

ADDENDUM

SUMMARY

In 2007, the CATS HV subcommittee studied the CATS HV transmission system for the year 2016 to investigate the ability of the planned CATS HV system to accommodate local load growth beyond that forecast for 2016. During the investigation, transmission system overloads and voltage violations were noted in the CATS HV study area for single contingency outages. These violations occurred on the Western 115 kV system that has been slated for upgrade to 230 kV in the future. This addendum documents additional studies performed with planned upgrades to Western's 115 kV transmission system incorporated. Load in the CATS HV study area was increased in 100 MW increments above the level modeled in the 2016 base case until new violations occurred with the Western system upgrades.

The Western 115 kV transmission lines described in the chart below were modeled with new size conducted and a 230 kV designed structures but operated at 115 kV:

Conductor	From Bus	To Bus	Length in Miles
954ACSS	Casa Grande	Thornton	2.06
954ACSS	Thornton	Empire	15.14
954ACSS	Empire	ED-5B	9.20
954ACSS	ED-5	ED-4	9.20
954ACSS	ED-4	ED-2	9.30
954ACSS	ED-2	Coolidge	11.50
954ACSS	ED-2	Signal	4.30
954ACSS	Signal	Coolidge	7.90

In addition some adjustments to the original 2016 base case voltage profile were made to help resolve the Arizona VAR import situation. The specific changes made as a part of the voltage profile adjustments are described below:

- Adjusted Navajo generator busses to a scheduled per unit voltage of 1.05 per unit
- Adjusted Palo Verde generator busses to a scheduled per unit voltage of 1.05 per unit and made them self regulating

INCREMENTAL LOAD ANALYSIS

The increased load cases tested the addition of load in 100 MW increments (with a unity power factor) in the study region until 800MW of load was added or a voltage or thermal violation occurred. The generation used to offset the increased load was dispatched equally from simulated generation modeled at Palo Verde and Tortolita substations. The following results were found with the additional cases studied:

Addition of only the Voltage Profile Adjustments

With the addition of only the voltage profile adjustments, no additional load growth was able to be accommodated due to the same overload in Western's transmission system that occurred in the load growth 100 (LG100) case.

Addition of only Western's Upgrades

The additional load, from 100 MW to 400 MW, did not have an impact on voltage or thermal loadings under normal operating conditions. Under contingency conditions, however, the first violation occurred with 500 MW of additional load. The violations were voltage deviations of greater than 5% at the Casa Grande 115 kV and the Thornton 115 kV bus (despite the addition of a 25 MVAR shunt capacitor at the Thornton substation that mitigated voltage deviation in the prior Ten Year Plan Analysis).

Addition of both Western's Upgrades and Voltage Profile Adjustments

The additional load, from 100 MW to 500 MW, did not have an impact on voltage or thermal loadings under normal operating conditions. Under contingency conditions, however, the first violation occurred with 600 MW of additional load. The violations were voltage deviations of greater than 5% at the Empire 115 kV, Casa Grande 115 kV, Casa Grande 230 kV bus, and the Thornton 115 kV bus (despite the addition of a 25 MVAR shunt capacitor at the Thornton substation that mitigated voltage deviation in the Ten Year Plan Analysis).

The following tables highlight the results of the incremental load analysis with "Load Growth" describing the Load Growth base case, "Voltage Profile" describing the addition of the voltage profiles (as described above) to the base case, "Western" describing the addition of Western's transmission system upgrades and "Voltage Profile & Western" describing the addition of both adjustments to the Load Growth base cases.

No Outage (N-0) Thermal Results

There were no base case or incremental Load Growth 100 MW (LG100) thru Load Growth 800 MW (LG800) base case overloads in the study area during no outage conditions.

FR-Name	KV	TO-Name	KV	CK	Rtg 1	Contingency Description	CASE			
							Load Growth 200	Voltage Profile 200	Western 800	Voltage Profile & Western 800
NONE							NONE	NONE	NONE	NONE

Single Contingency (N-1) Thermal Results

There were no overloads for the BASE or Load Growth 100 MW (LG100). thermal overloads commence with Load Growth 200 MW (LG200) cases during single contingency conditions. This can be mitigated up to the 800 MW load growth level by implementing the Western system upgrades.

FR-Name	KV	TO-Name	KV	CK	Rtg 2 (Pre Upgrades)	Contingency Description	CASE			
							Load Growth 200	Voltage Profile 200	Western 800	Voltage Profile & Western 800
ED-5B	115	EMPIRE	115	1	110	Line TESTTRAK 230.0 to CASAGRND 230.0 Circuit 1	102%	102%	NONE	NONE
						Tran CASAGRND 230.00 to CASAGRND 115.00 Circuit 1	102%	102%	NONE	NONE

Single Contingency (N-1) Voltage Results

The table below shows the voltage violations for each of the load growth simulation cases. Only the voltage deviation (Delta V) violations following the contingency (Vcont) are shown. Voltage deviation violations are not experienced until the Load Growth 200 MW (LG200) level. The voltage profile case adjustments reduces the voltage deviation violation at the incremental 200 MW load level but does not resolve it. The Western system upgrade eliminates the voltage violations up to the 500 MW incremental load addition. When the study area load is increased to 600 MW (LG600) a number of voltage violations appear even with both the voltage profile adjustments and the Western upgrades.

Name	kV	Outage	Contingency Description	Data	CASE			
					Load Growth 200	Voltage Profile 200	Western 500	Voltage Profile & Western 600
EMPIRE	115	line_21	Line TESTTRAK 230.0 to CASAGRND 230.0 Circuit 1	_DeltaV	N/A	N/A	N/A	-0.0511
		tran_560	Tran CASAGRND 230.00 to CASAGRND 115.00 Circuit 1	_DeltaV	N/A	N/A	N/A	-0.509
THORNTON	115	line_21	Line TESTTRAK 230.0 to CASAGRND 230.0 Circuit 1	_DeltaV	-0.062	-0.0590	-0.0503	-0.0597
		tran_560	Tran CASAGRND 230.00 to CASAGRND 115.00 Circuit 1	_DeltaV	-0.062	-0.0590	N/A	-0.0595
CASA GRANDE	230	line_21	Line TESTTRAK 230.0 to CASAGRND 230.0 Circuit 1	_DeltaV	-0.06	-0.0570	N/A	-0.056
CASA GRANDE	115	line_21	Line TESTTRAK 230.0 to CASAGRND 230.0 Circuit 1	_DeltaV	-0.063	-0.0600	-0.0503	-0.0598
		tran_560	Tran CASAGRND 230.00 to CASAGRND 115.00 Circuit 1	_DeltaV	-0.063	-0.0600	N/A	-0.0597

CONCLUSIONS

The addition of the Western line upgrades allowed for the following conclusions to be drawn:

1. Without the Western 115kV to 230kV line upgrades the CATS HV Study Area can accommodate between 100MW and 200MW of load growth beyond the 2016 time before it experiences an N-1 Thermal violation.
2. Without the Western 115kV to 230kV line upgrades the CATS HV Study Area can accommodate less than 100MW of load growth beyond the 2016 time frame before it experiences an N-1 Voltage violation.
3. With the Western 115kV to 230kV line upgrades the CATS HV Study Area can accommodate between 500 and 600 MW of additional load growth beyond the 2016 time frame before it experiences an N-1 Voltage violation
4. With the Western 115kV to 230kV line upgrades the CATS HV Study Area can accommodate at least 800 MW of additional load growth beyond the 2016 time frame with no N-1 thermal violations. Load growth beyond 800MW was not looked at in this study.

The chart below displays graphically the conclusions above:

2016 CATS HV Load Increment Results Chart
 Base Case Load Level in Arizona: 24600.9 MW

Study Case	Load Growth that Caused Violation /AZ Load Level (MW)	Violation Limiting Load Growth
Base Study Case	+200 / 24800.9	Thermal
Base Case with Voltage Revisions	+200 / 24800.9	Thermal
Base Case with WAPA System Upgrades	+500 / 25100.9	%5 or greater voltage deviation
Base Case with both Voltage Revisions and WAPA System Upgrades	+600 / 25200.9	%5 or greater voltage deviation