



2009 Transmission Study

Analysis of Ten-Year (2019)
Transmission Plan Projects

For
Central Arizona Transmission System – High Voltage
“CATS-HV”

A sub-committee of the Southwest Area Transmission
 (“SWAT”) sub regional planning group



FINAL REPORT
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Executive Summary

Previous CATS-HV subcommittee reports have included a “saturated load” study to identify what the total electric load between Phoenix and Tucson could ultimately be if land development occurs according to county and municipal General Plans in the region, as well as the expected performance of the regional transmission system for the 2016 Ten-Year Plans. There have been significant changes within the CATS-HV region and a significant swing in load growth in multiple directions; however the continual review of the long term (ten years and beyond) requirements to meet the expected loads and resources for the multiple load serving entities serving this area will continually give the visibility for all of the planning jurisdictions within the CATS-HV area.

The 2007 and 2008 CATS-HV study efforts, two key issues had been identified and addressed as a component of the 2008 CATS-HV Transmission Plan. Specifically, the 2008 Transmission Plan included additional detailed 69kV subtransmission facilities as a component of the coordinated CATS-HV 2008 Ten-Year Transmission Plan; as well as the potential impacts of the CATS-HV transmission system with new generation resources to serve local and regional loads.

For 2009, the CATS-HV technical planning efforts included a coordinated Ten-Year Plan analysis that included the expected facilities, loads and resource conditions for the 2019 time frame. The analysis included continuous (N-0) and emergency (N-1 only) to determine any voltage or thermal issues within the CATS-HV area.

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Introduction

Previous CATS-HV subcommittee reports have included a “saturated load” study to identify what the total electric load between Phoenix and Tucson could ultimately be if land development occurs according to county and municipal General Plans in the region, as well as the expected performance of the regional transmission system for the 2016 Ten-Year Plans. There have been significant changes within the CATS-HV region and a significant swing in load growth in multiple directions; however the continual review of the long term (ten years and beyond) requirements to meet the expected loads and resources for the multiple load serving entities serving this area will continually give the visibility for all of the planning jurisdictions within the CATS-HV area.

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For 2009, the CATS-HV technical planning efforts included a coordinated Ten-Year Plan analysis that included the expected facilities, loads and resource conditions for the 2019 time frame. The analysis included continuous (N-0) and emergency (N-1 only) to determine any voltage or thermal issues within the CATS-HV area. The specific tasks identified in the 2009 Study Plan are included below.

Task 1

Prepare a coordinated Ten-Year Transmission Plan (specifically 2019) for the CATS-HV study area to be included in the 2009 SWAT Transmission Plan. The coordination of the 2009 CATS-HV Transmission Plan will require (but is not limited to) the following steps:

- Coordinate 2019 base case development for the CATS-HV region; including individual stakeholders ten-year transmission plans, subtransmission facilities and the associated system representations. The 2009 WestConnect coordinated base case will be used as the source for this case development.
- In addition to incorporating the detailed system representation, each LSE will be responsible for supplying their respective load and resource information for the 2019 heavy summer season.
- Conduct an assessment of the coordinated 2019 CATS-HV Transmission Plan in accordance with NERC/WECC planning criteria. Specifically for 2009, Category A and Category B contingencies will be included for this assessment.¹

¹ The 2008 CATS-HV Ten-Year Plan included an analysis of multiple contingencies. Due to fact that the system configuration for the CATS-HV has not significantly changed for the 2009 Ten-Year Plan, the decision was made to not include multiple contingencies as a component of the 2009 CATS-HV Ten-Year Plan.

Task 2

The final task for the 2009 SWAT CATS-HV Transmission Plan is to document the findings of the analysis identified in this Study Plan as a component of the overall 2009 SWAT Transmission Plan assessment, specifically:

- Document the findings of the 2009 CATS-HV Transmission Plan and coordinate the final report with the overall 2009 SWAT/WestConnect Transmission Plan report.

Base Case Assumptions

The following sections identify the assumptions used in performing this study. The 2019 CATS-HV base case development was initiated using with the approved CATS-HV 2018 base case (the seed case was the July 2008 Western Electricity Coordinating Council (WECC) approved 2018HS1A base case). A “round robin” approach was used to develop the CATS-HV base case among the regional CATS-HV transmission owners and load serving entities (WECC members only due to confidentiality of the power flow case information). Each entity updated the case to reflect their expected 2019 heavy summer loads and resources, as well as planned transmission additions (69kV and above). Entities include in the detailed review included were ED2, ED3, ED4, ED5, SPPR, APS, SRP, Western, TEP, and SWTC.

Transmission and Generation Configurations

The coordinated 2019 CATS-HV base case was reviewed by Arizona entities and included the companies’ ten year plan elements that would be in service by 2019. A few note-worthy transmission and generation items include:

Significant Additions or Exclusions:

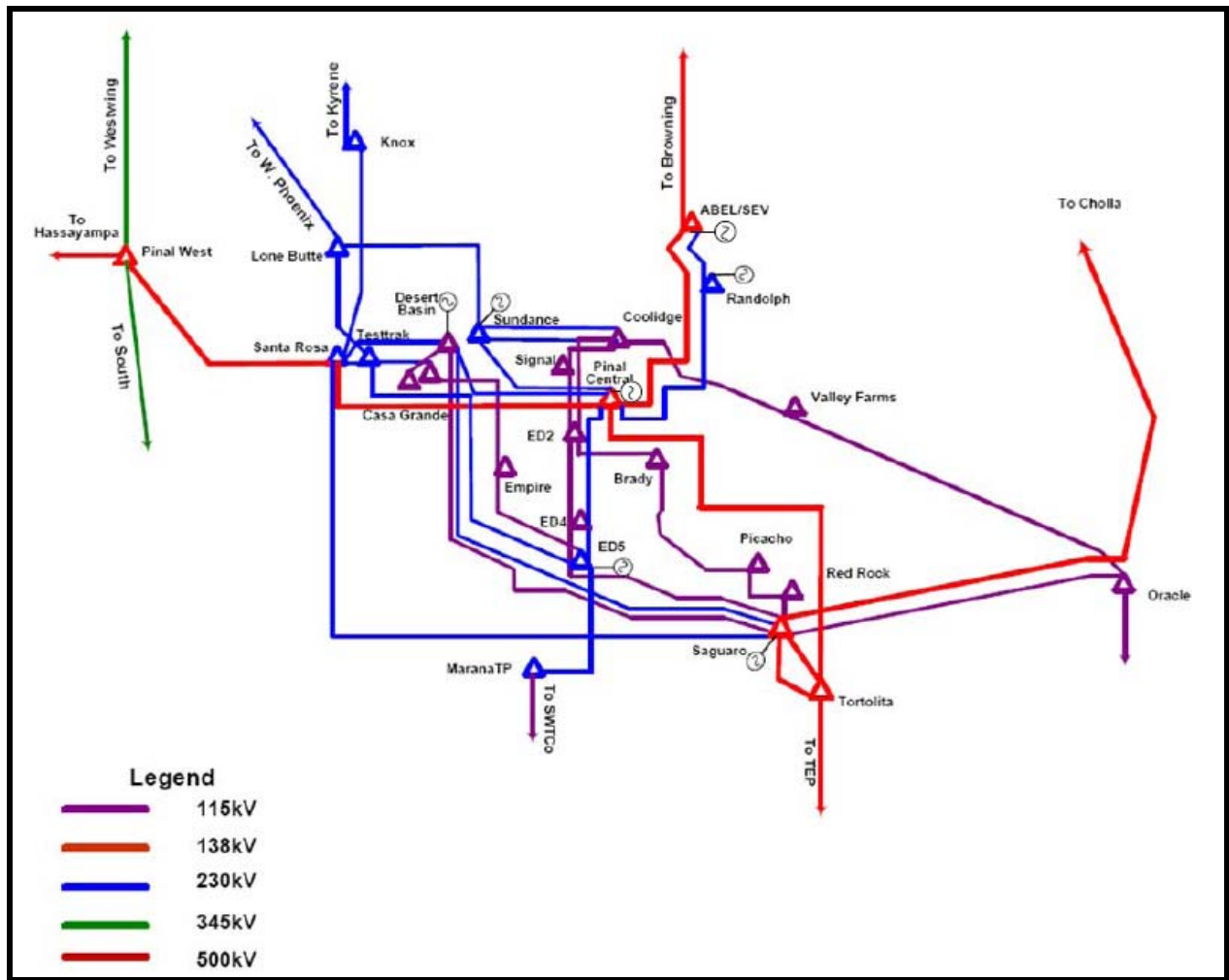
- Southeast Valley (SEV) 500kV line (Pinal West-Santa Rosa-Pinal Central-Abel-Browning) was included.
- Pinal Central 230kV lines to Desert Basin, Sundance, and Randolph/Browning were included.
- The SPPR “Three-Terminal” transmission plan (Pinal Central to ED5 230kV, ED5 to Test Track 230kV, ED5 to Marana 230kV) was included.
- Planned generation at Coolidge Energy (Randolph), Abel, Pinal Central, SPPR and Bowie were included in the base case and dispatched as needed to meet load and resource requirements for the region. Specific CATS HV area generation included in the base case is shown in Table 1.
- The SunZia Southwest and other EHV injections (transmission) into the state of Arizona were not included in this transmission configuration as none of these projects had been classified as in Phase 2 of the WECC Three-Phase Rating process or “Planned” projects in the WestConnect model at the time of the base case development.
- Total Arizona Generation (dispatched): 33,802 MW
- Total Arizona Load (w/o losses): 25,183 MW

Table 1: CATS-HV Area Base Case Generation Assumptions

Generation Location	Existing or Planned	Base Case Dispatch Level (MW)	Max Generation Available (MW)
Desert Basin	Existing	570	630
Sundance	Existing	394.6	437
Saguaro	Existing	398	398
Randolph (Coolidge)	Planned	561.6	561.6
Abel	Planned	780	842
Pinal Central	Planned	1200	1394
SPPR Gen	Planned	0	627

The transmission configuration for the 2019 CATS-HV base case was reviewed by Arizona entities and included the companies' ten year plan elements that would be in service by 2019. Figure 1 depicts the CATS-HV region and associated transmission configuration.

Figure 1: 2019 CATS-HV Regional Transmission Configuration



Methodology

With the CATS-HV loads and resources incorporated into the 2019 heavy summer base case, an initial base case screening was performed to document transmission facility overloads during normal operating conditions. Following the initial screening, power flow contingency analyses were performed to review for reliability criteria violations. Specific studies conducted and their evaluation criteria are outlined below:

Contingency Analysis

The CATS-HV 2019 base case was used to perform a reliability assessment under normal operating conditions (NERC Category A, N-0), as well as, single (NERC Category B, N-1) contingencies. These outages included:

- All single (69-500kV) transmission circuit outages within Arizona (1938 line contingencies, via PSLF generated outage list).
- All single transformer outages within the Arizona area (297 transformer contingencies, via PSLF generated outage list).
- All single generation unit (G-1) outages within the Arizona area (171 generator contingencies, via PSLF generated outage list).

The WECC/NERC planning standards were used to assess the adequacy of the study results. The power flow analysis related evaluation criteria that were used are summarized below:

- Pre-contingency bus voltage must be between 0.95 per unit and 1.05 per unit (although note that several 500kV buses operate at approximately 1.06 per unit).
- Maximum voltage deviation allowed at all buses under contingency conditions will be 5% for N-1 contingencies.
- Pre-disturbance loading to remain within continuous ratings of all equipment and line conductors; specifically referencing Rating 1 as included in the CATS-HV base case.
- Post-disturbance (N-1 contingencies) loading to remain within emergency ratings of all equipment and line conductors; specifically referencing Rating 2 as included in the CATS-HV base case.

Task 1 – Reliability Assessment of Ten-Year Plans

The CATS-HV 2019 heavy summer base case was initially screened for any NERC Category A (N-0) thermal overloads based on the ratings contained in the base case to ensure it meets reliability criteria during normal operating conditions. NERC Category B (N-1) were also conducted; it should be noted however that a full outage listing (i.e. contingency list) is not included with this report due to the magnitude of outages taken but are available upon request. The detailed summary output tables are included in Appendix A.

Key findings from the power flow studies using the CATS-HV 2019 heavy summer base case are:

- As shown in Table 3, no CATS-HV area facilities were identified as overloaded under normal, all lines in service, conditions.

Table 3: NERC Category A Overloads within CATS-HV Area

Outage	Overloaded Facility	Recommended Mitigation
NERC Category A (N-0)		
ALL LINES IN SERVICE	None	N/A

Following the base case screening, power flow contingency simulations were conducted on the CATS-HV 2019 heavy summer base case. Power flow solutions were achieved for all N-1 outages simulated.

- As shown in Table 4, no CATS-HV area facilities were identified as overloaded under emergency conditions for a single contingency.

Table 4: NERC Category B Overloads within CATS-HV Area

Outage	Overloaded Facility	Recommended Mitigation
NERC Category B (N-1)		
N/A	None	

- Multiple transmission facility overloads were identified outside of the CATS-HV area under emergency operating conditions for a single contingency outage. These overloads will be addressed as part of the other subregional transmission planning efforts.

- Table 5 summarizes the findings related to violations within the CATS-HV area of “delta Voltages” greater than 5% voltage deviation and “Voltage Magnitude” for load buses less than 0.90 p.u. The load serving entity for these facilities has confirmed that power factor correction will be required and examined as part of the routine planning cycle.

Table 5: NERC Category B Voltage Violations within CATS-HV Area

Outage	Substation	Delta Voltage		Voltage Magnitude		Recommended Mitigation (shunt caps)
		No Caps	w/caps	No Caps	w/caps	
NERC Category B (N-1)						
Coolidge to Valley Farms 115kV line	Merrill 69kV	14.4 %	2.2 %	0.86 p.u.	0.99 p.u.	Merrill 2 x 7.2MVAR SE5 1 x 7.2MVAR
	SE5 69kV	14.8 %	2.2 %	0.86 p.u.	0.99 p.u.	
	Valley Farms 69kV	14.8 %	4.0 %	0.88 p.u.	0.99 p.u.	

- A few other voltage violations were identified outside of the CATS-HV area (south of Marana) under emergency operating conditions for a single contingency outage. These violations will be addressed as part of the SATS transmission plan.

Conclusions

In summary for the 2009 CATS-HV Ten-Year Plan analysis found there were no voltage or thermal issues within the CATS-HV area in the coordinated SWAT 2019 base case under pre and post outage conditions.



APPENDIX A TASK 1

CATS HV N-0 Violations

CATS HV N-1 Flow Violations

CATS HV N-1 Delta Voltage Flow Violations

CATS HV N-1 Voltage Magnitude Violations



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CATS HV N-0 VIOLATIONS

NONE NOTED WITHIN CATS HV AREA

CATS HV N-1 FLOW VIOLATIONS

NONE NOTED WITHIN CATS HV AREA

CATS HV 2009 Study: Task 1

CATS HV N-1 DELTA VOLTAGE VIOLATIONS

BUS NUMBER	BUS NAME	BU	BU	BUS	CONT	CONTINGE	CONTINGENCY DESCRIPTION	Catshv_rev4
84875	MERRIL	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.	-14.81%
84904	SE5	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.	-14.79%
84926	MERRILTP	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.	-14.74%
84908	VLYFARMS	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.	-14.37%

*** NOTE: Above outage does not include shunt capacitors at Merrill (2 x 7.2MVAR) and SE5 (1 x 7.2MVAR). No violations were noted with these capacitors switched on for this outage.**

CATS HV N-1 VOLTAGE MAGNITUDE VIOLATIONS

NUMBER	NAME	KV	AREA	ZONE	OTG	OTG DESCRIPTION	CONTINGENCY DESCRIPTION	Catshv_rev4
84908	VLYFARMS	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.0 Circuit 1	0.886
84926	MERRILTP	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.0 Circuit 1	0.867
84875	MERRIL	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.0 Circuit 1	0.864
84904	SE5	69	14	845	336	"line_335"	Line COOLIDGE 115.0 to VLYFARMS 115.0 Circuit 1	0.864

*** NOTE: Above outage does not include shunt capacitors at Merrill (2 x 7.2MVAR) and SE5 (1 x 7.2MVAR). No violations were noted with these capacitors switched on for this outage.**