A subsidiary of Pinnacle West Capital Corporation

Q90 Transient Stability Re-Study

APS Contract No. 52238

By

Arizona Public Service Company
Transmission Planning

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Prepared by
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EXECUTIVE SUMMARY

The customer indicated a turbine change after completion of the Facilities Study. The customer indicated a change back to Gamesa wind turbines from the Sinovel wind turbines studied in the Facilities Study. Issues had been discovered with the Gamesa user-written dynamic model, but the customer provided an updated user-written model as part of this change request. In addition to providing an updated model, the customer indicated the "ModelType" parameter should be changed from "3" to "2" changing from a "G9X ABB USA FERC 661-A Weak Grids" model to a "G9X ABB 60Hz USA LVRT" model. The planned capacity and power factor capability of the project did not change, requiring a re-study of only the transient stability portion compared to what was modeled in the Facilities Study.

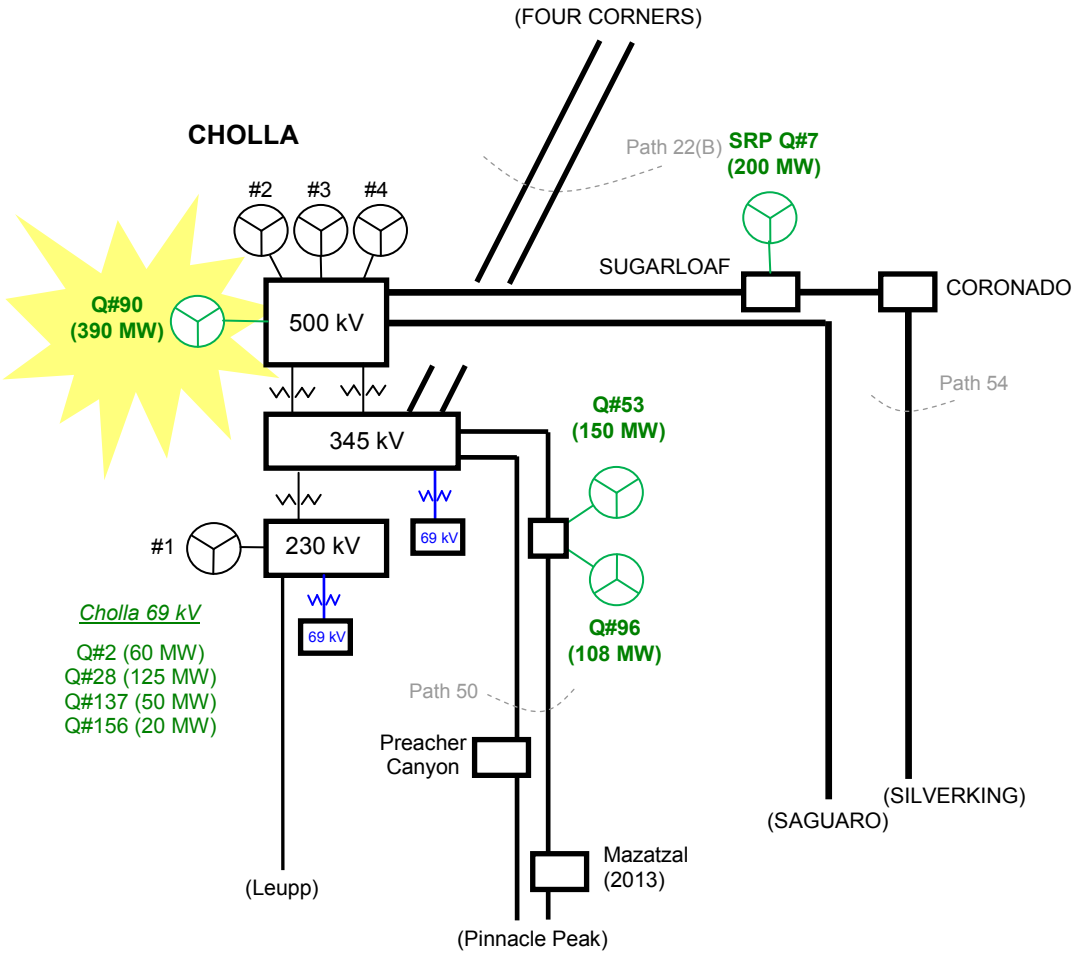

Figure 1. Q90 Interconnection

1 STUDY DESCRIPTION AND ASSUMPTIONS

This transient stability re-study utilized cases 1-4 from the SIS which modeled the Q90 interconnection without any nearby interconnection requests. A fifth case was created which added nearby Q53 to the basecase. Nearby Q37 was not added to the case because is recently dropped out of the queue.

1.1 Project Modeling

The turbine manufacturer selected by the customer was revised after the Facilities Study. The Applicant indicated the project will now consist of Gamesa G9X turbines capable of +/- 0.95 power factor. No changes were made to the power flow model. Only changes to the transient stability model were necessary. The new transient stability data provided by the customer is provided in **Appendix B**.

1.2 Transient Stability Analysis

This study utilized the same comprehensive contingency list used in the Facilities Study. Fifty-two (52) Western Electricity Coordinating Council (WECC) Category B and C outages were applied to the case. The contingency list is provided in **Appendix A**. All of the transient stability simulations met the WECC Disturbance Performance Criteria.

The switch back to the Gamesa wind turbines does not appear to cause any transient stability concerns. Dynamic simulation issues previously observed with the Gamesa wind turbine model appear to have been resolved with the updated model and parameters.

Appendix C contains transient stability plots of the contingencies that provide a representative illustration of the transmission system's Post-Project performance.

Appendix A

CONTINGENCY LIST

The following selected single element outages (N-1) and double element outages (N-2) were simulated.

WECC Category B Outages

1. N-1 Cholla-Sugarloaf 500kV Line
   - Bypass Coronado-Silver King Series Caps
2. N-1 Cholla-Saguaro 500kV Line
3. N-1 Sugarloaf-Coronado 500kV Line
   - Bypass Coronado-Silver King Series Caps
   - Insert 2 caps at PP, Papago, or Rogers
4. N-1 Coronado-Silver King 500kV Line
   - Insert 2 caps at PP, Papago, or Rogers
   - Drop Coronado Unit 2
5. N-1 Browning-Silver King 500kV Line
6. N-1 Pinnacle Peak-Morgan 500kV Line
7. N-1 Four Corners-Moenkopi 500kV Line
8. N-1 Four Corners-Cholla #1 345kV line
9. N-1 Cholla-Preacher Canyon 345kV Line
10. N-1 Preacher Canyon-Pinnacle Peak 345kV Line (with PP Xfmr #4)
11. N-1 Cholla-Mazatzal 345kV Line
12. N-1 Mazatzal-Pinnacle Peak 345kV Line (with PP Xfmr #7)
13. N-1 Flagstaff-Pinnacle Peak 345kV Line #1 or #2
14. N-1 Coronado-Springerville 345kV Line
    - Bypass the Coronado-Silver King series caps
15. N-1 Springerville-Vail 345kV Line
16. N-1 McKinley-Springerville 345kV Line
17. N-1 Springerville-Greenlee 345kV Line
18. N-1 Cholla-Leupp 230kV Line
19. N-1 Sugarloaf 500/69kV Xfmr (insert 69kV caps, close Vernon back-tie)
    - Insert Shumway and Showlow caps
    - Close Vernon Back Tie
20. N-1 Coronado 500/345kV Xfmr #1 or #2
21. N-1 Coronado 500/69kV Xfmr
22. N-1 Four Corners 500/345kV Xfmr
23. N-1 Four Corners 345/230kV Xfmr #1 or #2
24. N-1 Silver King 500/230kV Xfmr
25. N-1 Kyrene 500/230kV Xfmr #6, #7, or #8
26. N-1 Pinnacle Peak 500/230kV Xfmr #1, #2, or #3
27. N-1 Pinnacle Peak 345/230kV Xfmr #1, #2, or #3
28. N-1 Cholla 500/345kV Xfmr #3 or #6
29. N-1 Cholla #7 345/230kV Xfmr

30. N-1 Cholla 345/69kV Xfmr
31. N-1 Cholla 230/69kV Xfmr #1
32. N-1 Cholla 230/69kV Xfmr #2
33. N-1 Mazatzal 345/69kV Xfmr
34. N-1 Preacher Canyon 345/69kV Xfmr #1 or #2

WECC Category C Outages

35. Four Corners-Moenkopi 500kV Line and Four Corners 500/345kV Xfmr
    - Category C3
    - 3 phase fault at Four Corners 500kV bus cleared in 4 cycles
    - Four Corners Unit 5 tripped in 4 cycles
36. Cholla-Saguaro 500kV Line and Cholla Unit 3 with Delayed-Clearing
    - Category C6
    - 1 phase fault at Cholla 500kV bus cleared in 10 cycles
37. Cholla-Sugarloaf 500kV Line and Cholla 3 500/345kV Xfmr with Delayed-Clearing
    - Category C7
    - 1 phase fault at Cholla 500kV bus cleared in 10 cycles
38. Cholla-345kV West Bus with Delayed-Clearing
    - Category C9 (simulated as a 3 phase fault)
    - 3 phase fault at Cholla 345kV bus cleared in 12 cycles
39. Cholla-345kV East Bus with Delayed-Clearing
    - Category C9 (simulated as a 3 phase fault)
    - 3 phase fault at Cholla 345kV bus cleared in 12 cycles
40. Pinnacle Peak-230kV West Bus with Delayed-Clearing
    - Category C9
    - 1 phase fault at Pinnacle Peak 230kV bus cleared in 16 cycles
41. Pinnacle Peak-230kV Central Bus with Delayed-Clearing
    - Category C9 (simulated as a 3 phase fault)
    - 3 phase fault at Pinnacle Peak 230kV bus cleared in 16 cycles
42. Pinnacle Peak-230kV East Bus with Delayed-Clearing
    - Category C9 (simulated as a 3 phase fault)
    - 3 phase fault at Pinnacle Peak 230kV bus cleared in 16 cycles
43. Pinnacle Peak-230kV North Bus with Delayed-Clearing
    - Category C9
    - 1 phase fault at Pinnacle Peak 230kV bus cleared in 16 cycles
44. Cholla-500kV Bus with Cholla Unit 4 with Delayed Clearing
    - Category C6
    - 1 phase fault at Cholla 500kV bus cleared in 10 cycles
45. Pinnacle Peak-Mazatzal 345kV Line with Pinnacle Peak 345/230kV Xfmrs 7 and 14 with Delayed Clearing
    - Category C8 (modeled as a 3 phase fault)
    - 3 phase fault at Pinnacle Peak 345kV bus cleared in 12 cycles

46. Pinnacle Peak-Preacher Canyon 345kV Line with Pinnacle Peak 345/230kV Xfmrs 4 and 14 with Delayed Clearing
    - Category C8 (modeled as a 3 phase fault)
    - 3 phase fault at Pinnacle Peak 345kV bus cleared in 12 cycles
47. Four Corners-Moenkopi 500kV Line with Four Corners Unit 5 with Delayed Clearing
    - Category C6 (modeled as a 3 phase fault)
    - 3 phase fault at Four Corners 500kV bus cleared in 10 cycles
48. Cholla-Mazatzal and Cholla-Preacher Canyon 345kV Lines
    - Category C5
    - 3 phase fault at Cholla 345kV bus cleared in 5 cycles
49. Cholla-Four Corners 345kV Lines 1 and 2
    - Category C5
    - 3 phase fault at Cholla 345kV bus cleared in 5 cycles
50. Cholla-Saguaro and Coronado-Silverking 500kV Lines
    - Category C5
    - 3 phase fault at Cholla 500kV bus cleared in 4 cycles
51. Morgan-Pinnacle Peak 500kV Line and Avery-Raceway 230kV Line
    - Category C3
    - 3 phase fault at Pinnacle Peak 500kV bus cleared in 4 cycles
52. Cholla-Saguaro and Sugarloaf-Cholla 500kV Lines
    - Category C5
    - 3 phase fault at Cholla 500kV bus cleared in 4 cycles

Appendix B

TRANSIENT STABILITY MODELING

Project Q90 - Dynamic Data

Wind Turbine Model – Q90

The Q90 applicant indicated that turbines will be Gamesa model G9X turbines.

Model Name:	**epcmod**
Description	User-written dynamic model for a wind turbine
Inputs:	G9X_WMdl.p – the generator model G9X_PRT.p – the protection model
Parameters:	Defined by user. Applicant provided this model as part of their application

G8X_WMdl.p	**Parameters**
0.009494	Rsrc
0.212808	Xsrc
2	Model Type (2 = “G9X ABB 60Hz USA LVRT”)
1	Crowbar Enable
1	Dip Detection Enable
1	Speed Control Enable
0	Force Crowbar
0	Keep Iq in Dip
15	Wind Speed (m/s)
0	Voltage Mode

G8X_PRT.p	**Parameters**
1	Protection Enable
1	Undervoltage/Overvoltage protection enabled
1	Underfrequency/Overfrequency protection enabled
0	Overcurrent protection enabled

Appendix C

TRANSIENT STABILITY PLOTS