DISIS-2020-001

Phase 2 Study Report - Addendum

9/15/2021

This addendum captures the corrections to the DISIS-2020-001 Phase 2 report posted on 8/19/2021 and the additional information requested by the Interconnection Customer(s) at the Phase 2 study report meeting held on 8/30/2021.

The following corrections to DISIS-2020-001 report were identified: Table 11 had incorrect costs. The correct values are shown below

Table 11 – Total cost of Station Network Upgrades by POI

POI	Total Cost	GIRs Sharing the POI
Mirasol 230kV Station	$20.563 Million ~~$42.848 Million~~	GI-2020-1 and GI-2020-4
Mirasol 345kV Station	$24.224 Million ~~$42.848 Million~~	GI-2020-7
GI-2020-3 230kV Switching Station	$19.416 Million ~~$17.182 Million~~	GI-2020-3
GI-2020-6 230kV Switching Station	$18.794 Million ~~$16.977 Million~~	GI-2020-6
Existing Fort Saint Vrain4	0	GI-2020-5
Breaker addition at GI-2014-9 230kV Switching Station	$1.098 Million ~~$2.229 Million~~	GI-2020-10

- Section 9.0: Contingent Facilities section had incorrect rating for Daniels Park – Priarie3 230kV line.
  Upgrade Daniels Park – Priarie3 230kV line to 756MVA ~~576MVA~~ – ISD under development

Short Circuit Study:

The following additional information regarding breaker duty study methodology and Pre DISIS-2020-001 breaker duty loadings was requested by the Interconnection Customers during the study report meeting.

Modeling: The Short circuit study was performed by modeling a Benchmark Case which represents the system before the DISIS-2020-001. The modeling assumptions for the Benchmark Care are same as Section 4.1 of the Phase 1 DISIS-2020-001 report.

A Study Case was created from the Benchmark Case by modeling the GIRs in the DISIS-2020-001 at their respective POIs, using the modeling data (impedance and configuration information) provided by the Interconnection Customer. All inverter-based generation, including generator step-up transformers, were modeled on an aggregate basis using appropriately scaled generic models at the low side of the main power transformer. In addition, the following Network Upgrades identified from the power flow analysis are modeled in the Study Case:

- Loop the Comanche – MidwayPS 230kV line into the Mirasol 230kV Station

All connected generating facilities were assumed capable of producing maximum fault current. As such, all generation was modeled at full capacity, whether NRIS or ERIS in the Benchmark Case and the Study case. In addition, where hybrid facilities are included (e.g. solar with battery storage), each technology is modeled as a separate generating resource in CAPE and included at full capacity in the short circuit study, regardless of any limitations to the combined output that would be imposed

Breaker Duty Analysis:

Breaker duty studies were performed on the Benchmark Case and the Study Case, and the results are compared, as shown in Table 1.

Breaker duty studies are conducted using the sub-transient fault analysis. Single and three phase faults are placed at each substation in the system. Each breaker on the PSCo system is modeled by the manufacturer and model number with the catalog characteristics for that breaker and its application, i.e., the relevant standard applying to that breaker's date of manufacture, kA interrupting rating, voltage rating, relay operate time, breaker interrupting time, proximity to generation, etc. The reclosing scheme is not considered in the analysis. The aforementioned factors are used to calculate an X/R factor according to ANSI C37.010-1999, ANSI C37.5-1979, or C37.6-1971. For evaluation of breaker opening by C37.010-1999, applicable to all breakers identified in this study, and with no reclosing and no additional derating, the equivalent current that the breaker is required to interrupt is simply the fault current multiplied by the X/R factor ($I_{breaking}$). This fault current is compared against that breaker's rated

interrupting capacity to determine whether the breaker is over-dutied. If it is greater than the breaker's interrupting capacity, it is considered to be over-dutied.

Transmission circuit breakers that were identified as over-dutied (0% margin) in the Benchmark Case are not included. Only breakers that are over-dutied with the addition of the DISIS-2020-001 GIRs are identified as Network Upgrades. The X/R factor, breaker interrupting capacity, fault current are listed in Table 2 for each over-dutied breaker identified in the study.

In cases where the current resulting from the removal of the GIR resulted in a current reduction at the over-dutied breaker, that cost allocation was set to 0%.

The steps for Breaker duty analysis are shown below.

Step -1: The results of the Benchmark Case and the Study Case are compared and additional breakers that are over-dutied in the Study Case are identified. See Table 2.

Table 1 Over-dutied Breakers Due to Cluster Addition

SUBSTATION	BASE KV	BREAKER NAME
COMANCHE (PSCO)	230	5400
COMANCHE (PSCO)	230	5401
COMANCHE (PSCO)	230	5402
COMANCHE (PSCO)	230	5403
COMANCHE (PSCO)	230	5405
COMANCHE (PSCO)	230	5406
COMANCHE (PSCO)	230	5407
COMANCHE (PSCO)	230	5409
COMANCHE (PSCO)	230	5410
COMANCHE (PSCO)	230	5411
COMANCHE (PSCO)	230	5415
COMANCHE (PSCO)	230	5417
COMANCHE (PSCO)	230	5419
COMANCHE (PSCO)	230	5418
COMANCHE (PSCO)	230	5404
DANIELS PARK (PSCO)	230	5100
DANIELS PARK (PSCO)	230	5103
DANIELS PARK (PSCO)	230	5107
DANIELS PARK (PSCO)	230	5110
DANIELS PARK (PSCO)	230	5111
DANIELS PARK (PSCO)	230	5112
DANIELS PARK (PSCO)	230	5115
DANIELS PARK (PSCO)	230	5113
DANIELS PARK (PSCO)	230	5707
DANIELS PARK (PSCO)	230	5104

SUBSTATION	BASE KV	BREAKER NAME
DANIELS PARK (PSCO)	230	5116

Step-2: To identify the impact of each GIR, breaker duty studies were re-performed while excluding each individual GIR and associated network upgrade, one at a time. Faults current at each identified over-dutied breaker was used to determine the relative contribution of each GIR and associated network upgrade. The impact of each GIR (which determines the cost allocation) was determined as follows:

$$Allocation\% = \frac{Fault\ Current\ Reduction\ due\ to\ Removal\ of\ GI\ of\ interest}{\sum Fault\ Current\ Reduction, All\ GIs} * 100$$

Where

$$Fault\ Current\ Reduction = (Fault\ Current\ at\ Breaker, All\ GIs\ connected\ ) - (Fault\ Current\ at\ Breaker, All\ GIs\ connected\ except\ GI\ of\ interest)$$

And,

the Fault Type matches the fault type (3-phase or phase-to-ground) causing the breaker to be overstressed.

Table 3. Cost Allocation of Over-dutied Breakers Due to GIRs in DISIS-2020-001

Substation	Base (kV)	Bkr Name	Bkr. Interr. Rating	Fault Current Before DISIS (kA)	Fault Current with all GIs connected (kA)	XR Factor	Ibreaking (XRFACT*Fault Current)	Fault type	GI-2020-1		GI-2020-3		GI-2020-4		GI-2020-6		GI-2020-7		GI-2020-10		Sum of all reductions (kA)
									Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal*	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	
Comanche (PSCO)	230	5400	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5401	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5402	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5403	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5405	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5406	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5407	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5409	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5410	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5411	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5415	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5417	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5419	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5418	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Comanche (PSCO)	230	5404	40	29.88	34.23	1.17	40.05	L-G	0.379	10.0%	0.435	11.5%	0.202	5.3%	0.008	0.2%	2.140	56.3%	0.635	16.7%	3.799
Daniels Park (PSCO)	230	5100	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5103	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5107	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5110	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5111	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5112	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5115	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997

Substation	Base (kV)	Bkr Name	Bkr. Interr. Rating	Fault Current Before DISIS (kA)	Fault Current with all GIs connected (kA)	XR Factor	Ibreaking (XRFACT*Fault Current)	Fault type	GI-2020-1		GI-2020-3		GI-2020-4		GI-2020-6		GI-2020-7		GI-2020-10		Sum of all reductions (kA)
									Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal*	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	Reduction after removing GI (kA)	% of sum of all reductions resulting from removal	
Daniels Park (PSCO)	230	5113	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5707	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5104	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997
Daniels Park (PSCO)	230	5116	40	38.77	40.11	1	40.11	3 PH	0.070	7.0%	0.076	7.6%	0.039	3.9%	0.256	25.7%	0.527	52.9%	0.029	2.9%	0.997

percentage values calculated in the table reflect the breaker cost allocation to each GIR in DISIS-2020-001