path 47 import→	0		300		600	
		MW	Δ	MW	Δ	MW	Δ
Reference	Existing, PST at 64 MW south	1944	-	1950	-	1935	-
Option 1	PST Bypassed	1980	36	1955	5	1910	-35
Option 2	PST 200N	2024	80	*	*	*	*
	PST 400 N	1906	-38	*	*	*	*
Option 3	VL Tap	2079	135	2057	107	2036	-58
	VL Tap, series compensation	2154	210	2116	166	1865	-171
Option 4	VL Tap, PST 200N	2066	122	2058	108	2014	79
	VL Tap, PST 400 N	2081	137	2080	130	2065	130

* These scenarios were not evaluated.

Table 2 – Path 48 voltage stability limit and increment with OJ East line

	Path 47 import→	0		300		600	
		MW	Δ	MW	Δ	MW	Δ
Reference	Existing, PST at 64 MW south	2398	-	2384	-	2372	-
Option 1	PST Bypassed	2414	16	2390	6	2346	-26
Option 2	PST 200N	2449	51	*	*	*	*
	PST 400 N	2359	-39	*	*	*	*
Option 3	VL Tap	2482	84	2472	88	2434	62
	VL Tap, series compensation	2559	161	2532	148	2482	110
Option 4	VL Tap, PST 200N	2482	84	2491	107	2459	87
	VL Tap, PST 400 N	2468	70	2458	74	2144	-228

* These scenarios were not evaluated.

The studies indicated that Albuquerque area transmission buses (Sandia and West Mesa 345 kV buses) had the least reactive margin. Without additional reactive support, the options studied would have only a modest benefit to Path 48 in terms of the voltage stability limit. With Path 47 import at 0 MW, only Option 3 with series compensation of the EP line resulted in a Path 48 voltage stability benefit larger than 100 MW.

4.2 – Thermal Limits

Additional studies were conducted to determine the impact of each of the options on Path 48's thermal limit. This assumed that dynamic reactive compensation is installed in the Albuquerque area (SVC at Sandia 345 kV) to overcome voltage stability issues in the Albuquerque area. Tables 3 and 4 show the results. For Options 1 and 3, the benefit to Path 48 increases as Path 47 import decreases. In contrast, the benefit of Option 4 is independent of Path 47 import level.

Again, Option 2 scenarios because they require elevated flows through the El Paso area, and transmission contingencies in the El Paso area are likely to be constraining. Evaluation of those contingencies would require direct involvement from El Paso Electric. In general, contingencies

internal to the El Paso transmission system in the El Paso area should be considered in a follow-up study by the appropriate entity.

Table 3 – Path 48 thermal limit and increment without OJ East line

	Path 47 import→	0		300		600	
		MW	Δ	MW	Δ	MW	Δ
Reference	Existing, PST at 64 MW south	1986		1966		1939	
Option 1	PST Bypassed	2058	72	1942	-24	1827	-112
Option 2	PST 200N	*	*	*	*	*	*
	PST 400 N	*	*	*	*	*	*
Option 3	VL Tap	2205	219	2073	107	1955	16
	VL Tap, series compensation	2264	278	2108	142	1961	22
Option 4	VL Tap, PST 200N	2281	295	2260	294	2237	298
	VL Tap, PST 400 N	2469	483	2426	460	2399	460

* These scenarios were not evaluated.

Table 4 – Path 48 thermal limit and increment with OJ East line

	Path 47 import→	0		300		600	
		MW	Δ	MW	Δ	MW	Δ
Reference	Existing, PST at 64 MW south	2827		2818		2803	
Option 1	PST Bypassed	2901	74	2805	-13	2708	-95
Option 2	PST 200N	*	*	*	*	*	*
	PST 400 N	*	*	*	*	*	*
Option 3	VL Tap	3074	247	2926	108	2820	17
	VL Tap, series compensation	3082	255	2959	141	2827	24
Option 4	VL Tap, PST 200N	3111	284	3098	280	3082	279
	VL Tap, PST 400 N	3273	446	3258	440	3235	432

* These scenarios were not evaluated.

The results show that the benefits of Options 3 and 4 range from 220 to 480 MW with Path 47 import at 0 MW. By comparison, Option 1 provides only a modest benefit (approximately 70 MW) when Path 47 import is 0 MW. It should be noted that the voltage stability limits for each option is lower than the thermal limit, indicating that system reinforcements (addition of reactive support) beyond those described in Section 2 are needed to realize the full benefit of each option. As discussed below, reactive support would be needed in the Albuquerque area to obtain the full benefit of each option.

5 – Conclusion

This study considered several alternatives for transmission system expansion in Southern New Mexico. The study focused on the impact to Path 48. A full evaluation of the impact on Path 47 was not undertaken. However, it is recommended that El Paso Electric conduct a follow-up study to characterize the impact of a similar set of options on Path 47. Based on the results of this preliminary study, Options 3 and 4 are promising.

Appendix A – Methodology and Assumptions

Methodology and Assumptions

1. The following assumptions will be used to set up the base cases:

   - The WECC 2011 heavy summer case was used to develop the base cases to evaluate each of the transmission expansion options. Load adjustments in the New Mexico area were made to reflect the latest projections to 2013 time frame.

   - The following planned transmission projects were included: Rio Puerco 345 kV switching station (planned for 2010); Alamogordo – Holloman tie (planned for 2007); Alamogordo SVC (planned for 2009).

2. The following methodology will be used to find path limits:

   - Starting from the base case, increase generation in southern New Mexico such that Path 47 flow is approximately 600 MW, 300 MW and 0 MW in the import direction. This was accomplished by increments, up to the capacity of all existing generation resources. Units will be dispatched in the following order: Any remaining EPE resources, Afton, Luna, Lordsburg, Pyramid.

   - For each generation dispatch scenario as described above, increase PNM loads in northern New Mexico until a limiting condition is identified. It is anticipated that constraints on Path 48 will be identified. The analysis will be continued until thermal limit on significant facilities or reactive power deficit at major buses are identified. At the limiting condition, Path 47 and Path 48 limit, limiting constraint and load served will be tabulated.

   - Generation/load balance will be reconciled in the southwest region.

3. For Options 2 and 4, a sensitivity study was conducted to determine whether there are any impacts to the existing Path 47 import rating. This will be accomplished by setting up base cases with Path 47 and Path 48 at the simultaneous import rating, increasing southern New Mexico load until a limiting condition is identified for southern New Mexico contingencies.

4. The following contingencies were evaluated:

Contingency	Option 1	Option 2	Option 3	Option 4
Four Corners – Rio Puerco 345 kV	X	X	X	X
San Juan – Rio Puerco 345 kV	X	X	X	X
West Mesa – Arroyo 345 kV	X	X	X	X
Greenlee – Hidalgo 345 kV	X	X	X	X
Springerville – Luna 345 kV	X	X	X	X
West Mesa – New Tap 345 kV			X	X
Springerville – New Tap 345 kV			X	X
Luna – New Tap 345 kV			X	X
New Tap – Arroyo 345 kV			X	X
New Tap 345 / 115 kV			X	X

In addition to the above, other southern New Mexico contingencies were included to evaluate the impact of Options 2 and 4 on Path 47 import capability.

5. Each option will be tested against NERC/WECC reliability criteria and additions/exceptions as listed in the following table:

Area	Conditions	Loading Limit	Voltage (p.u.)	Voltage Drop	Comments
EPE	Normal	< Normal Rating	0.95 - 1.05		69kV and above
			0.95 - 1.10		Artesia 345 kV
			0.95 - 1.08		Arroyo 345 kV PST source side
			0.90 - 1.05		Alamo, Sierra Blanca and Van Horn 69kV
	Contingency	< Emergency Rating	0.925 - 1.05	7%	60 kV to 115 kV
			0.95 - 1.10	7%	Artesia 345kV
			0.95 - 1.08	7%	Arroyo 345kV PST source side
			0.90 - 1.05		Alamo, Sierra Blanca and Van Horn 69kV
			0.95 - 1.05	7%	Hidalgo, Luna, or other 345 kV buses
PNM	Normal	< Normal Rating	0.95 - 1.05		Above 1 kV with ALIS
					46 kV buses not monitored
	Contingency	< Emergency Rating	0.95 - 1.05	6%	Above 1 kV
				7%	for Deming area only
Tri-State	Normal	< Normal Rating	0.95 - 1.05		All voltages with ALIS
	Contingency	< Emergency Rating	0.90 - 1.10		All voltages for N-1 contingency conditions

6. The following methodology will be used for the contingency studies:

- Following fault clearing, for single contingencies, voltage on load buses may not dip more than 25% of the pre-fault voltage or dip more than 20% of the pre-fault voltage for more than 20 cycles. For double contingencies, voltage on load buses may not dip more than 30% of the pre-fault voltage or dip more than 20% of the pre-fault voltage for more than 40 cycles.

- The most reactive deficient bus must have adequate reactive power margin for the worst single contingency to satisfy either of the following conditions for n-1 outages, whichever is worse: (i) a 5% increase beyond maximum forecasted loads or (ii) a 5% increase beyond maximum allowable interface flows. The worst single contingency is one that causes the largest decrease in the reactive power margin." For double contingencies (i.e., breaker failures) the reactive margin is reduced to 2.5%.

- All manually operated voltage control and phase shifting devices will be fixed.

- All generators which control a high side remote bus will be set to control the pre-disturbance voltage at the terminal bus except for PEGS, San Juan and ETA SVC.

7. The following items will be monitored during the study and tabulated in the report as needed:

   - Path 47, Path 48, Path 22 flows.

   - All buses, lines, and transformers with base voltages greater than 1 kV in the New Mexico and Arizona.

   - Post contingency element loadings will only be tabulated if they increased more than 1% from the normal system loading. To clarify, if an element was overloaded in the normal condition and increased no more than 1% in the outage condition, the overload will not be reported.

   - Post contingency voltage violations will be tabulated only if they deviate more than 0.005 p.u. from the normal system voltage. To clarify, if a bus had a low voltage violation in the normal condition and decreased no more than 0.005 p.u. in the outage condition, the bus will not be reported.