PI-2024-24 Provisional Interconnection Study Report

Xcel Energy
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Prepared by: Mitsubishi Electric Power Products, Inc on behalf of Public Service Company of Colorado

Peer Review by: James Nguyen, Principal Engineer

Approved by: Kevin Pera, OATT Program Manager

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1.0 Executive Summary

This Provisional Interconnection Service (PIS)[1] Study has been prepared in accordance with the Xcel Energy Open Access Transmission Tariff and the executed Provisional Interconnection Study Agreement between the Interconnection Customer (IC) and the Transmission Provider (TP) – Public Service Company of Colorado (PSCo). This PI request has been given the queue number as PI-2024-24 and associated with the 5RSC-2024-06 Generation Interconnection Request (GIR).

The PI request is for a 300 MW Photovoltaic (PV) plus 100 MW Battery Energy Storage System (BESS) with a Point of Interconnection (POI) at the Sandstone 345 kV switching station.

The total estimated cost of the PSCo transmission system improvements required for PI-2024-24 to qualify for Provisional Interconnection service is estimated to be **$15.753** million.

The initial maximum permissible output allowed for the Generating Facility is 300 MW and up to 100 MW of the BESS can be charged from the grid at the POI. The output amount of the Generating Facility in the PLGIA[2] will be reviewed quarterly and updated, if there are changes to the system conditions assumed in this analysis.

Security: PI-2024-24 is a request for Energy Resource Interconnection Service (ERIS). For ERIS requests, security shall estimate the risk associated with the Network Upgrades and the Interconnection Facilities and is assumed to be a minimum of $5 million.

The Interconnection Customer assumes all risks and liabilities with respect to changes between the PLGIA and the LGIA[3], including changes in output limits and Interconnection Facilities, Network Upgrades, Distribution Upgrades, and/or System Protection Facilities cost responsibility.

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[1] **Provisional Interconnection Service (PIS)** shall mean an Interconnection Service provided by Transmission Provider associated with interconnecting the Interconnection Customer's Generating Facility to Transmission Provider's Transmission System and enabling that Transmission System to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of the Provisional Large Generator Interconnection Agreement and, if applicable, the Tariff.

[2] **Provisional Large Generator Interconnection Agreement (PLGIA)** shall mean the interconnection agreement for Provisional Interconnection Service established between Transmission Provider and/or the Transmission Owner and the Interconnection Customer. The pro forma agreement is provided in Appendix 8 and takes the form of the Large Generator Interconnection Agreement, modified for provisional purposes.

[3] **Large Generator Interconnection Agreement (LGIA)** shall mean the form of interconnection agreement applicable to an Interconnection Request pertaining to a Large Generating Facility that is included in the Transmission Provider's Tariff.

This Provisional Interconnection Service in and of itself does not convey transmission service.

2.0 Introduction

This PI request is for a 300 MW Solar Photovoltaic (PV) plus 100 MW Battery Energy Storage System (BESS) Generating Facility located in Pueblo County, Colorado. The Study will evaluate the impacts on the PSCo transmission system and Affected Systems by modeling the Generating Facility at the nameplate amount minus any losses for the interconnection facilities.

- The POI of this project is at the Sandstone 345 kV switching station.
- The Commercial Operation Date (COD) to be studied for PI-2024-24 is 6/1/2028.

The geographical location of the transmission system near the POI is shown in Figure 1.

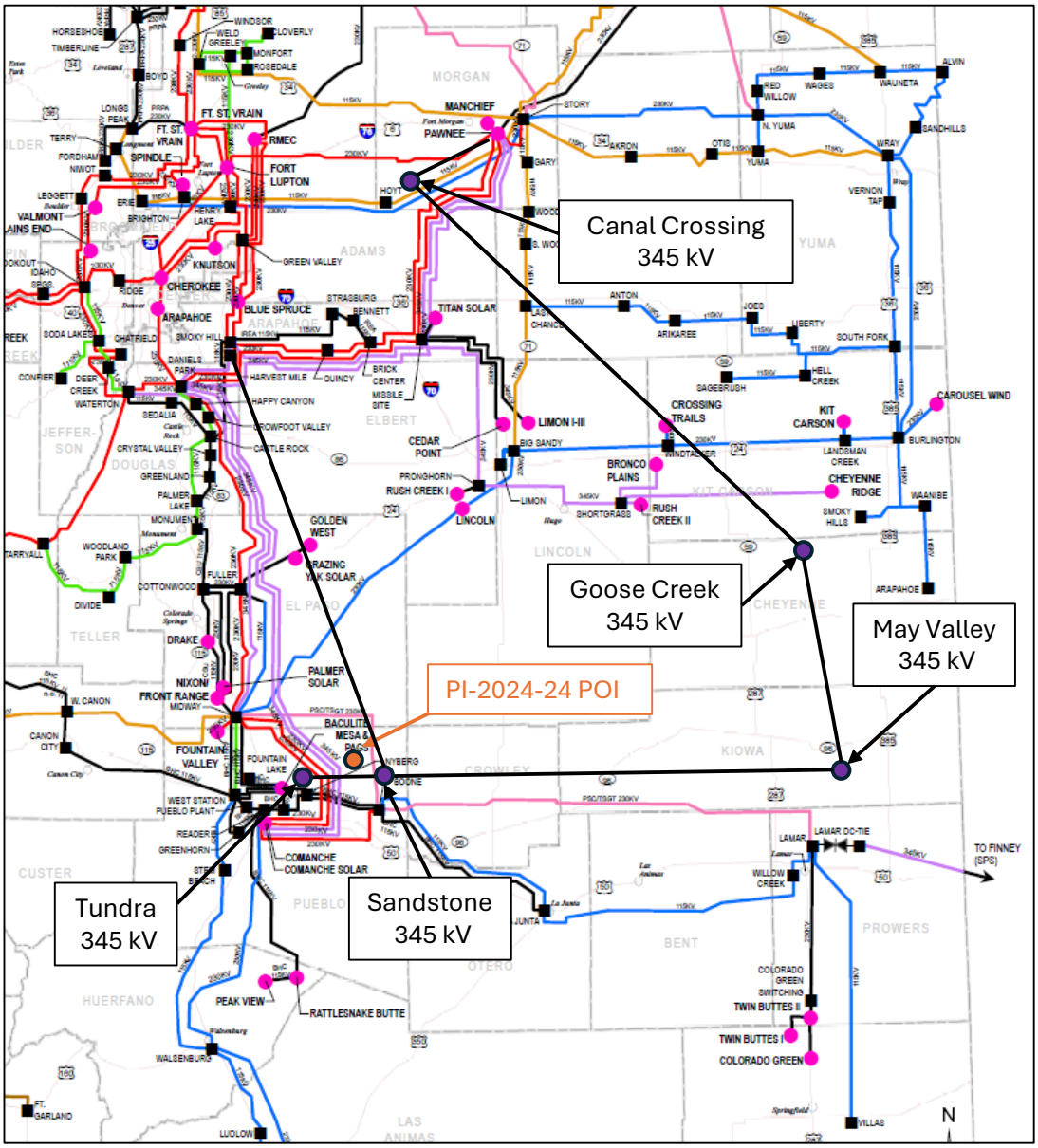


Figure 1: Point of Interconnection of PI-2024-24

3.0 Study Scope

The Study Scope includes Power Flow (thermal and voltage) analysis, Stability analysis, Voltage and Reactive Capability analysis, Short-Circuit analysis, and Cost Estimates for Interconnection Facilities and Station Network Upgrades. The study also identifies the Contingent Facilities associated with the Provisional Interconnection service.

3.1 Power Flow and Stability Analysis Criteria

The Power Flow and Stability Analysis criteria used for this study follow the guidelines set forth in the TPL-001-WECC-CRT-4 under requirement WR1.

3.2 Short-Circuit Analysis Criteria (Breaker Duty)

Fault Current after PI addition should not exceed 100% of the Breaker Duty rating. PSCo can only perform breaker duty analysis on the PSCo Transmission System. Before the PI goes in-service the Affected Systems may choose to perform a breaker duty analysis to identify breaker duty violations on their system.

3.3 Benchmark Case Modeling

The Benchmark Case was created from the Base Case (2028HS) as described in Chapter 3 of the BPM by changing the study pocket generation dispatch to reflect heavy generation in the Western Slope study pocket.

3.4 Grid Charging Benchmark Case Modeling

The Grid Charging Benchmark Case was created from the Base Case (2028HS) as described in Chapter 3 of the BPM by changing the study pocket generation dispatch to reflect heavy generation in the Western Slope study pocket.

3.5 Study Case Modeling

The PI-2024-24 is a 300 MW net output at the Point of Interconnection with 300 MW (312.82 MW gross) Photovoltaic (PV) plus 100 MW (107.53 MW gross) Battery Energy Storage System (BESS) Generating Facility.

- Solar PV Machine model – Ninety-six (96) inverters, PE FS3430M, rated for 3.43 MVA.
- BESS Machine model – Thirty-three (33) inverters, PE FP3430K, rated for 3.43 MVA 4-hour standalone grid-charge storage project using FREEMAQ PCSK 645V batteries.
- Length of Gen-Tie – 3.5 miles
- Number of main step-up transformer, voltage and rating – Two (2) main step-up transformers: GSU #1 is 34.5/13.8/345 kV, 69/92/115 MVA associated with the BESS facility and GSU #2 is 34.5/13.8/345 kV, 135/180/225 MVA associated with Solar PV facility.

The Discharging Study Case was created from the Benchmark Case by turning on the PI-2024-24 generation. The additional 300 MW output at POI was balanced against PSCo generation outside of the South Colorado study pocket.

The Grid Charging Study Case was created from the Grid Charging Benchmark Case by turning on the PI-2024-24 BESS facility as a 100 MW of load. The additional 100 MW of load from PI-2024-24 was balanced against PSCo generation outside of the South Colorado study pocket.

3.6 Short-Circuit Modeling

All connected generating facilities were assumed capable of producing maximum fault current. As such, all generators were modeled at full capacity, whether NRIS or ERIS is requested. Generation 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 output that would be imposed otherwise.

3.7 Voltage and Reactive Power Capability Evaluation

Per Section 4.1.1.1 of the BPM, the following voltage regulation and reactive power capability requirements are applicable to non-synchronous generators:

- Xcel Energy's OATT requires all non-synchronous generator Interconnection Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI voltage schedule specified by the Transmission Operator.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVar), and the locations (on the Interconnection Customer's facility) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/- 0.95 power factor at the high side of the main step-up transformer.
- It is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure minimal reactive power flow under no load conditions.

All the summary tables representing the GIR's Voltage and Reactive Power Capability tests adhere to the following color formatting representing the different aspects of the tests:

- Values highlighted in red indicate a failed reactive power requirement.
- Voltages outside the range of 0.95 p.u. to 1.05 p.u. are highlighted in yellow to provide additional information.

The PI-2024-24 GIR is modeled as follows:

PV: Pmax = 312.82 MW, Pmin = 0.00 MW, Qmax = 102.81 Mvar, Qmin= -102.81 Mvar

BESS: Pmax = 107.58 MW, Pmin = -107.58 MW, Qmax = 35.35 Mvar, Qmin= -35.35 Mvar

The summary for the Voltage and Reactive Power Capability Evaluation for PI-2024-24 is:

- The GIR is capable of meeting ±0.95 pf at the high side of the main step-up transformer while maintaining a normal operating voltage at the POI.

- The GIR is capable of meeting ±0.95 pf at its terminals while meeting the interconnection service request.
- The reactive power exchange and voltage change across the gen-tie are acceptable under no load conditions.

The Voltage and Reactive Power Capability tests performed for PI-2024-24 are summarized in Table 1.

Table 1 – Reactive Capability Evaluation for PI-2024-24

PV Generator Terminals					BESS Generator Terminals					High Side of Main Transformer				POI			
Pgen (MW)	Qgen (Mvar)	Qmax (Mvar)	Qmin (Mvar)	V (p.u.)	Pgen (MW)	Qgen (Mvar)	Qmax (Mvar)	Qmin (Mvar)	V (p.u.)	P (MW)	Q (Mvar)	V (p.u.)	PF	P (MW)	Q (Mvar)	V (p.u.)	PF
228.0	23.0	102.4	-102.4	1.05	77.0	35.2	35.2	-35.2	1.03	300.8	99.3	1.02	0.950	300.8	99.3	1.02	0.950
228.0	-96.0	102.4	-102.4	0.99	77.0	-35.2	35.2	-35.2	0.98	300.6	-100.0	1.01	-0.949	300.5	-100.1	1.01	-0.949
305.0	61.9	102.4	-102.4	1.03	OFFLINE					300.6	102.5	1.02	0.946	300.6	102.5	1.02	0.946
OFFLINE					107.5	-28.8	35.2	-35.2	1.01	104.5	41.6	1.02	0.929	104.5	41.9	1.02	0.928
305.0	-63.6	102.4	-102.4	0.99	OFFLINE					300.6	-102.9	1.01	-0.946	300.5	-102.9	1.01	-0.946
OFFLINE					107.5	-22.0	35.2	-35.2	0.99	104.5	-37.3	1.02	-0.942	104.5	-37.0	1.02	-0.943
0.0	-102.4	102.4	-102.4	0.99	0.0	-35.2	35.2	-35.2	0.96	-2.3	-60.1	1.02	-0.038	-2.3	-59.8	1.02	-0.038

3.8 Power Flow Analysis Results

Contingency analysis was performed on the South Colorado study pocket Grid Charging Study Case.

- Results of the system intact analysis showed no overloads or voltage violations attributable to the Study GIR.
- Results of the single contingency analysis showed no overloads or voltage violations attributable to the Study GIR.
- Results of the multiple contingency analysis showed no overloads or voltage violations attributable to the Study GIR.

Contingency analysis was performed on the South Colorado study pocket Discharging Study Case.

- Results of the system intact analysis are shown in Table 2. System intact contingency analysis showed no voltage violations attributable to PI-2024-24.
- Results of the single contingency analysis are shown in Table 3. Single contingency analysis showed no voltage violations attributable to PI-2024-24.

Results of the multiple contingency analysis are shown in

- Table 4. Multiple contingency analysis showed violations attributable to PI-2024-24 and are shown in Table 5.

Note two P7 contingencies were divergent as shown in

  - Multiple contingency issues are resolved using system adjustments, including generation redispatch (includes GIRs under study) and/or operator actions. Therefore, they are not attributable to the study GIR.

All the system intact and single contingency overloads identified in Table 2 and Table 3 are alleviated through generation redispatch as shown in the last column of Table 2 and Table 3, respectively.

Multiple contingency overloads are mitigated using system adjustments, including generation redispatch (includes GIRs under study) and/or operator actions. None of the multiple contingency overloads are attributed to the study GIRs.

Table 2 – South Colorado – System Intact Overloads

Ref. No.	Monitored Facility	Contingency Name	kV	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)	Re-dispatched Study Case Loading (%)
1	Foxrun (73414) – Flyhorse N2 (73738) 115 kV ckt 1	Base Case	115	73	142	105.32	111.08	5.76	67.76
2	Flyhorse S (73576) – Kettleck N (73711) 115 kV ckt 1	Base Case	115	73	162	104.81	109.93	5.12	71.60

Table 3 – South Colorado – Single Contingency Overloads

Ref. No.	Monitored Facility	Contingency Name	kV	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)	Re-dispatched Study Case Loading (%)
1	Cttnwd N (73391) – Kettleck S (73410) 115 kV ckt 1	Briargate S (73389) – Briargate N (73710) 115 kV ckt 1	115	73	162	169.42	175.06	5.64	137.30*
2	Foxrun (73414) – Flyhorse N2 (73738) 115 kV ckt 1	Vollmert (72413) – Fuller (73481) 115 kV ckt 1	115	73	142	159.99	167.47	7.48	113.09*
3	W.Canon (70550) – Hogback (71025) 115 kV ckt 1	Midwaybr (73413) – Hambone Tap (73638) 230 kV ckt 1	115	70	120	156.32	162.60	6.28	108.73*

4	Flyhorse S (73576) – Kettleck N (73711) 115 kV ckt 1	Vollmert (72413) – Fuller (73481) 115 kV ckt 1	115	73	162	152.74	159.37	6.63	111.27*
Ref. No.	**Monitored Facility**	**Contingency Name**	**kV**	**Areas**	**Rate Cont (MVA)**	**Benchmark Case Loading (%)**	**Study Case Loading (%)**	**Loading Difference (%)**	**Re-dispatched Study Case Loading (%)**
5	Smelter (70394) – W.Canon (70550) 115 kV ckt 1	W Canon (73551) – Ponchabr (79054) 230 kV ckt 1	115	70	73	151.98	158.62	6.64	101.14*
6	Ftn_Vly (70193) – Midwaybr (73412) 115 kV ckt 1	Midway_Ps (70286) – Midwaybr (73413) 230 kV ckt 1	115	70/73	179	127.97	135.67	7.70	70.38
7	Ft St Vrain (70410 to 70916) 230/345 kV transformer T8	Ft St Vrain (70410 to 70916) 230/345 kV transformer T7	230/ 345	70	560	123.43	126.20	2.77	81.75
8	Ft St Vrain (70410 to 70916) 230/345 kV transformer T7	Ft St Vrain (70410 to 70916) 230/345 kV transformer T8	230/ 345	70	560	123.43	126.20	2.77	81.75
9	Briargate N (73710) – Kettleck N (73711) 115 kV ckt 1	Cttnwd N (73391) – Kettleck S (73410) 115 kV ckt 1	115	73	186	118.95	123.23	4.28	94.35
10	Desrtcov (70449) – W.Staton (70456) 115 kV ckt 1	Midway Ps (70286) – Midwaybr (73413) 230 kV ckt 1	115	70	221	111.74	118.03	6.29	64.99
11	Vollmert (72413) – Fuller (73481) 115 kV ckt 1	Flyhorse S (73576) – Kettleck N (73711) 115 kV ckt 1	115	73	173	109.63	113.82	4.19	84.61

12	Portland (70330) – Skala (70390) 115 kV ckt 1	N_Penrose (71024) – Trk_Crk (71032) 115 kV ckt 1	115	70	110	107.71	111.62	3.91	78.98
13	Puebplnt (70339) – Reader (70352) 115 kV ckt 1	Greenhrn (70004) – Reader (70352) 115 kV ckt 1	115	70	160	106.84	112.44	5.60	64.65
Ref. No.	**Monitored Facility**	**Contingency Name**	**kV**	**Areas**	**Rate Cont (MVA)**	**Benchmark Case Loading (%)**	**Study Case Loading (%)**	**Loading Difference (%)**	**Re-dispatched Study Case Loading (%)**
14	Midway Ps (70286) – Midwaybr (73413) 230 kV ckt 1	Midway Ps (70286) – Fuller (73477) 230 kV ckt 1	230	70/73	637	105.87	111.23	5.36	63.96
15	Vollmert (72413) – Blk Sqmv (73460) 115 kV ckt 1	Flyhorse S (73576) – Kettleck N (73711) 115 kV ckt 1	115	73	173	104.48	108.62	4.14	79.52
16	Ftn Vly (70193) – Desrtcov (70449) 115 kV ckt 1	Midway Ps (70286) – Midwaybr (73413) 230 kV ckt 1	115	70	221	104.23	110.47	6.24	57.58
17	W.Canon (70550 to 73551) 115/230 kV transformer T1	Midwaybr (73413) – Hambone Tap (73638) 230 kV ckt 1	115/ 230	70/73	100	98.94	103.29	4.35	63.63
18	Kettleck S (73410) – Kettleck N (73711) 115 kV ckt 1	Briargate S (73389) – Briargate N (73710) 115 kV ckt 1	115	73	239	98.28	101.96	3.68	76.65
19	Conoco (70126) – Tbd_2025 (70103) 115 kV ckt 1	Cherokee_N (70110) – Tbd_2025 (70103) 115 kV ckt 1	115	70	239	55.90	108.13	52.23	33.22

*Re-dispatched Study Case loadings are considered resolved if they are less than Benchmark Case loadings.

Table 4 – South Colorado – Multiple Contingency Overloads

Ref. No.	Monitored Facility	Contingency Name	kV	Areas	Normal Rating (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
1	Foxrun (73414) – Flyhorse N2 (73738) 115 kV ckt 1	P7_129: Lines 5119, 7051	115	73	142	176.63	186.31	9.68
2	Flyhorse S (73576) – Kettleck N (73711) 115 kV ckt 1	P7_129: Lines 5119, 7051	115	73	162	165.11	173.56	8.45
3	W.Canon (70550) – Hogback (71025) 115 kV ckt 1	BF_094d: Midway 5120 stuck	115	70	120	159.23	166.10	6.87
4	Midway_Ps (70286) – Midwaybr (73413) 230 kV ckt 1	P7_130: Lines 5129, 7051	230	70/73	637	145.56	152.57	7.01
5	Cttnwd N (73391) – Kettleck S (73410) 115 kV ckt 1	P7_129: Lines 5119, 7051	115	73	162	137.94	143.85	5.91
6	Story (73192) – Pawnee (70311) 230 kV ckt 1	P7_160: Lines 7329, 7297	230	73/70	581	105.22	107.76	2.54
7	Smoky_Hl (70396) – Harvest_Mi (70596) 230 kV ckt 1	P7_137: Lines: 7081, 7087	230	70	956	103.60	110.26	6.66
8	Palmer_Lk (70308) – Foxrun (73414) 115 kV ckt 1	P7_129: Lines 5119, 7051	115	70/73	239	102.75	108.96	6.21
9	Portland (70330) – Skala (70390) 115 kV ckt 1	BF_094d: Midway 5120 stuck	115	70	110	99.93	104.42	4.49
10	W.Canon (70550/73551) 115/230 kV transformer T1	BF_094d: Midway 5120 stuck	115/ 230	70/73	100	98.76	103.32	4.56
11	Clark (70112) – Jordan (70241) 230 kV ckt 1	P7_58: Lines: 5707, 5111	230	70	331	98.22	104.61	6.39
12	Midwaybr (73412) – Rd_Nixon (73417) 115 kV ckt 1	BF_094d: Midway 5120 stuck	115	73	195	95.70	103.04	7.34

13	Midwaybr (73413) – Rd_Nixon (73419) 230 kV ckt 1	P7_130: Lines 5129, 7051	230	73	531	95.68	100.71	5.03

Table 5 – South Colorado – Multiple Contingency Voltage Violations

Ref. No.	Bus Name	Bus Number	Voltage (kV)	Area	Contingency Name	Benchmark Case Contingency Voltage (p.u.)	Study Case Contingency Voltage (p.u.)	Voltage Difference (p.u.)
1	Antonito	70029	69	70	BF_128f	0.8472	0.8370	-0.0102
2	Romeo	70367	69	70	BF_128f	0.8528	0.8427	-0.0101
3	Romeo_Tap	70552	69	70	BF_128f	0.8531	0.8429	-0.0102
4	Excel	73377	115	73	BF_014d	0.8910	0.8797	-0.0113
5	Fme	73310	115	73	BF_014d	0.8917	0.8804	-0.0113
6	Henderson	73309	115	73	BF_014d	0.8930	0.8817	-0.0113
7	Brushtap	73031	115	73	BF_014d	0.8931	0.8819	-0.0112
8	Fmn	73378	115	73	BF_014d	0.8934	0.8821	-0.0113
9	Efmorgtp	73305	115	73	BF_014d	0.8934	0.8821	-0.0113
10	Fms	73311	115	73	BF_014d	0.8954	0.8842	-0.0112
11	Fmwest	73379	115	73	BF_014d	0.8954	0.8842	-0.0112
12	Bijoutap	73023	115	73	BF_014d	0.9060	0.8950	-0.0110
13	Reunion	72026	230	73	BF_118a	0.9147	0.8998	-0.0149

3.9 Stability Analysis Results

The following results were obtained for the disturbances analyzed for Discharging Study Case and the Grid Charging Study Case models:

- ✓ No machines lost synchronism with the system.
- ✓ No voltage drop violations were observed.
- ✓ Machine rotor angles displayed positive damping.

The results of the contingency analysis are shown in Table 6 for Discharging scenario. The results for Grid Charging scenario are summarized in Table 7. The stability plots for Discharging and Grid Charging scenarios are shown in Appendix A and Appendix B, respectively, in Section 10.0 of this report.

Table 6 – Stability Analysis Results for Discharging Scenario

Ref. No.	Fault Location	Outage(s)	Clearing Time (Cycles)	Post-Fault Voltage Recovery	Angular Stability
1	No Fault	Flat Run	-	Stable	Stable
2	Sandstone 345 kV	PI-2024-24 Generation	4	Stable	Stable
3	Sandstone 345 kV (LoTC_316)	Sandstone – Crow 345 kV ckt 1 Crow – May Valley 345 kV ckt 1	4	Stable	Stable
4	Sandstone 345 kV (LoTC_318)	Sandstone – Kiowa 345 kV ckt 1 Kiowa – May Valley 345 kV ckt 1	4	Stable	Stable
5	Sandstone 345 kV (LoTC_317)	Sandstone – Tundra 345 kV ckt 1	4	Stable	Stable
6	Sandstone 345 kV (LoTC_324)	Sandstone – New H. Mile 345 kV ckt 1 Sandstone – Tundra 345 kV ckt 1	4	Stable	Stable
7	Sandstone 345 kV (BF_156a)	Sandstone – New H. Mile 345 kV ckt 1 Sandstone – Tundra 345 kV ckt 1	12	Stable	Stable
8	Sandstone 345 kV (BF_156b)	Sandstone – New H. Mile 345 kV ckt 2 Sandstone – Kiowa 345 kV ckt 1 Kiowa – May Valley 345 kV ckt 1	12	Stable	Stable
9	Sandstone 345 kV (Lines 7411, 7273)	Sandstone – Crow 345 kV ckt 1 Crow – May Valley 345 kV ckt 1 Sandstone – Kiowa 345 kV ckt 1 Kiowa – May Valley 345 kV ckt 1	4	Stable	Stable
10	Sandstone 345 kV (Lines 7405, 7231)	Sandstone – Tundra 345 kV ckt 1 Sandstone – Tundra 345 kV ckt 2	4	Stable	Stable
11	Sandstone 345 kV (Lines 7159, 7403)	Sandstone – New H. Mile 345 kV ckt 1	4	Stable	Stable

		Sandstone – New H. Mile 345 kV ckt 2			

Table 7 – Stability Analysis Results for Grid Charging Scenario

Ref. No.	Fault Location	Outage(s)	Clearing Time (Cycles)	Post-Fault Voltage Recovery	Angular Stability
1	No Fault	Flat Run	-	Stable	Stable
2	Sandstone 345 kV	PI-2024-24 Generation	4	Stable	Stable
3	Sandstone 345 kV (LoTC_316)	Sandstone – Crow 345 kV ckt 1 Crow – May Valley 345 kV ckt 1	4	Stable	Stable
4	Sandstone 345 kV (LoTC_318)	Sandstone – Kiowa 345 kV ckt 1 Kiowa – May Valley 345 kV ckt 1	4	Stable	Stable
5	Sandstone 345 kV (LoTC_317)	Sandstone – Tundra 345 kV ckt 1	4	Stable	Stable
6	Sandstone 345 kV (LoTC_324)	Sandstone – New H. Mile 345 kV ckt 1 Sandstone – Tundra 345 kV ckt 1	4	Stable	Stable
7	Sandstone 345 kV (BF_156a)	Sandstone – New H. Mile 345 kV ckt 1 Sandstone – Tundra 345 kV ckt 1	12	Stable	Stable
8	Sandstone 345 kV (BF_156b)	Sandstone – New H. Mile 345 kV ckt 2 Sandstone – Kiowa 345 kV ckt 1 Kiowa – May Valley 345 kV ckt 1	12	Stable	Stable
9	Sandstone 345 kV (Lines 7411, 7273)	Sandstone – Crow 345 kV ckt 1 Crow – May Valley 345 kV ckt 1 Sandstone – Kiowa 345 kV ckt 1 Kiowa – May Valley 345 kV ckt 1	4	Stable	Stable
10	Sandstone 345 kV (Lines 7405, 7231)	Sandstone – Tundra 345 kV ckt 1 Sandstone – Tundra 345 kV ckt 2	4	Stable	Stable
11	Sandstone 345 kV (Lines 7159, 7403)	Sandstone – New H. Mile 345 kV ckt 1	4	Stable	Stable

		Sandstone – New H. Mile 345 kV ckt 2			

3.10 Short-Circuit (Breaker Duty) Analysis Results

A study was completed to determine whether any over-dutied breakers resulted when several Provisional Interconnections (PIs) were added to the PSCo transmission system in the order of their Commercial Operation Date (COD). If the addition of the interconnection resulted in a requirement that one or more breakers be replaced in the PSCo transmission system, it was considered that that customer would not be able to connect under a Provisional Interconnection agreement and it was removed from the study.

Taken into consideration were any existing plans for breaker replacement by PSCo. Breakers that had already been assigned to projects were not considered as needing replacement by the interconnection customer.

The breaker duty study on the PSCo transmission system identified one breaker that became over-dutied because of adding PI-2024-24; however, is an existing project that will replace this breaker.

Table 8. Overstressed Breaker Due to PI-2024-24 Addition with Project to Replace

Substation	Base kV	Breaker ID	WBS Number
MIDWAY	230	5126	A.0000263.016.001.002

No other circuit breaker became over-dutied because of adding PI-2024-24. A network upgrade for this project is not required. The fault currents at the POI for can be made available upon request by the Customer.

3.11 Affected Systems

No Affected Systems were identified.

4.0 Cost Estimates

The total estimated cost of the required Upgrades for PI-2024-24 to interconnect for Provisional Interconnection Service at the Sandstone 345 kV switching station **$15.753** million.

- **Cost of Transmission Provider's Interconnection Facilities (TPIF) is $4.914 million** (Table 9)
- **Cost of Station Network Upgrades is $10.839 million** (Table 10)
- **Cost of System Network Upgrades is $0**

The list of improvements required to accommodate the Provisional Interconnection of PI-2024-24 are given in Table 13, and Table 14.

Table 9 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Million)
PSCo's Sandstone 345 kV switching station	Interconnection of 5RSC-2024-06 (PI-2024-24) at the Sandstone 345 kV switching station. The new equipment includes: • (1) 345 kV single bay dead end structure • (1) 345 kV 3-phase arrester • (1) 345 kV 3000 A line disconnect switch • (3) 345 kV 1-phase CTs for metering • (3) 345 kV 1-phase CCVTs • Dual fiber communication equipment • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing • Testing and Commissioning	$3.867
PSCo's Sandstone 345 kV switching station	Transmission Provider's dead-end structure at the Point of Change of Ownership (PCO) outside the switching station fence line and transmission line into switching station from the PCO. Single span, dead end structure, 3 conductors, insulators, hardware, jumpers and labor.	$1.047
Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities		**$4.914**

Table 10 – Station Network Upgrades

Element	Description	Cost Est. (Million)
PSCo's Sandstone 345 kV switching station	Interconnection of 5RSC-2024-06 (PI-2024-24) at Sandstone 345 kV switching station. The new equipment includes: • (2) 345 kV dead end structure • (2) 345 kV 3000 A SF6 circuit breakers • (4) 345 kV 3000 A disconnect switches • Yard fence extension with gates • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$10.382
PSCo's Sandstone 345 kV switching station	Install required communication in the EEE at the Sandstone 345 kV switching station	$0.457
Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities		**$10.839**

PSCo has developed cost estimates for Transmission Provider's Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of PI-2024-24 for Provisional Interconnection Service. The estimated costs provided in this report are based upon the following assumptions:

- The estimated costs are in 2025 dollars with escalation and contingencies applied.
- Allowances for Funds Used During Construction (AFUDC) is not included.
- The estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of these new PSCo facilities.
- The estimated costs do not include the cost for any Customer owned equipment and associated design and engineering.
- Labor is estimated for straight time only—no overtime included.
- PSCo (or its Contractor) will perform all construction, wiring, testing, and commissioning for PSCo owned and maintained facilities.

The customer requirements include:

- Interconnection Customer will install two (2) redundant fiber optic circuits (one primary circuit with a redundant backup) into the Transmission Provider's switching station as part of its interconnection facilities construction scope.
- Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into the POI.
- The Customer will be required to design, procure, install, own, operate and maintain a Remote Terminal Unit (RTU) at their Customer substation. PSCo will be provided with indications, readings and data from the RTU.
- The Interconnection Customer will comply with the most current version of the *Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW*, as amended from time to time, and available at: Interconnection | Transmission | Corporate | Xcel Energy

4.1 Schedule

This section provides proposed milestones for the interconnection of PI-2024-24 to the Transmission Provider's Transmission System. The customer requested a back-feed date (In-
Service Date for Transmission Provider Interconnection Facilities and Station Network Upgrades required for interconnection) for the Provisional Interconnection is October 1, 2027. This is attainable by the Transmission Provider, based upon the current schedule developed for this interconnection request. The Transmission Provider proposes the milestones provided below in Table 11.

Table 11 – Proposed Milestones for PI-2024-24

Milestone	Responsible Party	Estimated Completion Date
LGIA Execution	Interconnection Customer and Transmission Provider	December 2025
In-Service Date for Transmission Provider Interconnection Facilities and Station Network Upgrades required for interconnection	Transmission Provider	October 1, 2027
In-Service Date & Energization of Interconnection Customer's Interconnection Facilities	Interconnection Customer	October 1, 2027
Initial Synchronization Date	Interconnection Customer	January 2, 2028
Begin trial operation & testing	Interconnection Customer and Transmission Provider	February 1, 2028
Commercial Operation Date	Interconnection Customer	June 1, 2028

Some schedule elements are outside of the Transmission Provider's control and could impact the overall schedule. The following schedule assumptions provide the basis for the schedule milestones:

- Construction permitting (if required) for new facilities will be completed within 24 months of LGIA execution.
- The Transmission Provider is currently experiencing continued increases to material lead times which could impact the schedule milestones. The schedule milestones are based upon material lead times known at this time.
- Availability of line outages to interconnect new facilities to the transmission system.

5.0 Conclusion

The total estimated cost of the PSCo transmission system improvements required for PI-2024-24 to qualify for Provisional Interconnection Service would be **$15.753** million.

Based on the Power Flow and Stability analyses, the initial maximum permissible output allowed for the Generating Facility is 300 MW and up to 100 MW of the BESS can be

charged from the grid at the POI. The output amount of the Generating Facility in the PLGIA[4] will be reviewed quarterly and updated, if there are changes to the system conditions assumed in this analysis.

The Short-Circuit analysis (breaker duty) on the PSCo transmission system identified one breaker at Midway (5126) that became over-dutied because of adding PI-2024-24; however, there is an existing project that will replace this breaker.

Security: PI-2024-24 is a request for Energy Resource Interconnection Service (ERIS). For ERIS requests, security shall estimate the risk associated with the Network Upgrades and the Interconnection Facilities and is assumed to be a minimum of $5 million.

The Provisional Interconnection Service in and of itself does not convey transmission service.

[4] **Provisional Large Generator Interconnection Agreement (PLGIA)** shall mean the interconnection agreement for Provisional Interconnection Service established between Transmission Provider and/or the Transmission Owner and the Interconnection Customer. The pro forma agreement is provided in Appendix 8 and takes the form of the Large Generator Interconnection Agreement, modified for provisional purposes.

6.0 Contingent Facilities

The Contingent Facilities identified for PI-2024-24 include the overstressed breaker, TPIF and Station Network Upgrades identified in Table 8, Table 13 and Table 10, respectively.

7.0 Conceptual One-Line Diagram and General Arrangement for PI-2024-24

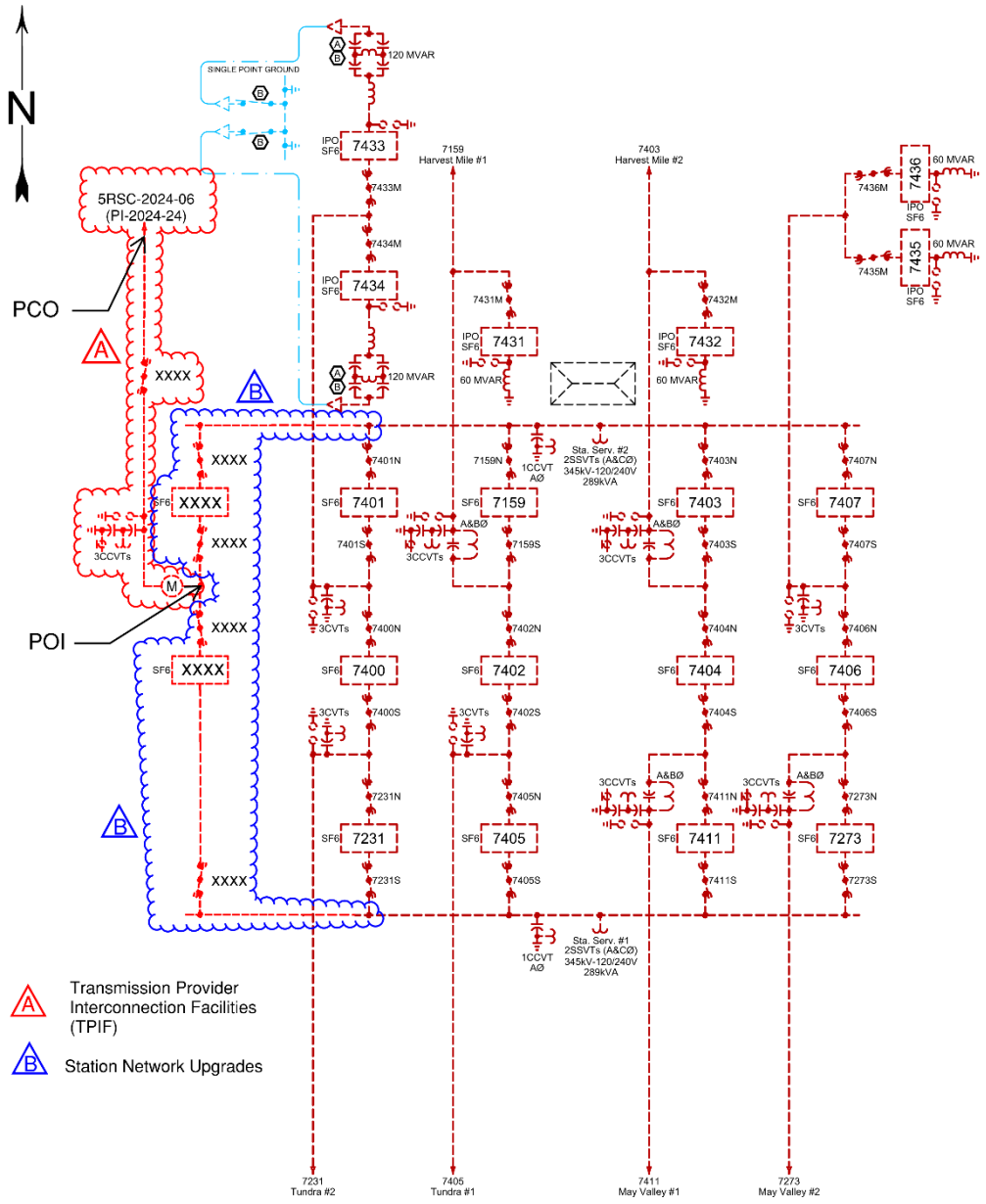


Figure 2: Preliminary One-Line of PI-2024-24 at the Sandstone 345 kV Switching Station

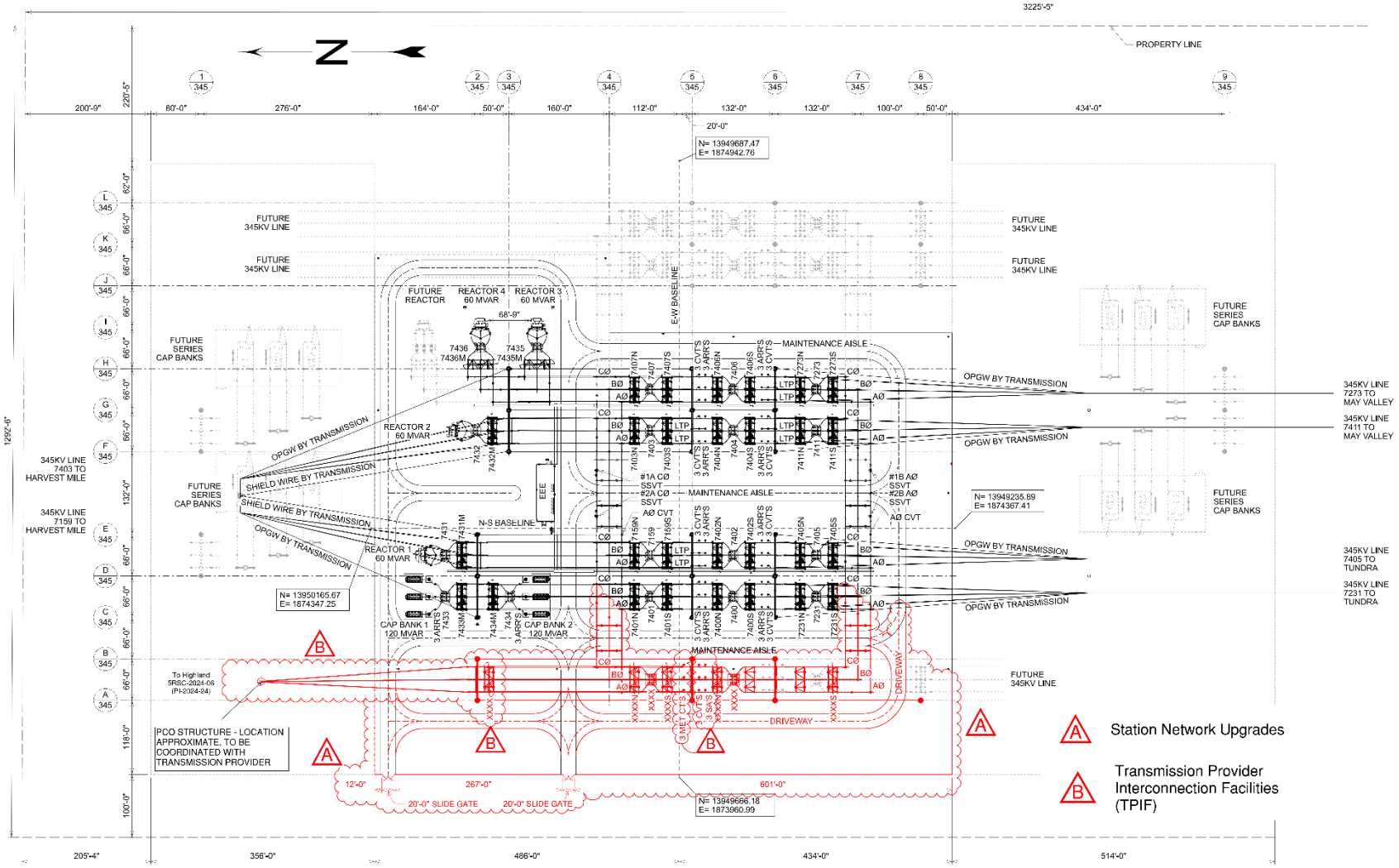
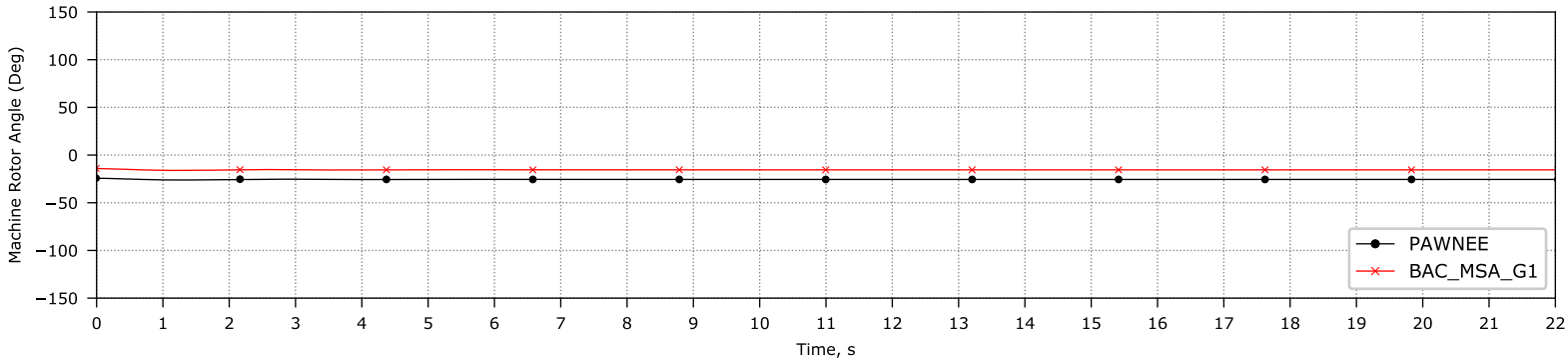


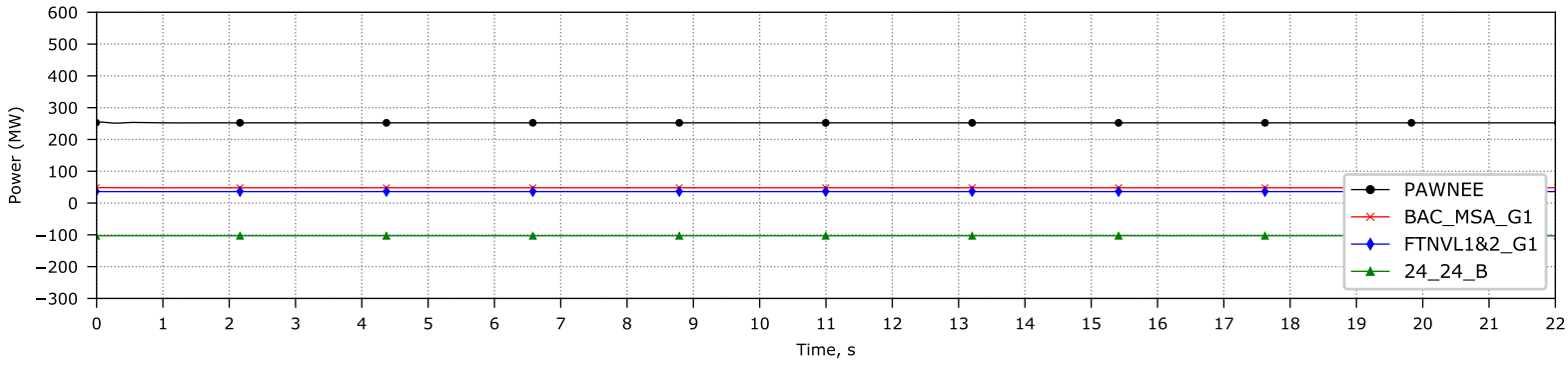
Figure 3: Preliminary General Arrangement of PI-2024-24 at the Sandstone 345 kV Switching Station

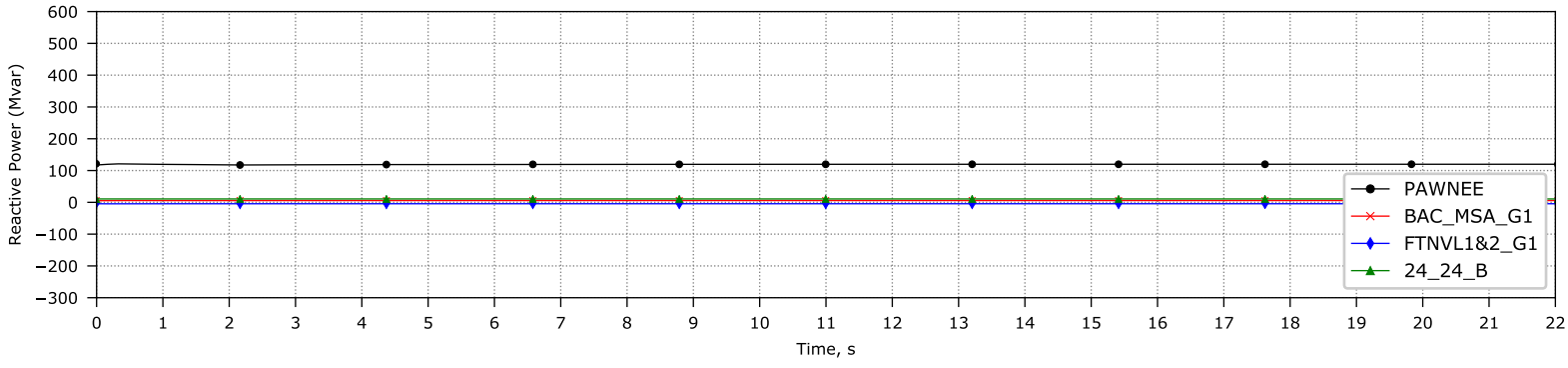
8.0 Appendices

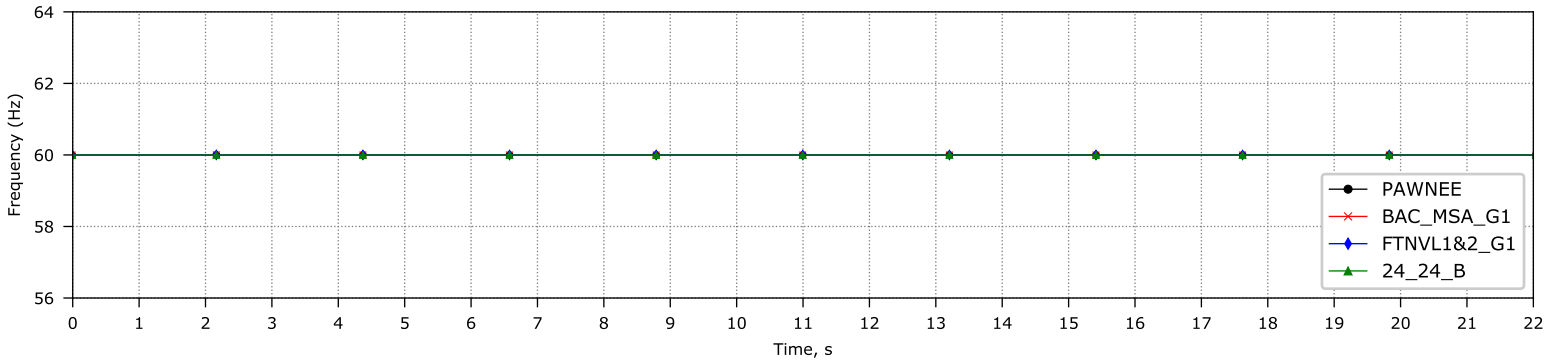
Appendix A: Stability Plots (Discharging)	PI-2024-24_Transient_Stability_Plots_GD.pc
Appendix B: Stability Plots (Grid Charging)	PI-2024-24_Transient_Stability_Plots_GC.pc

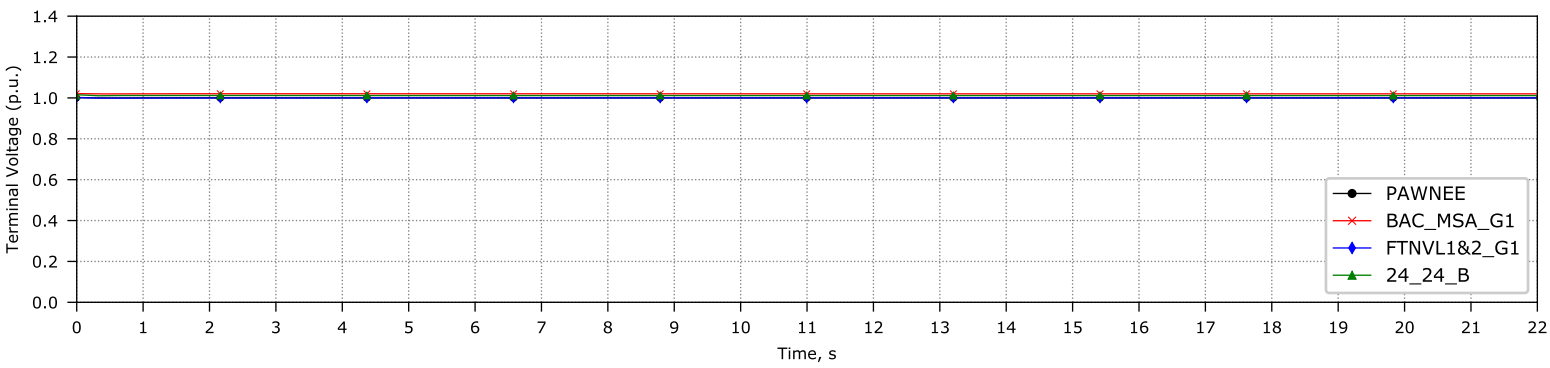
PI-2024-24_Study_GC_flatrun

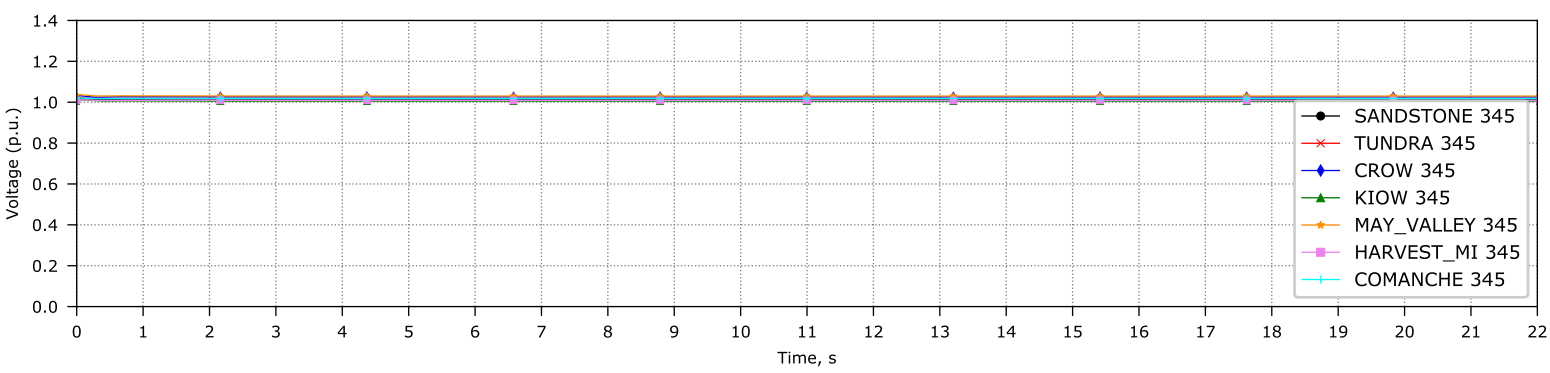












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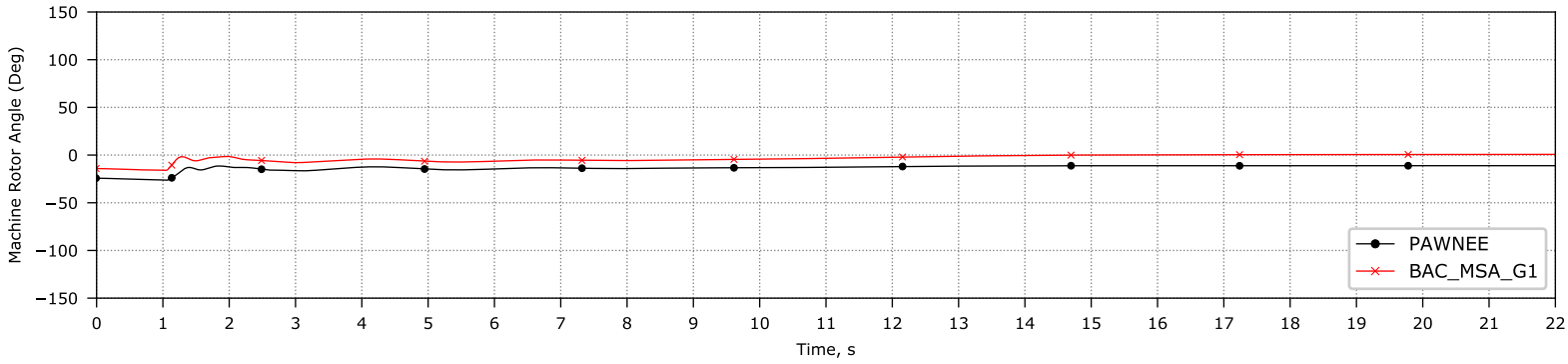

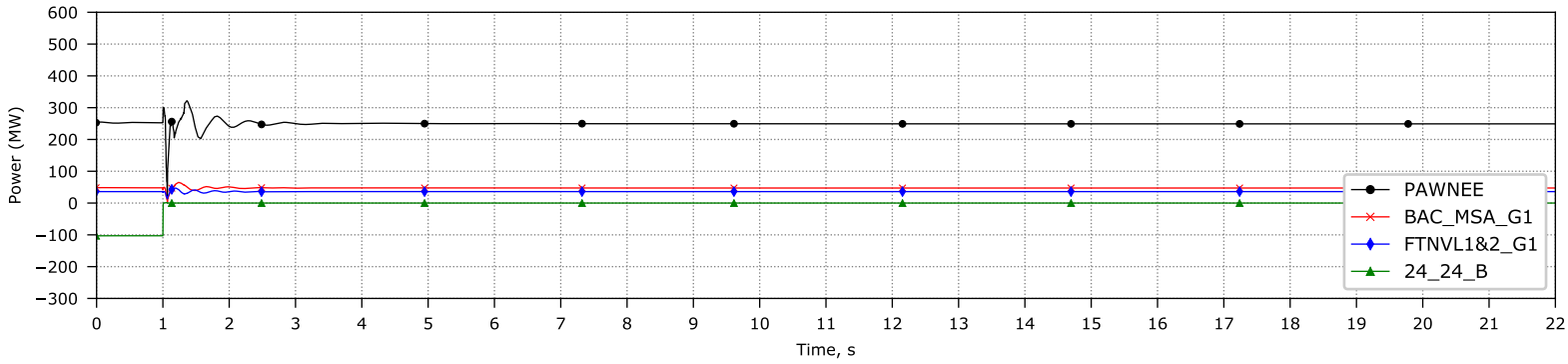

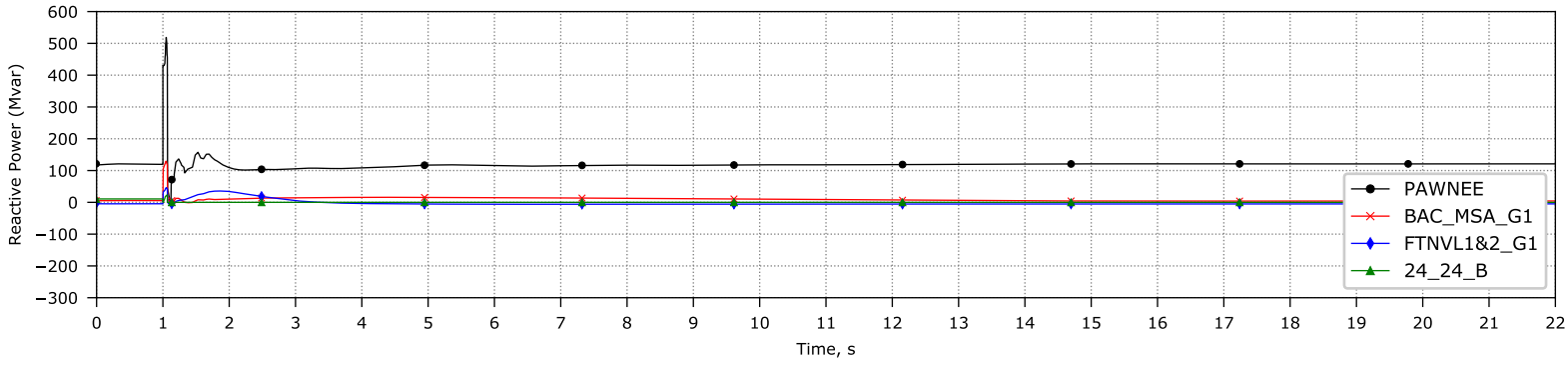

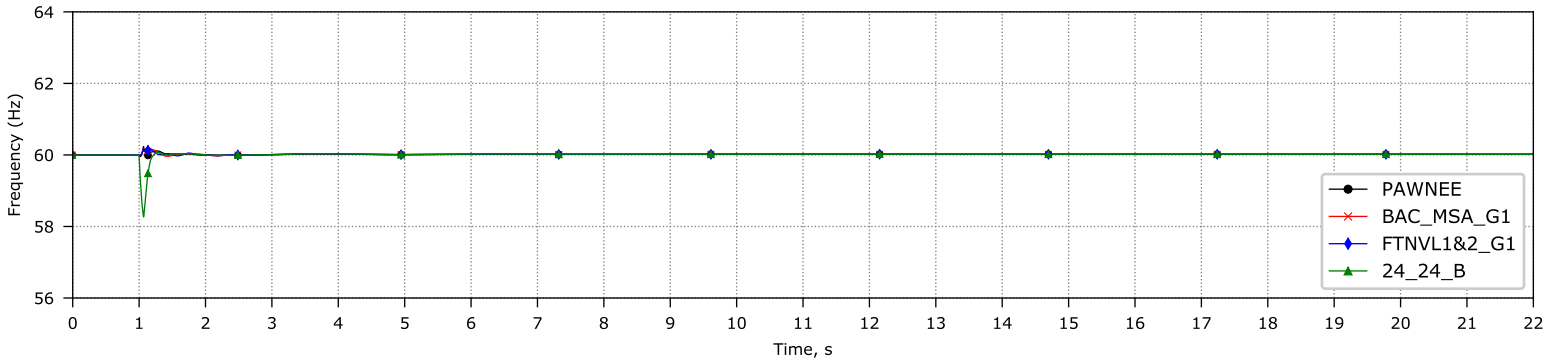

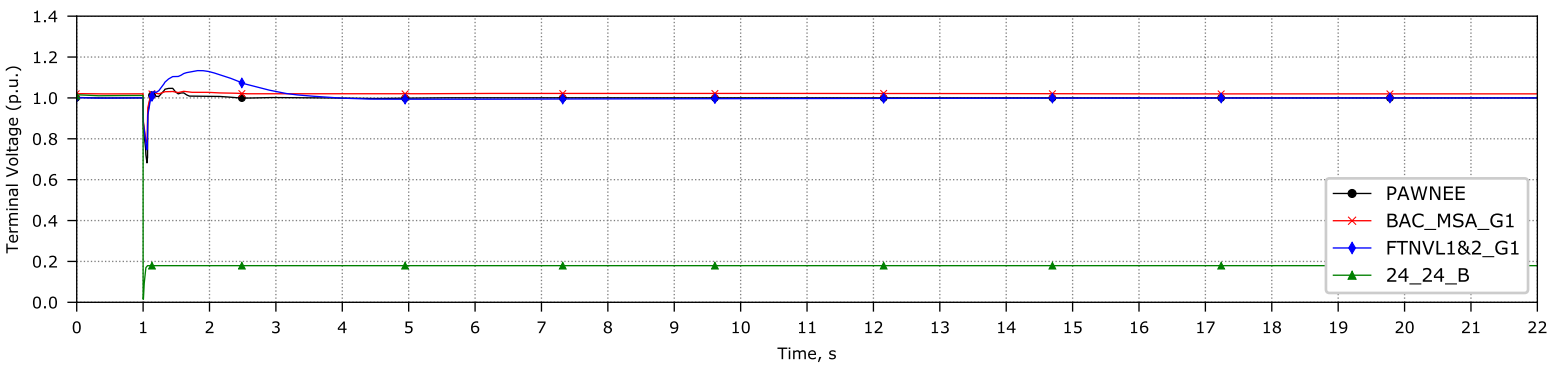

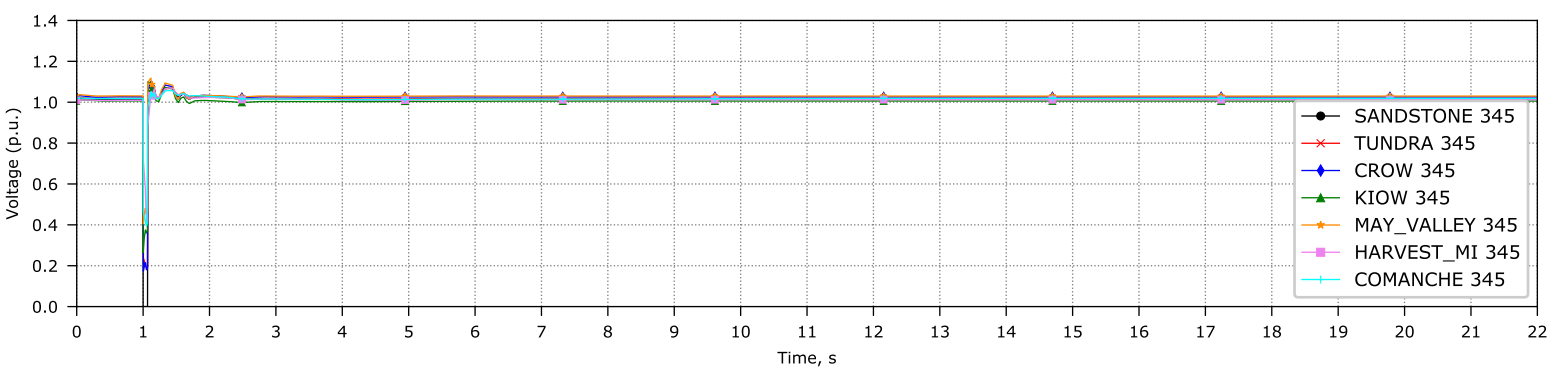

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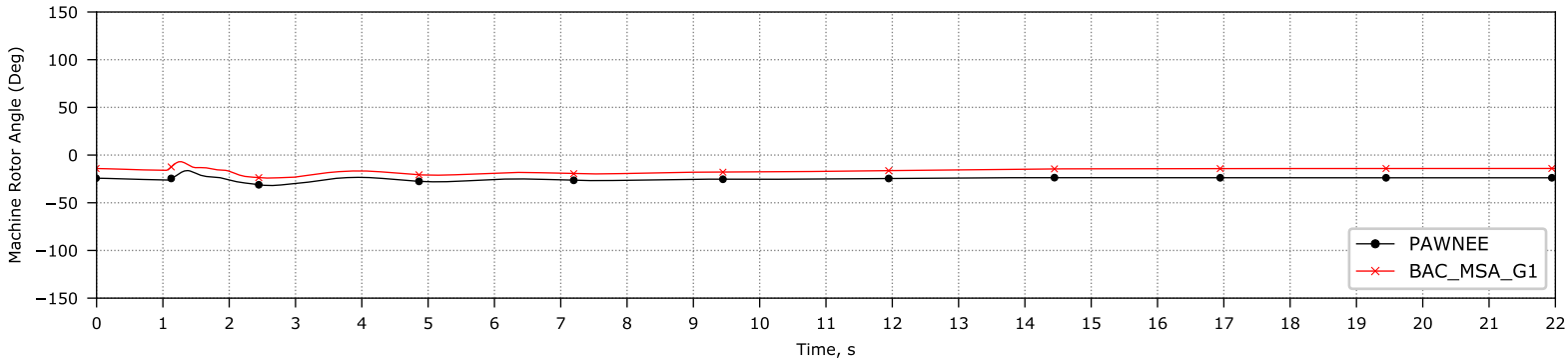

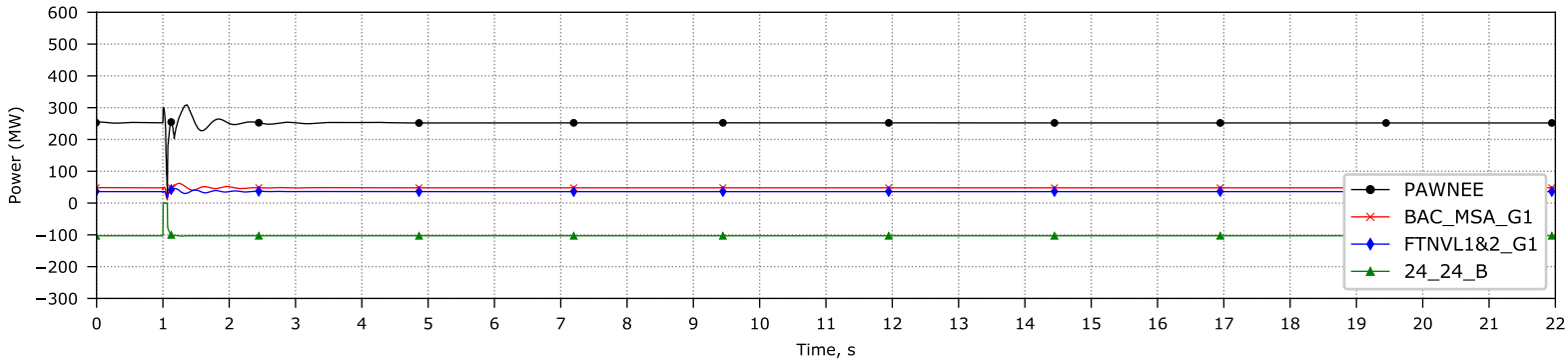

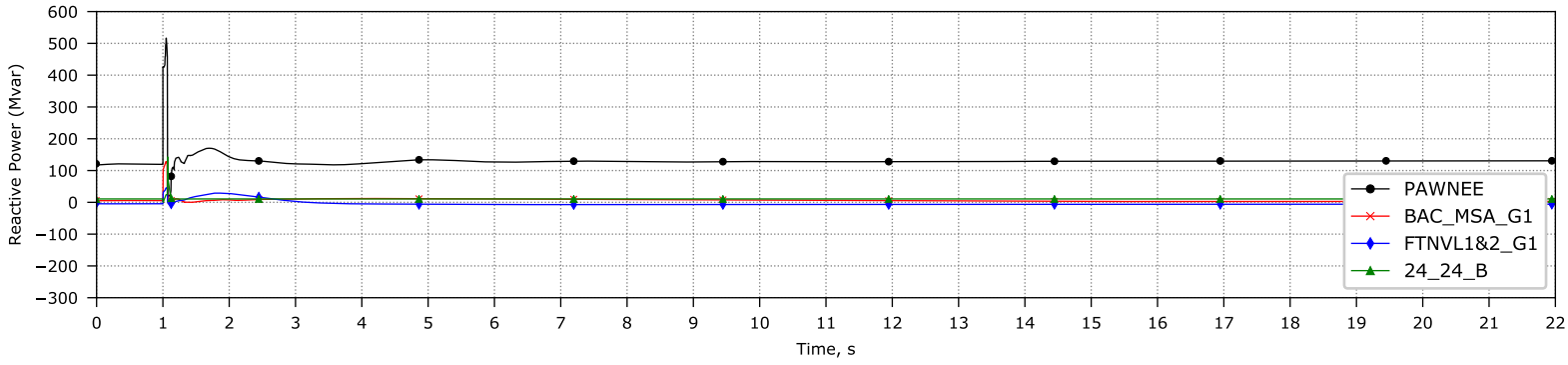

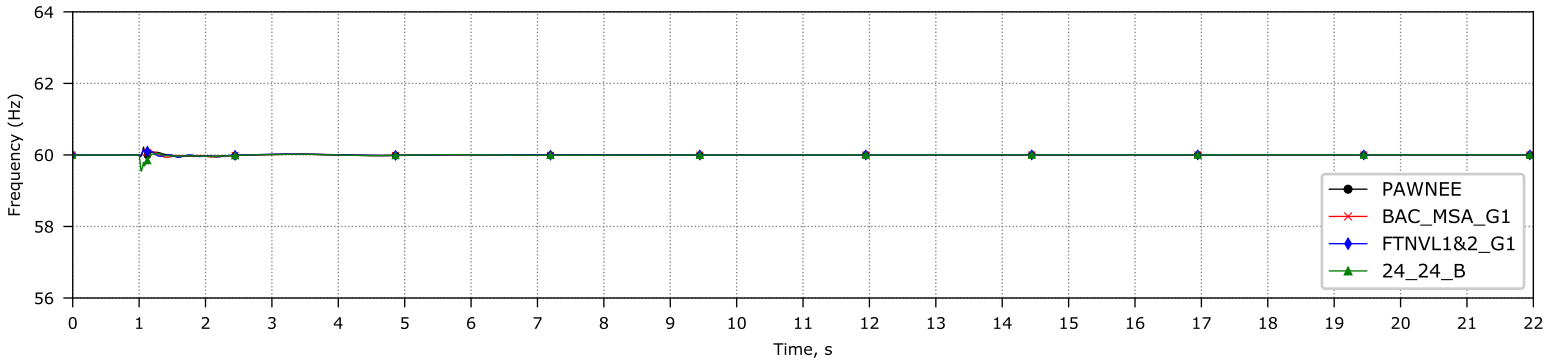

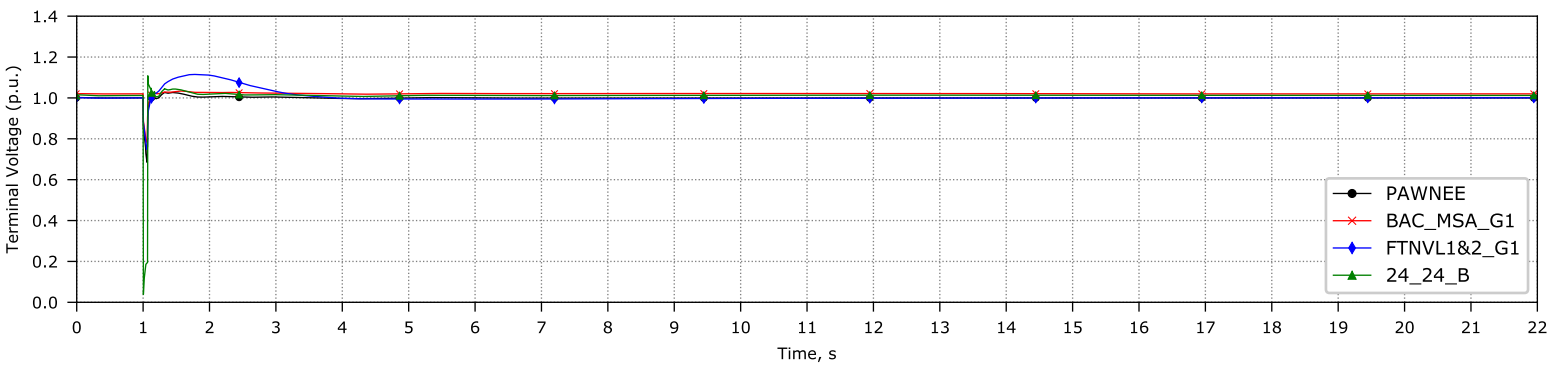

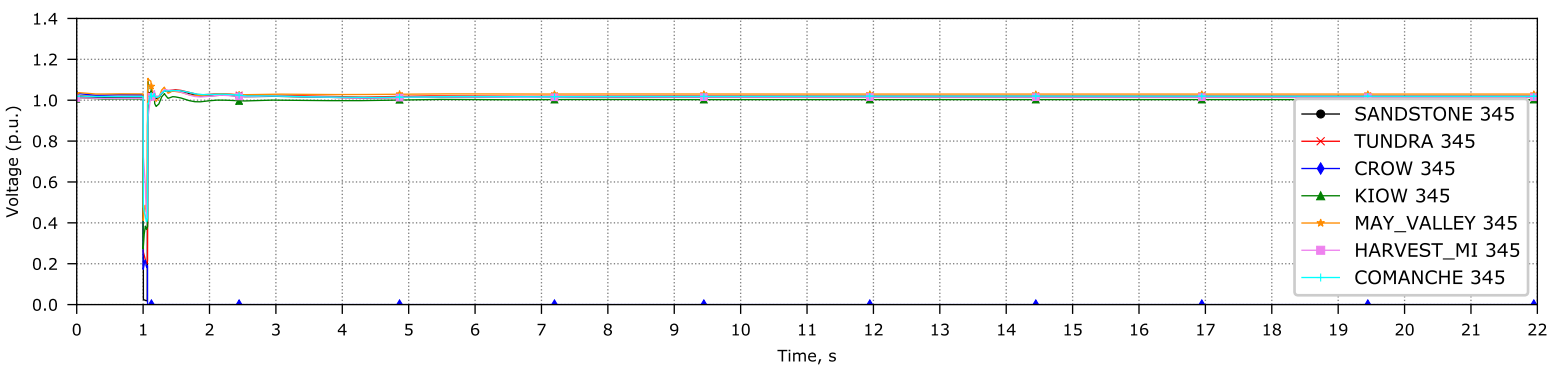

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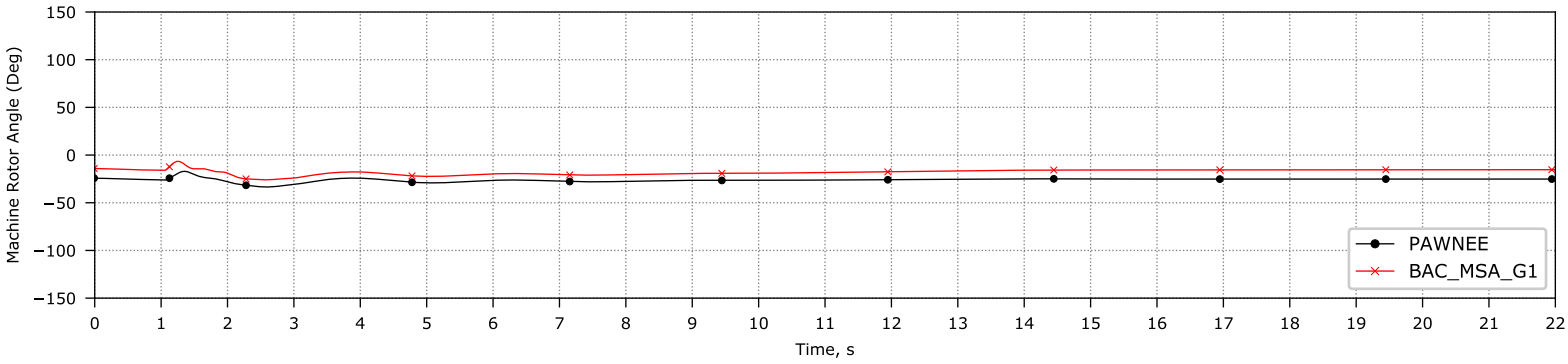

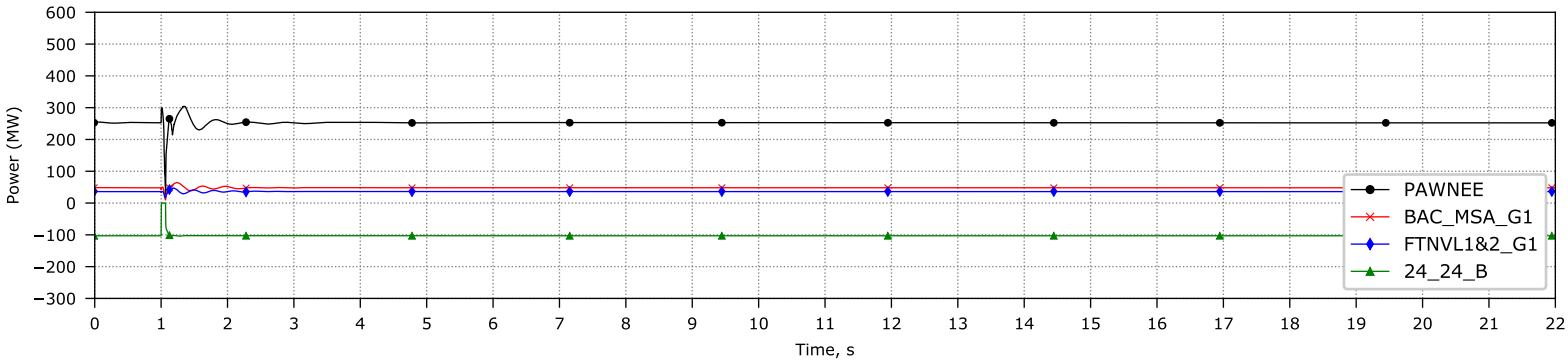

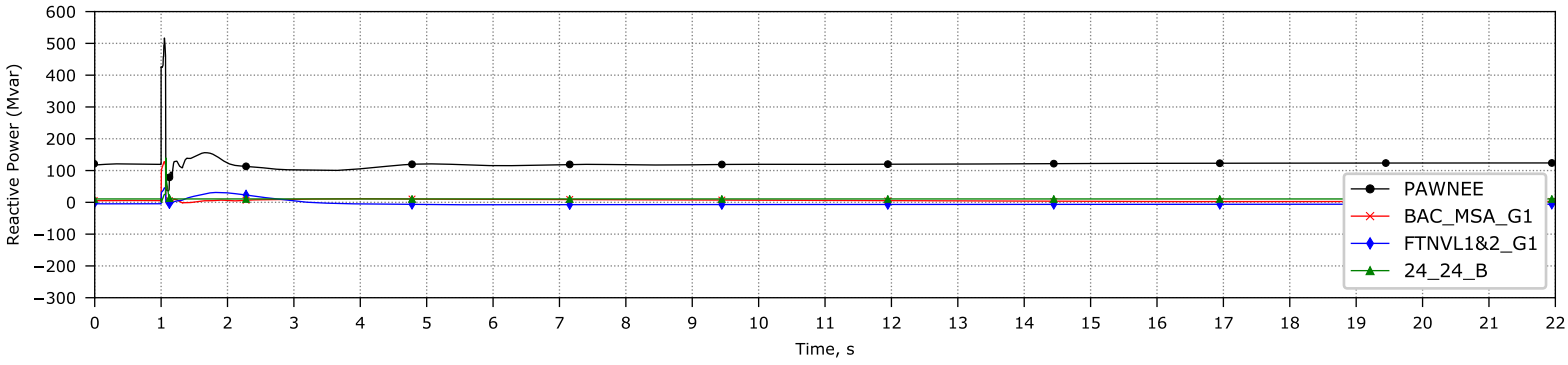

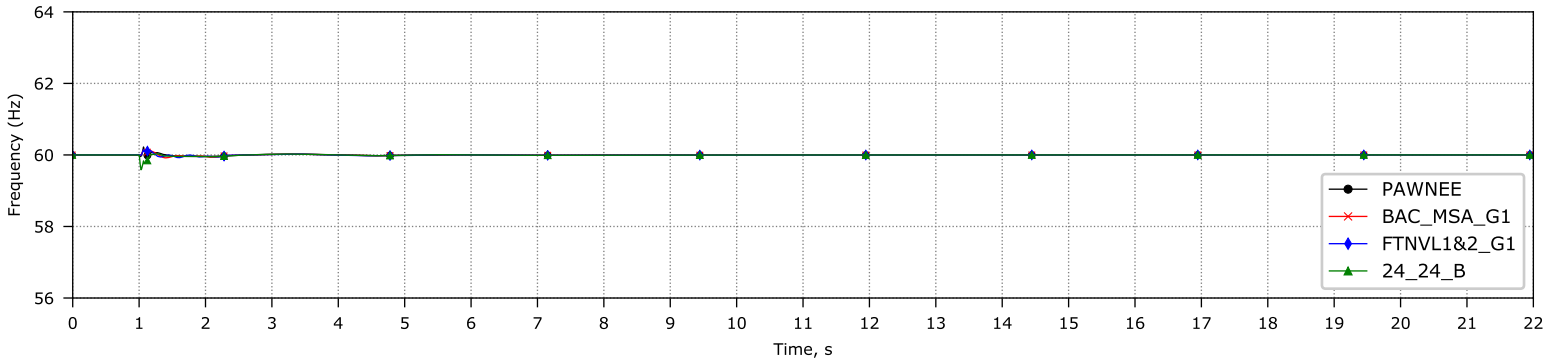

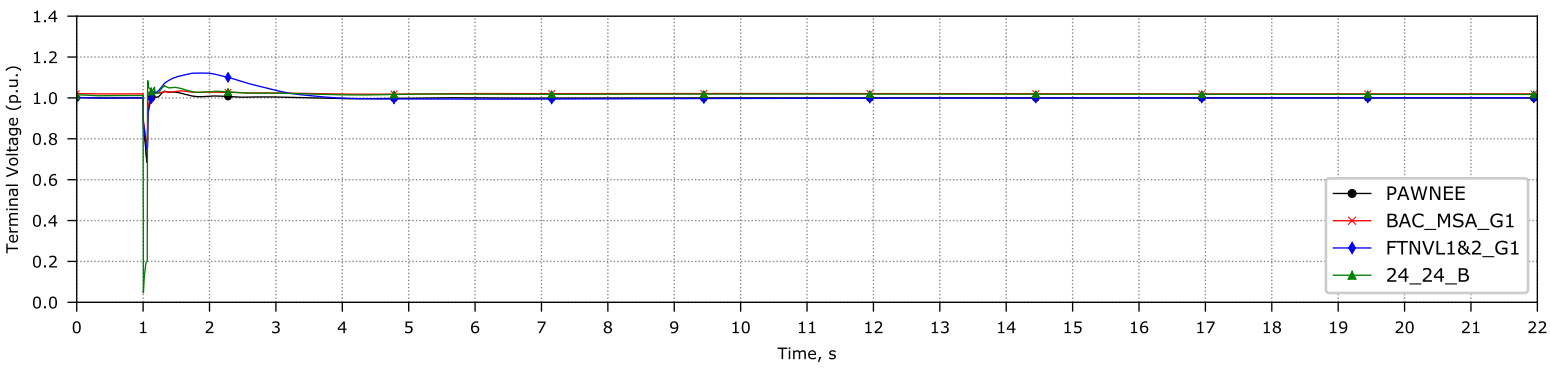

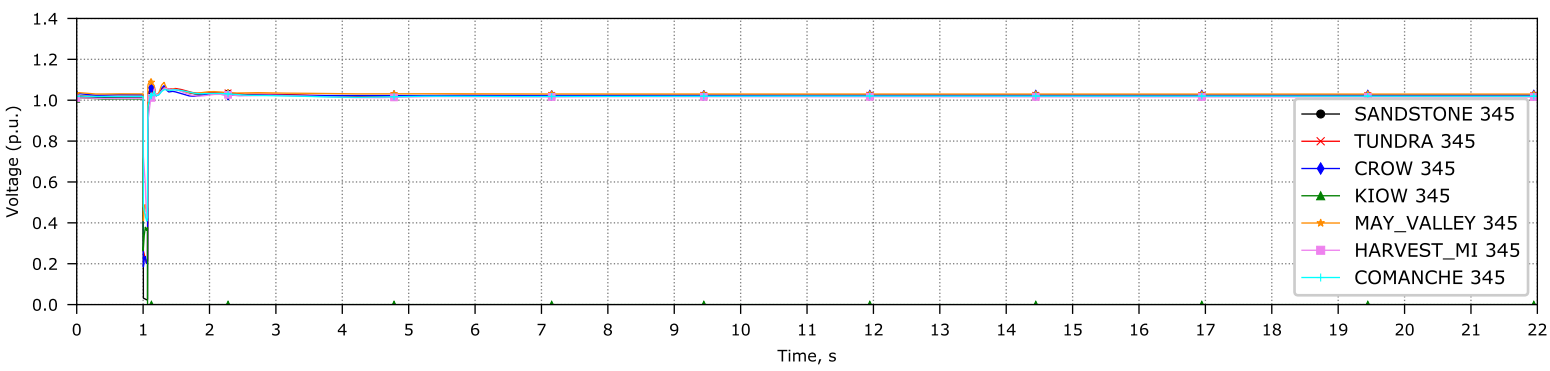

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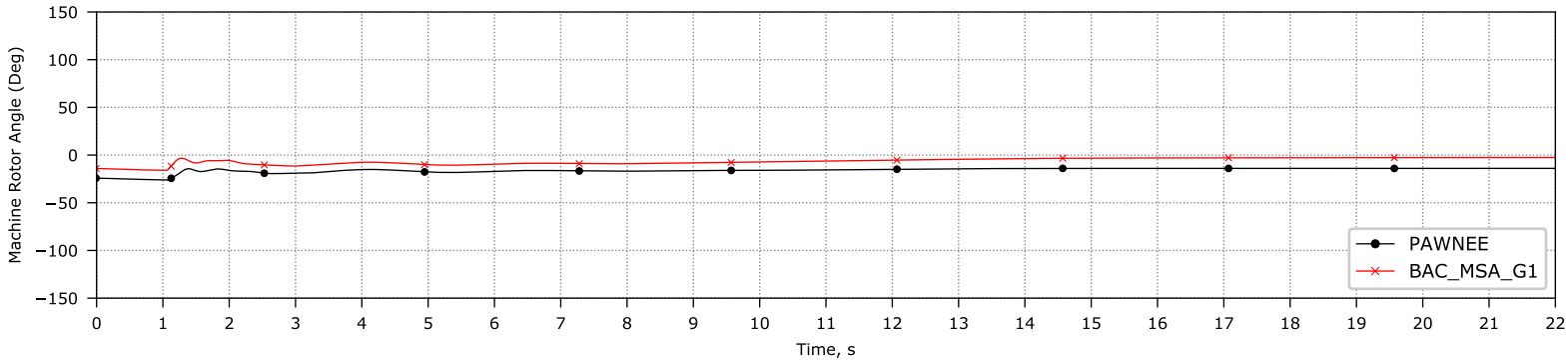

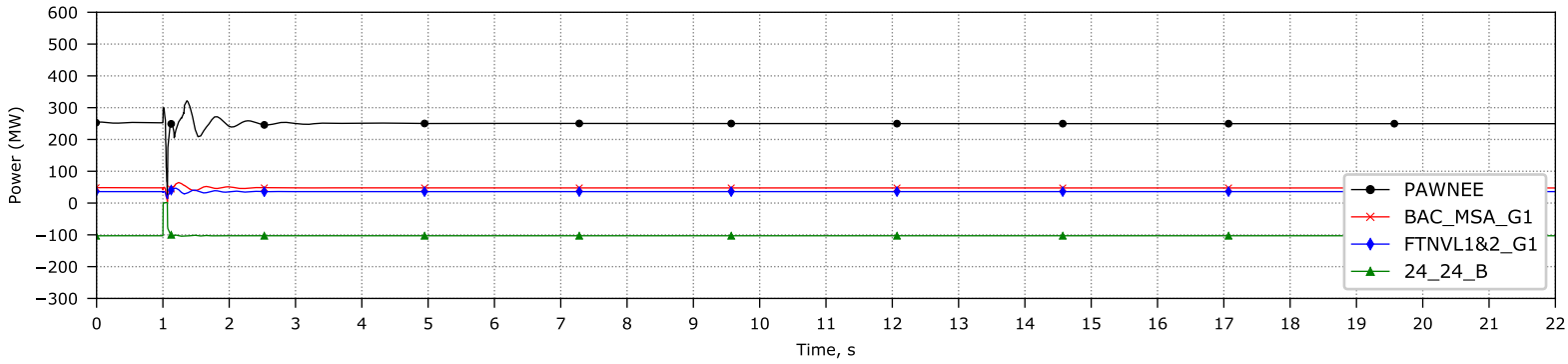

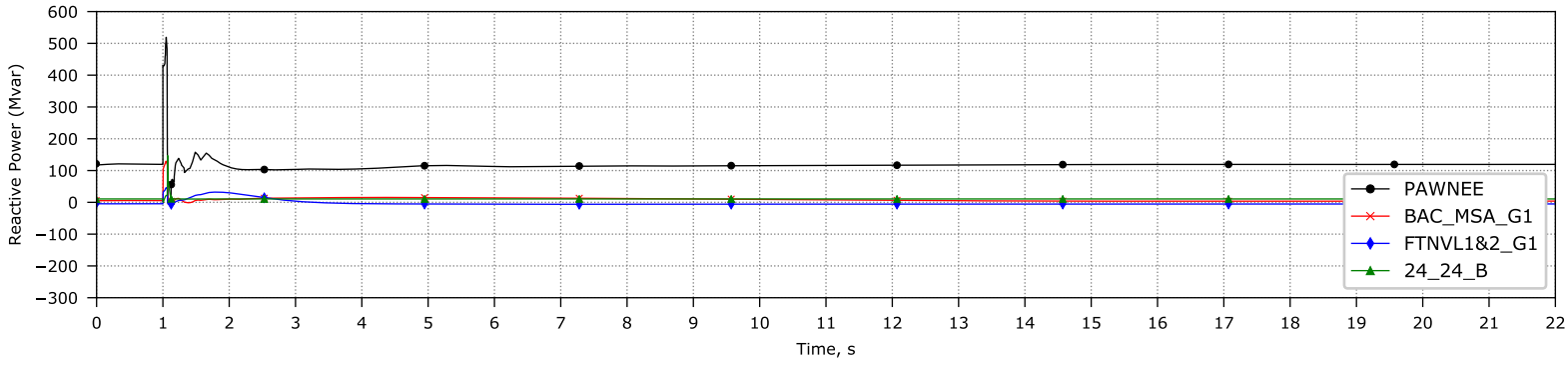

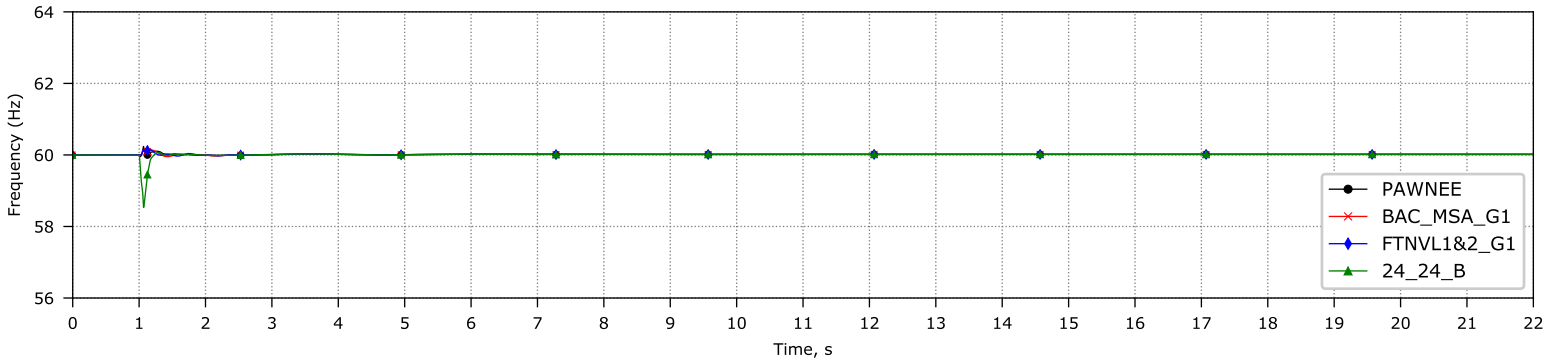

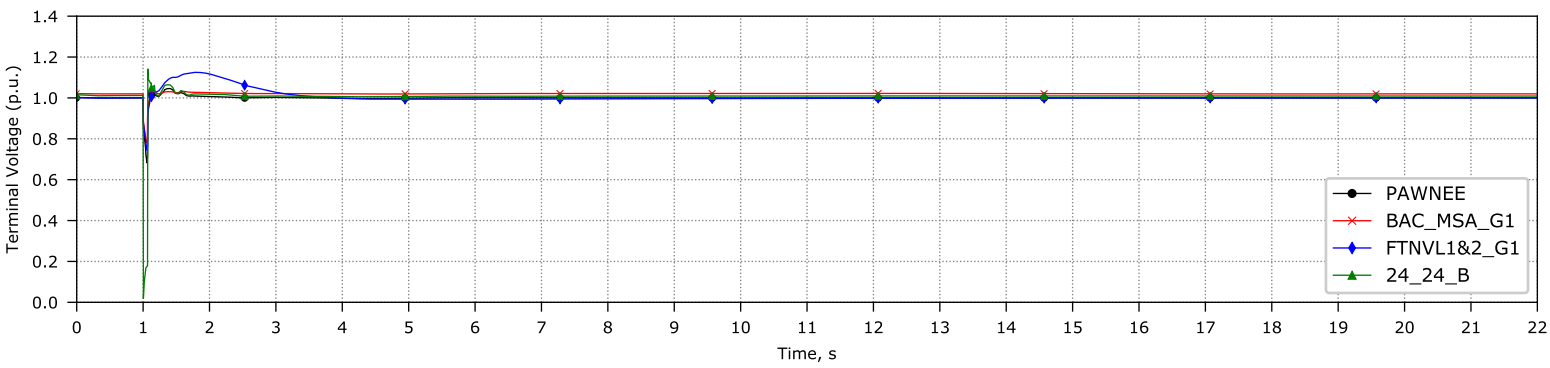

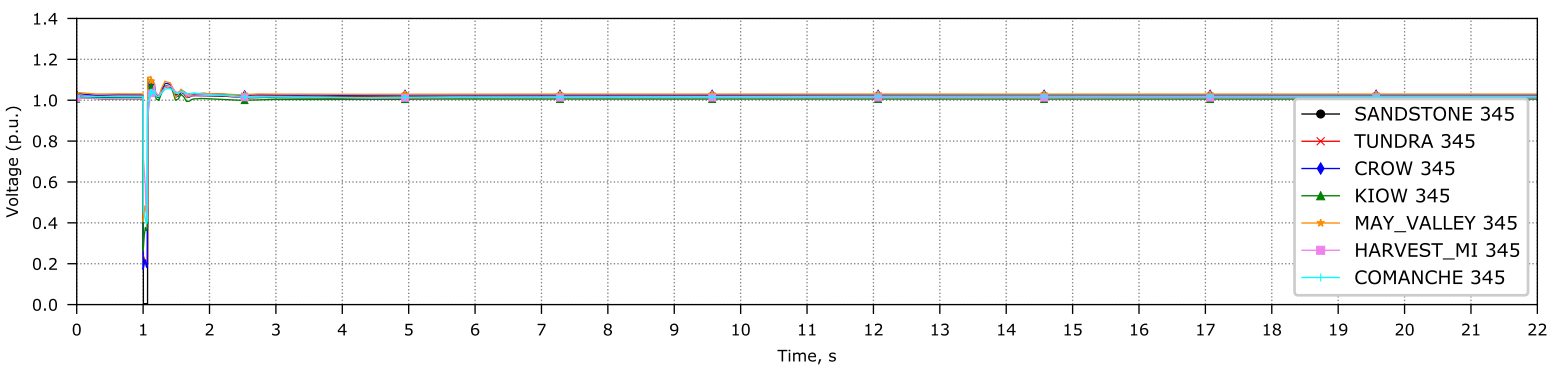

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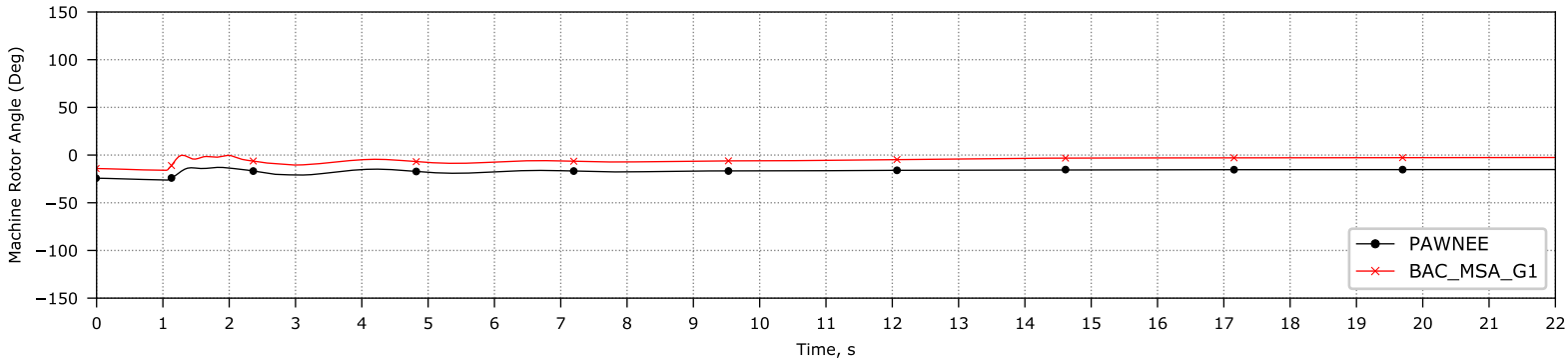

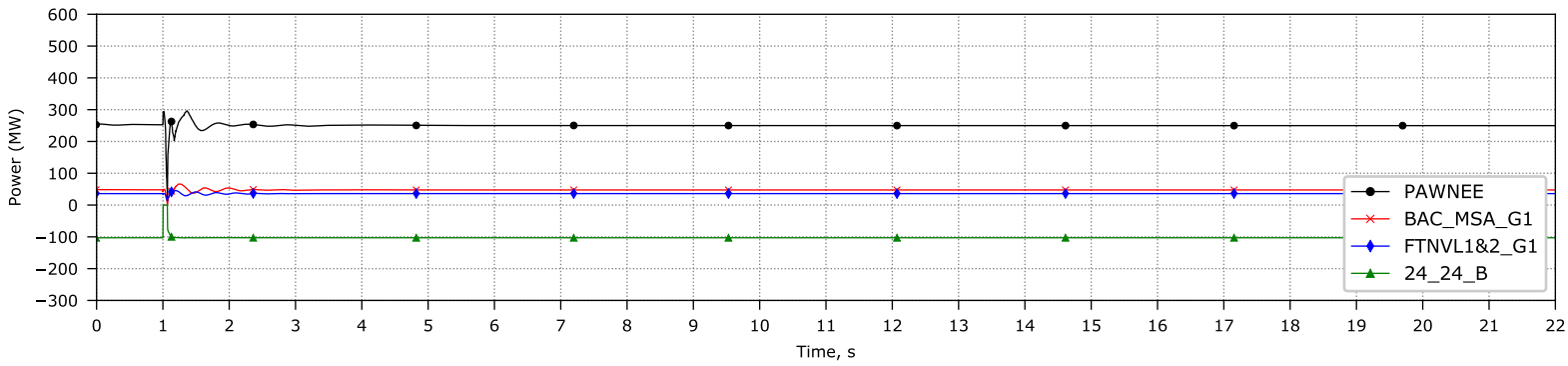

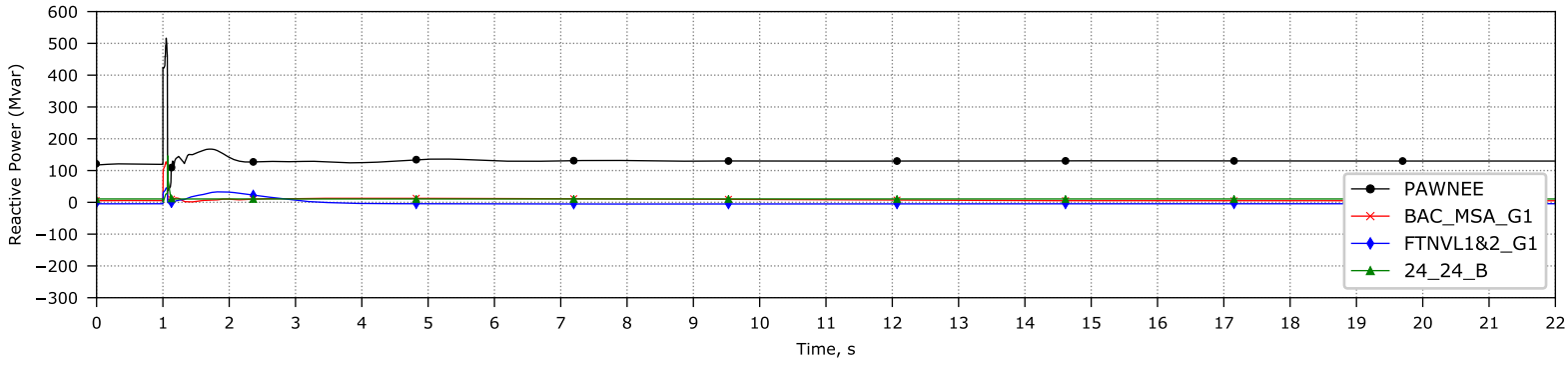

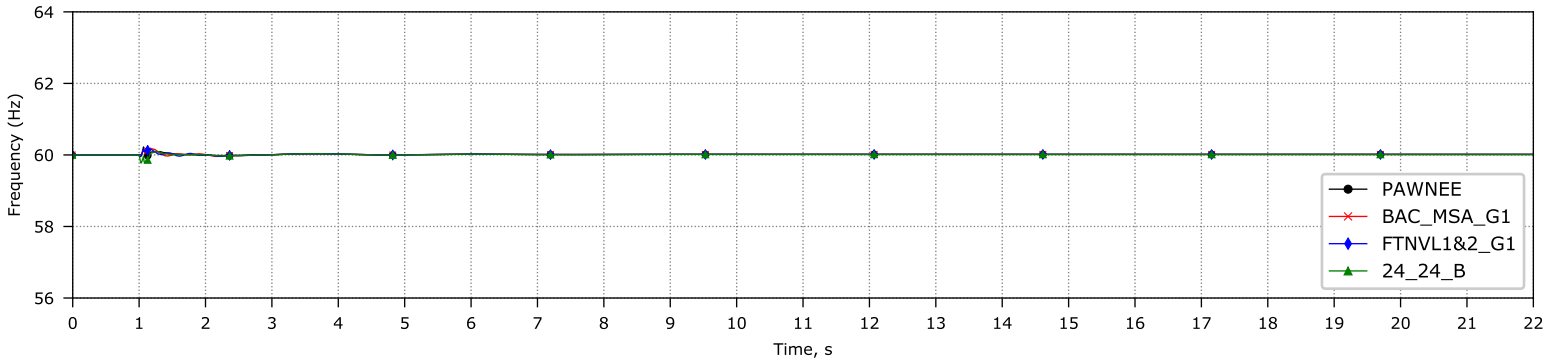

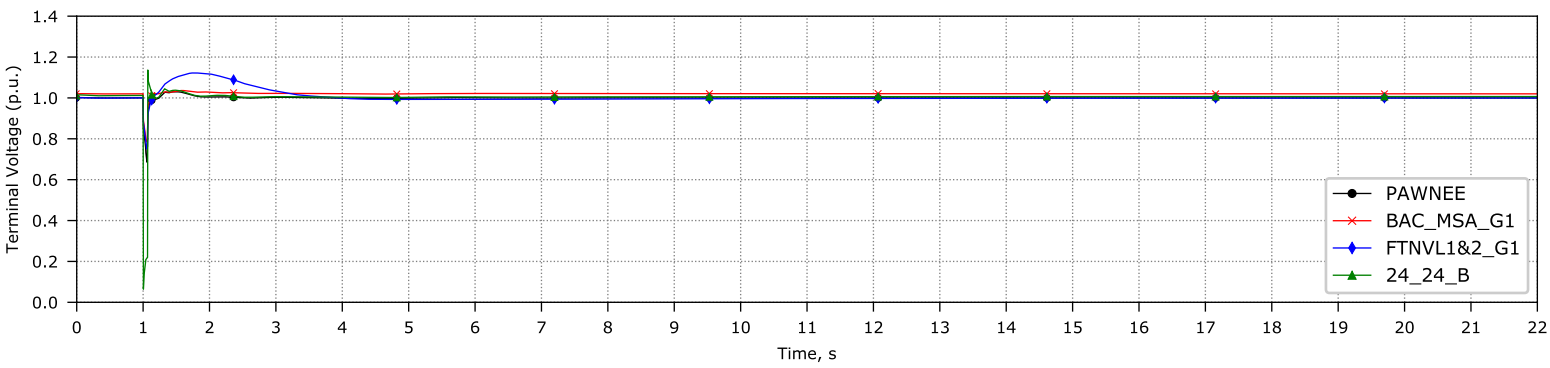

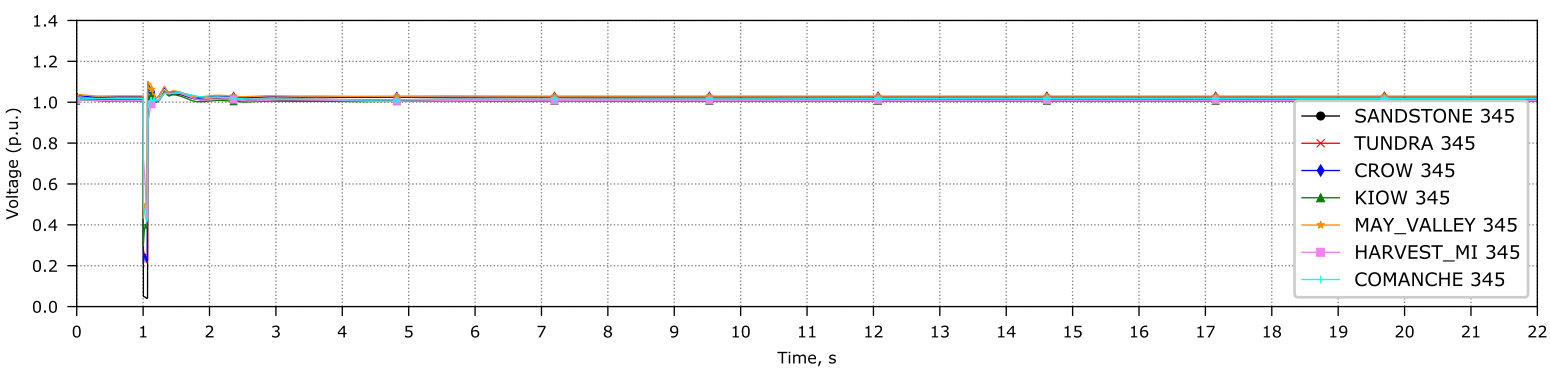

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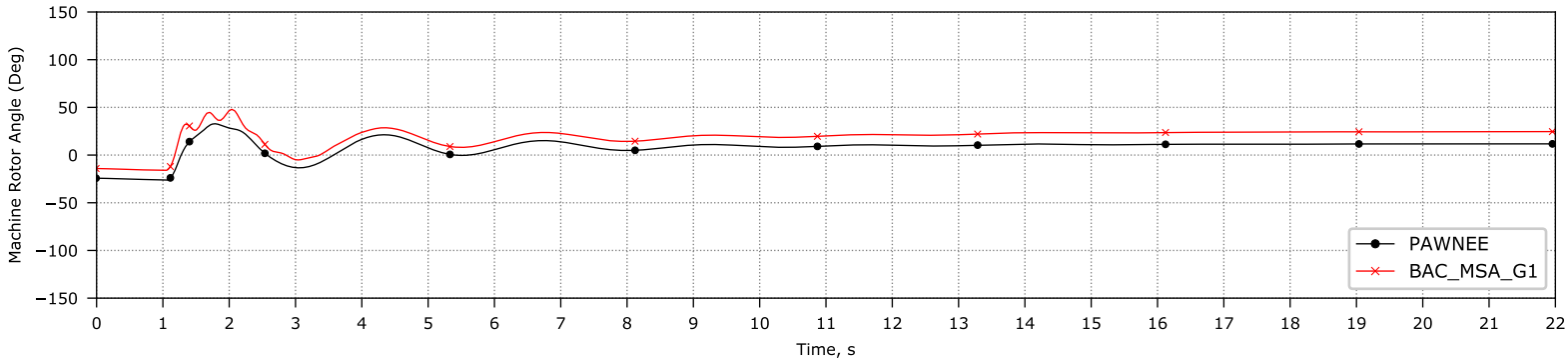
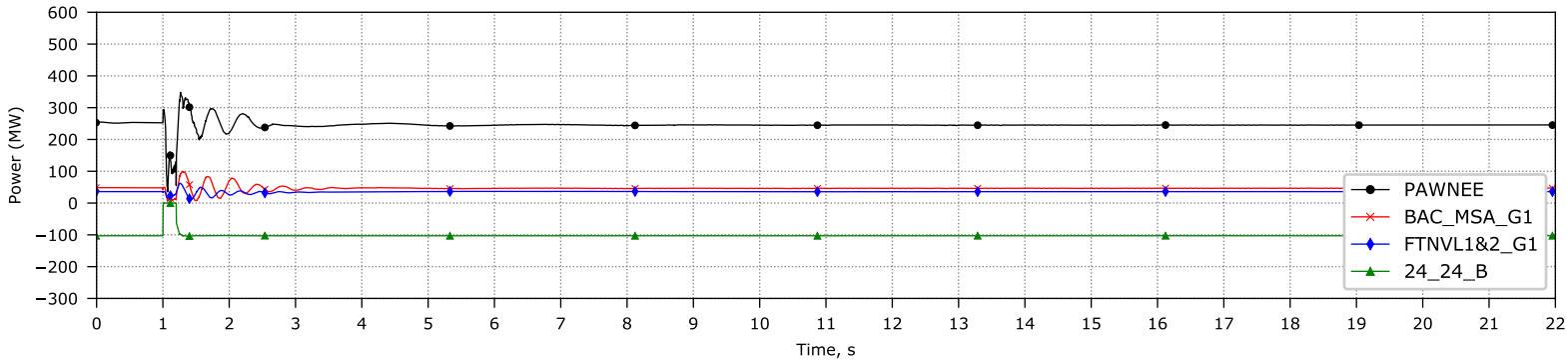
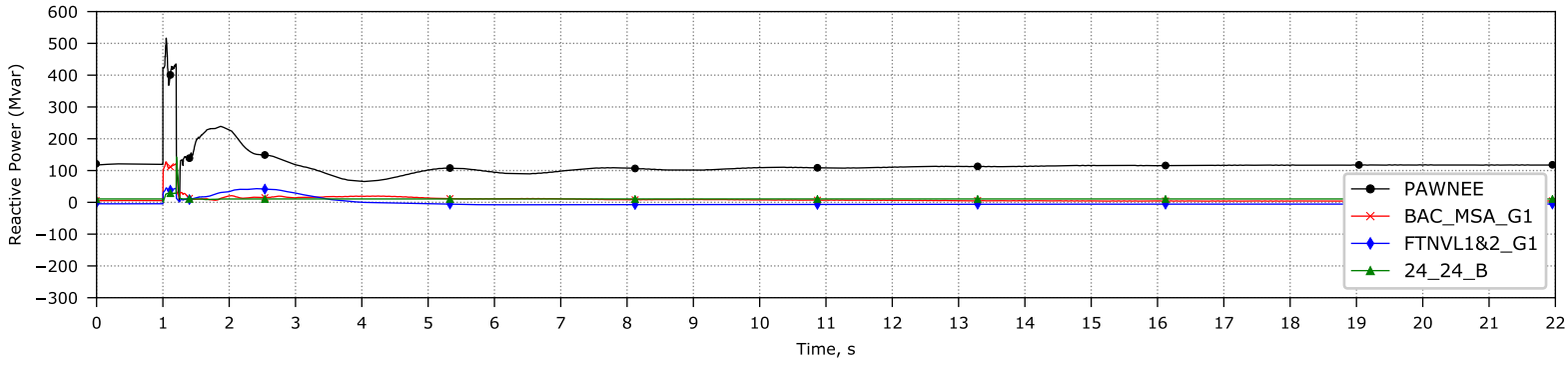
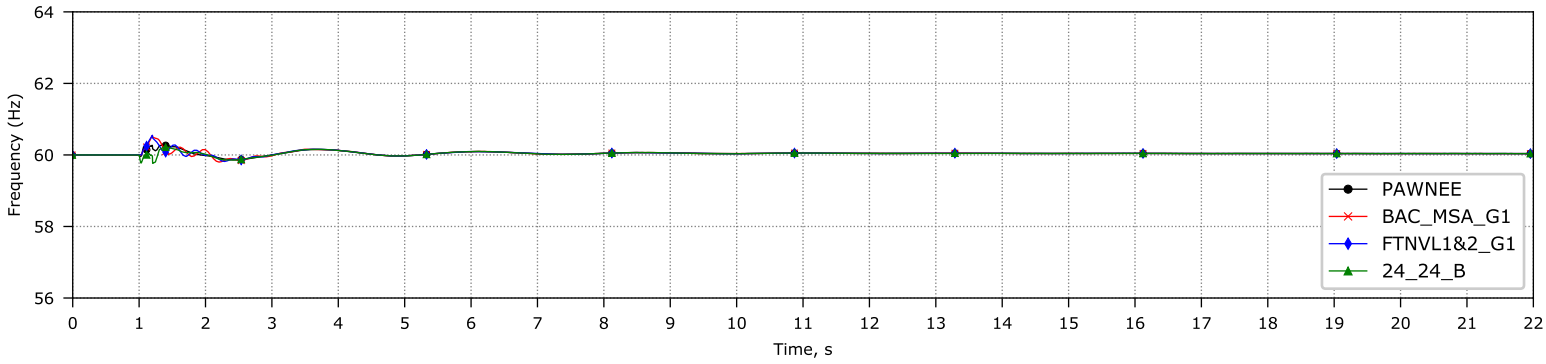
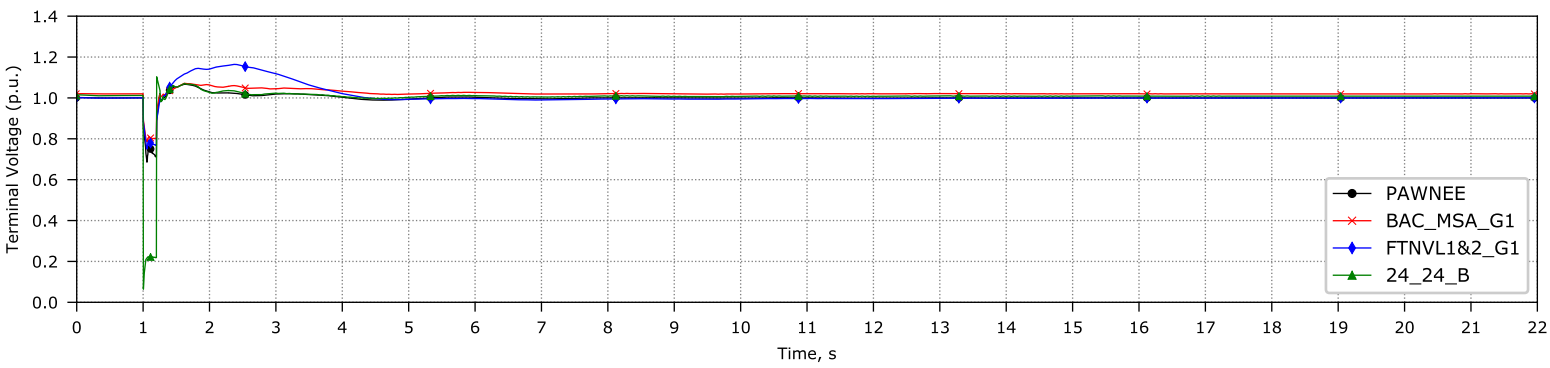
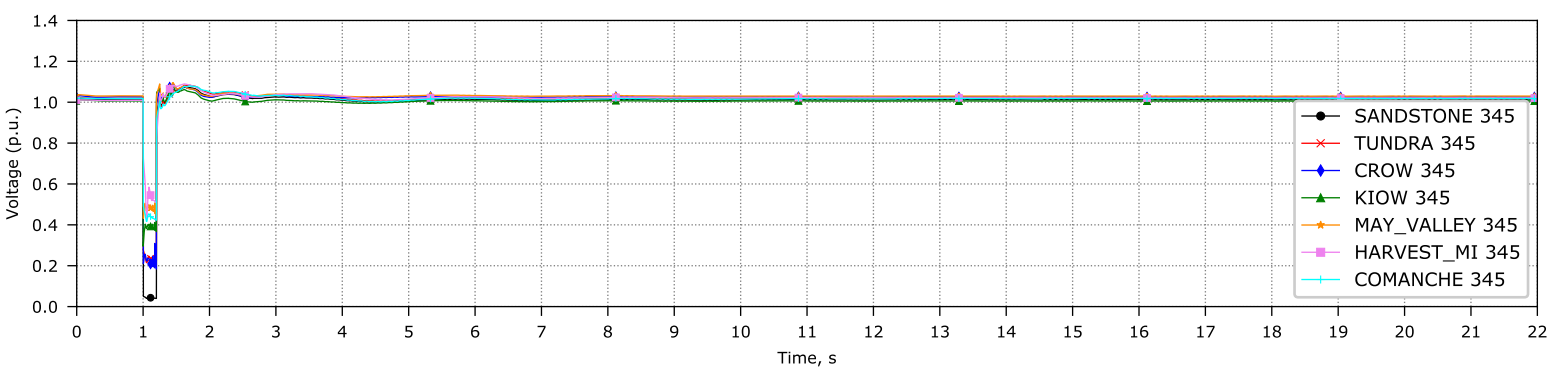




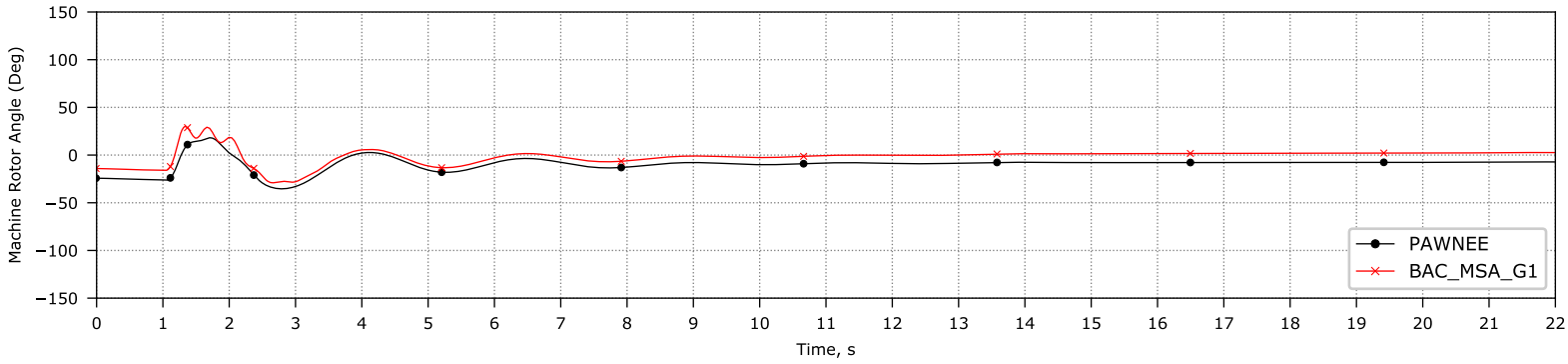


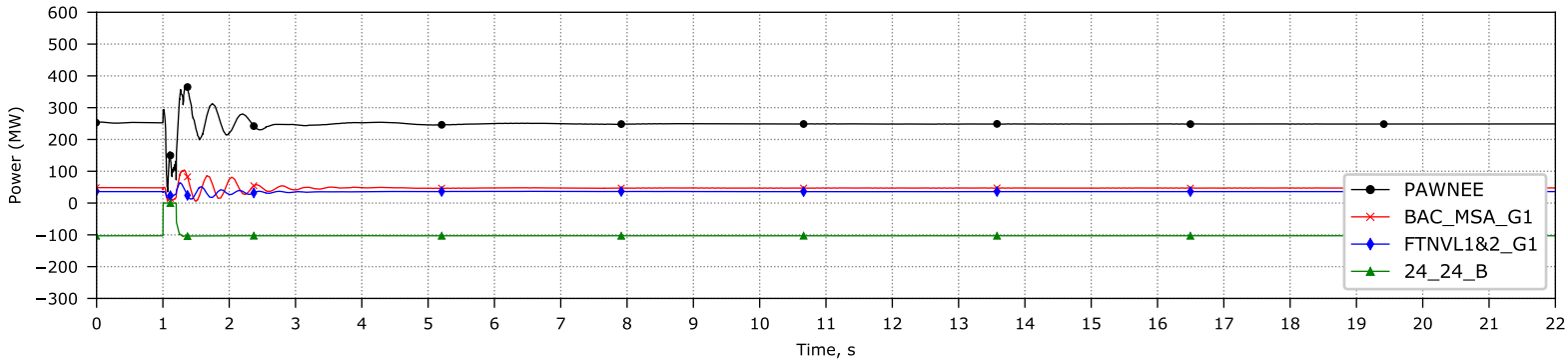


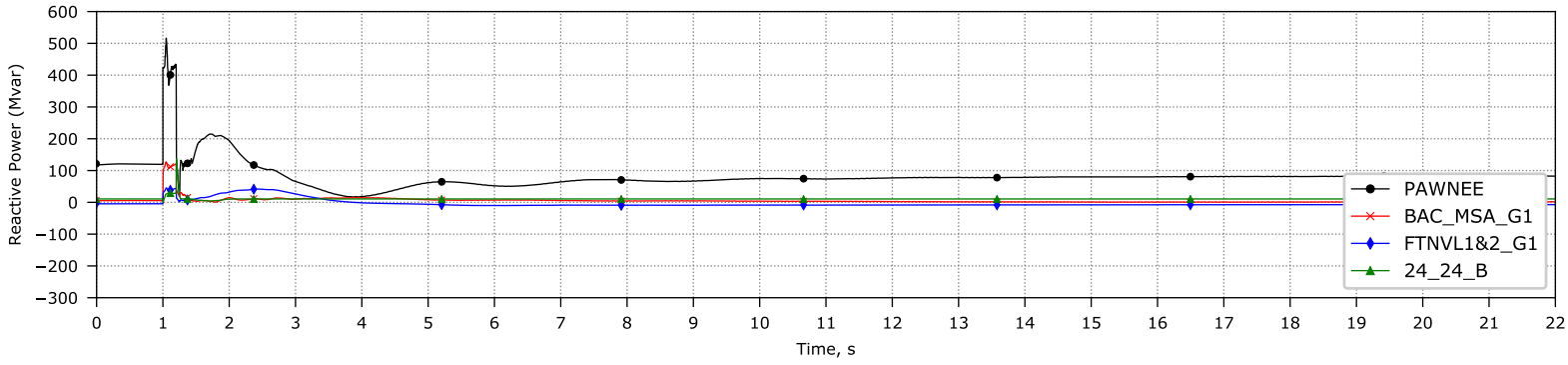


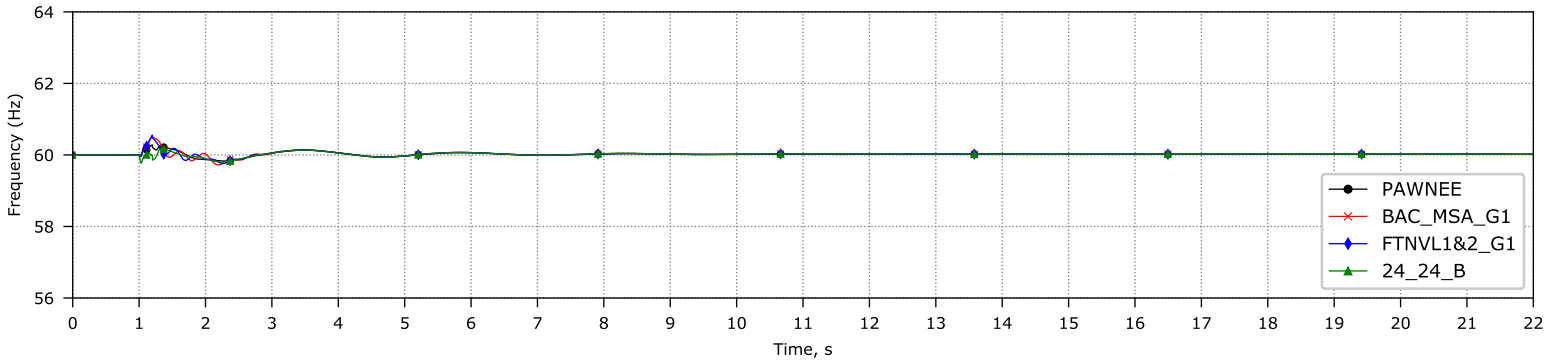


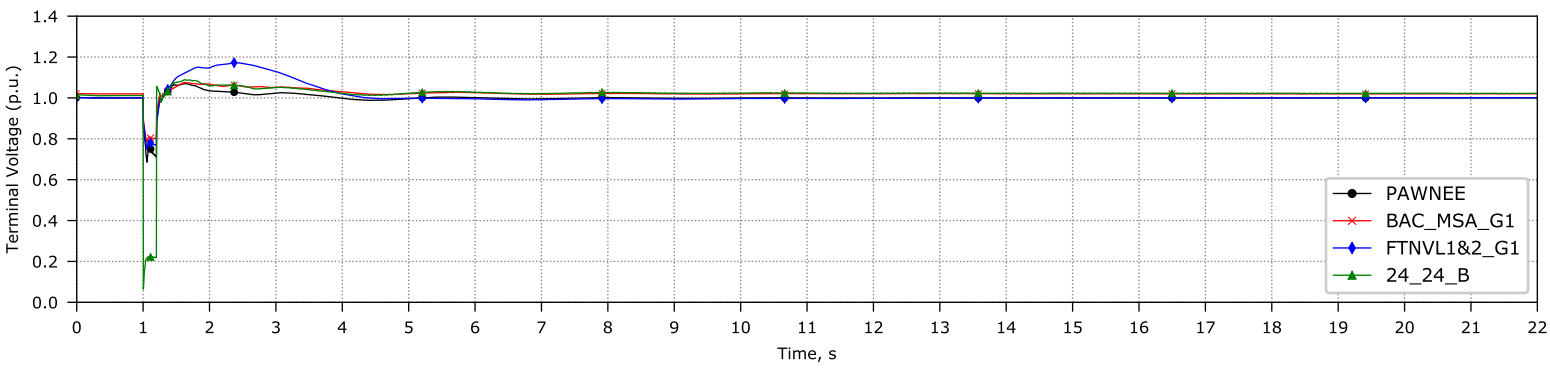
PI-2024-24_Study_GC_BF_156b

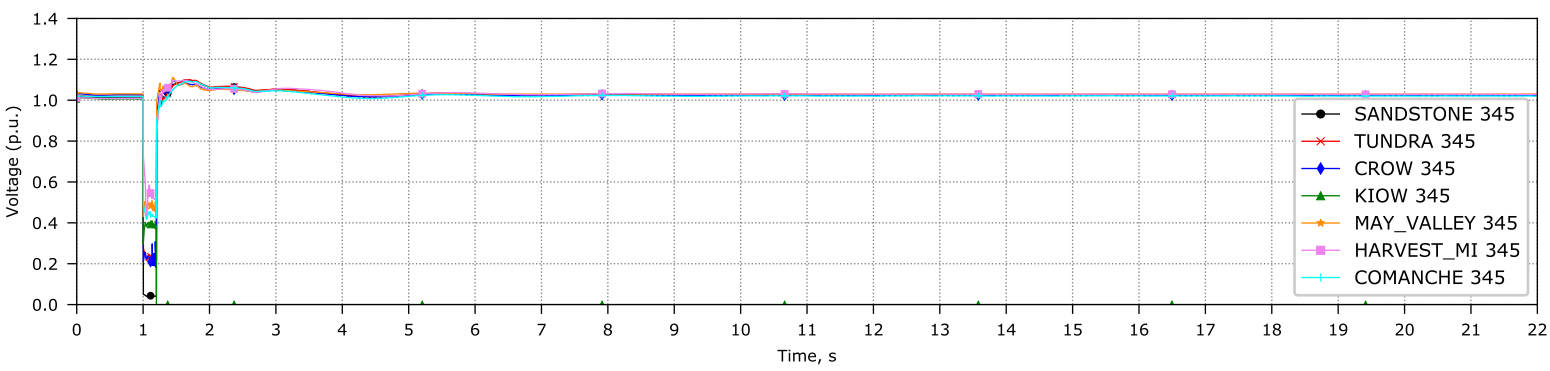




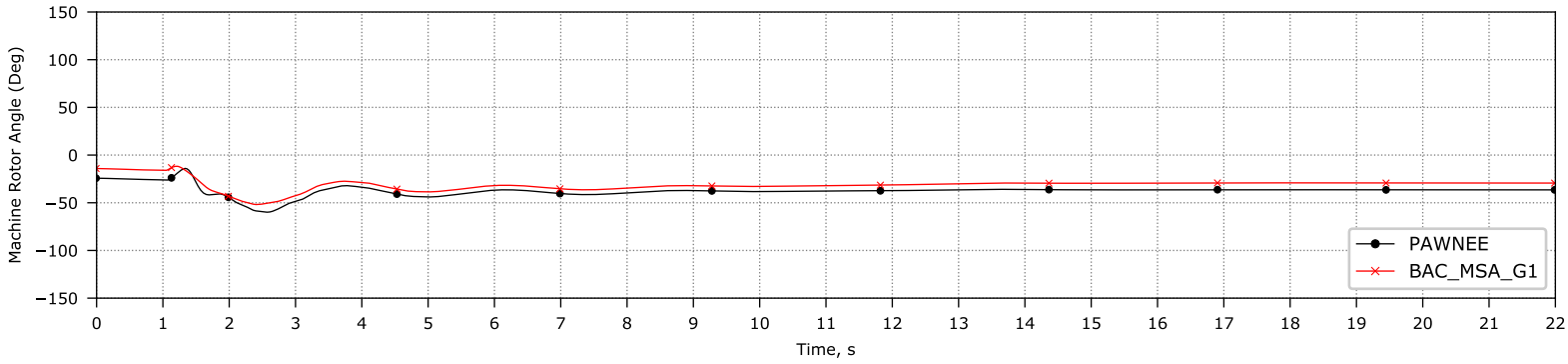


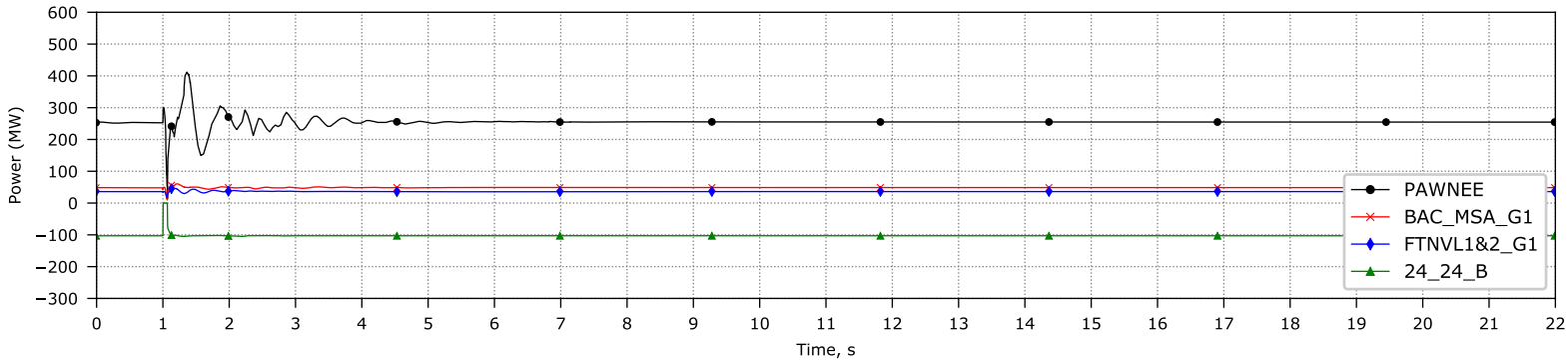


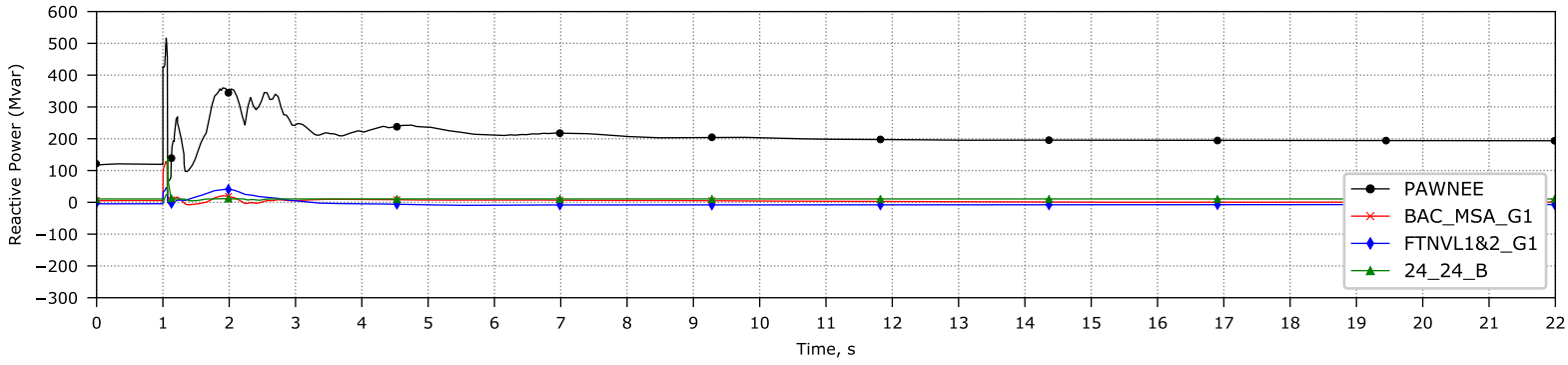


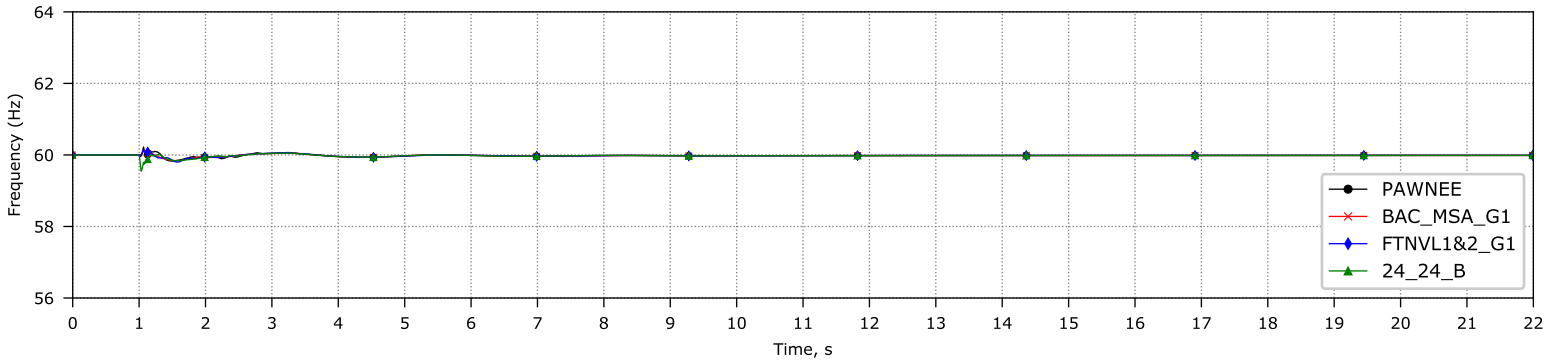


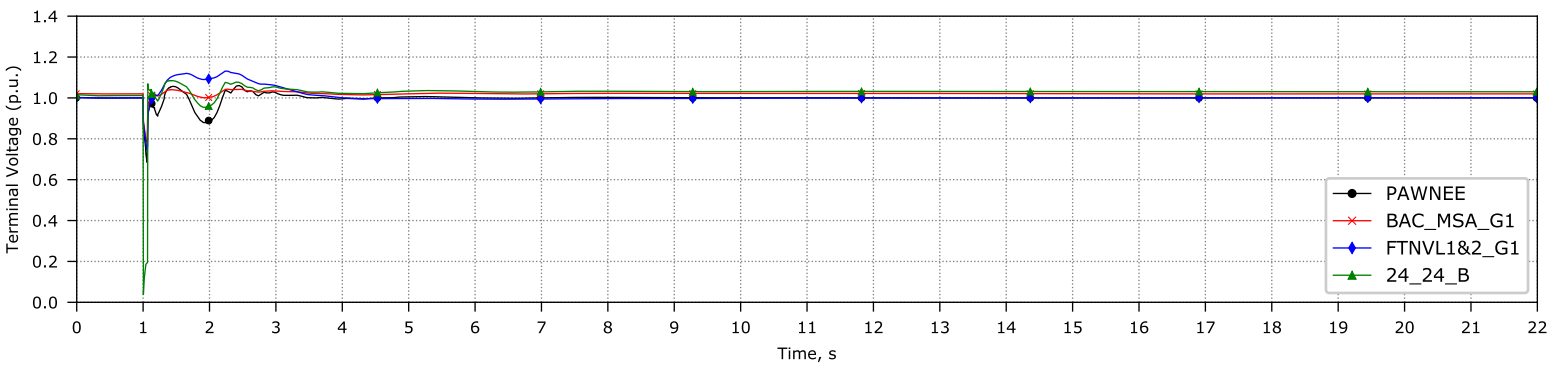
PI-2024-24_Study_GC_P7_163

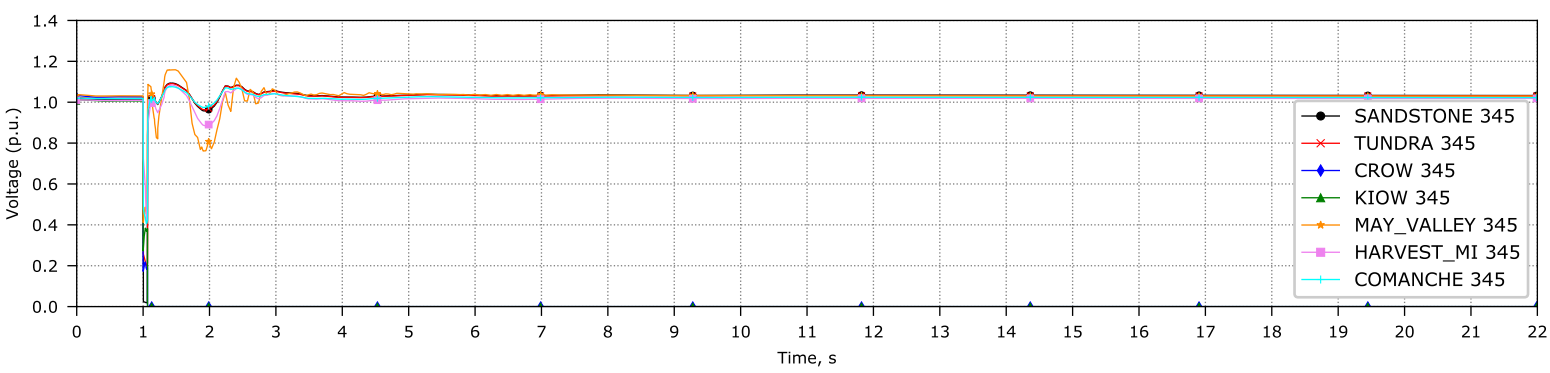




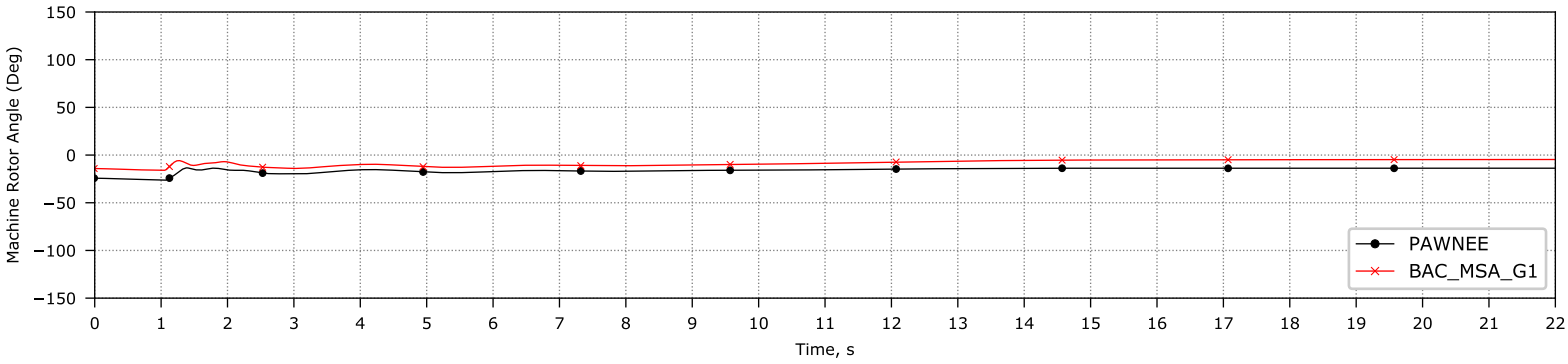


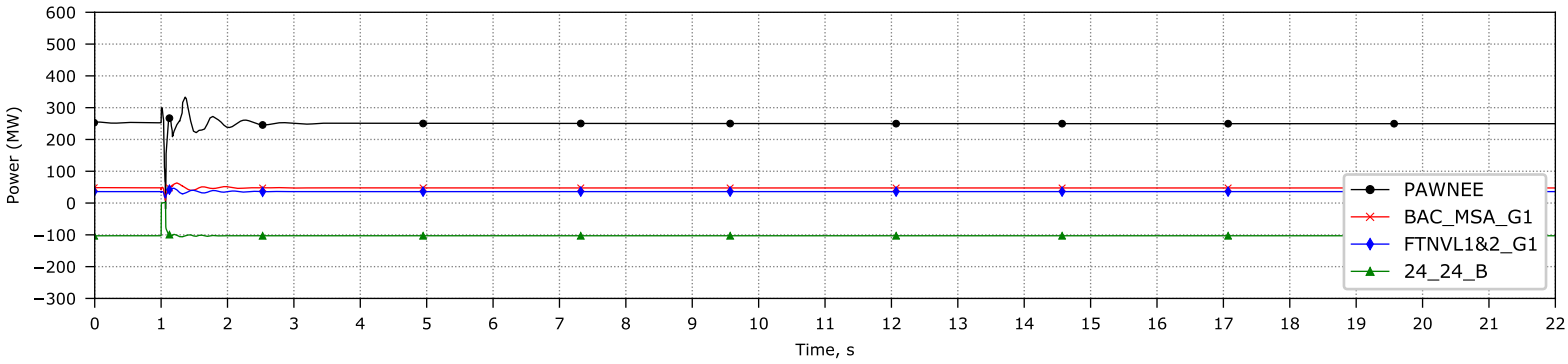


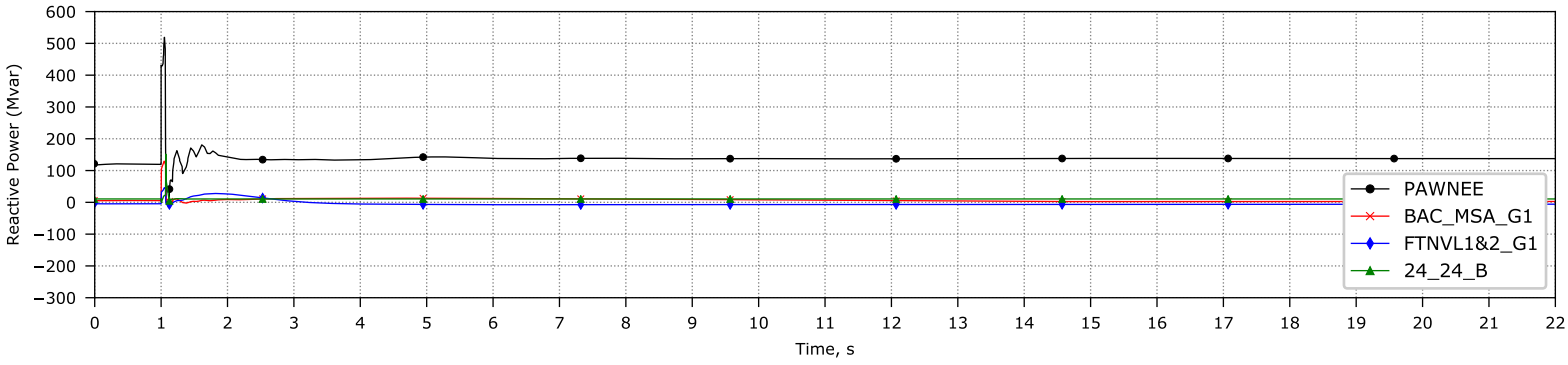


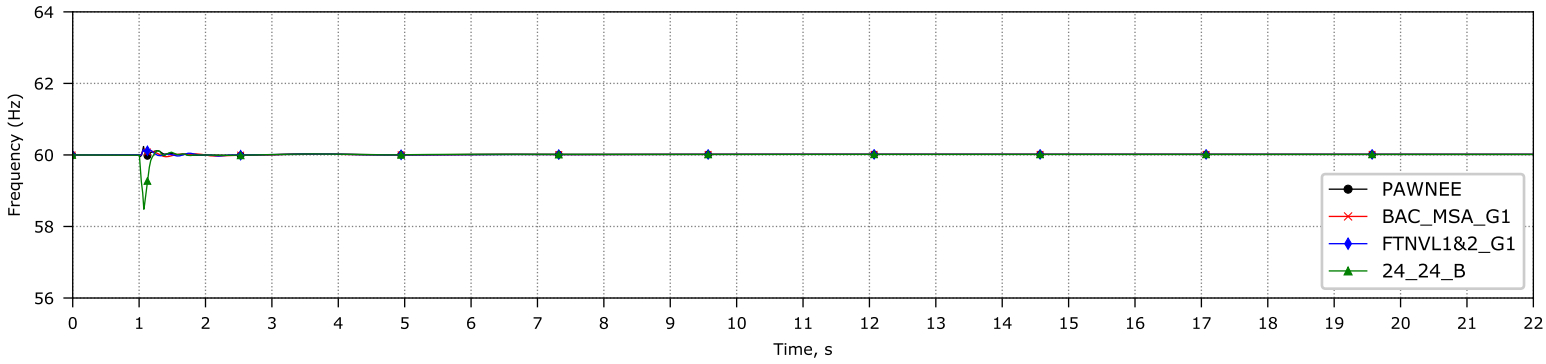


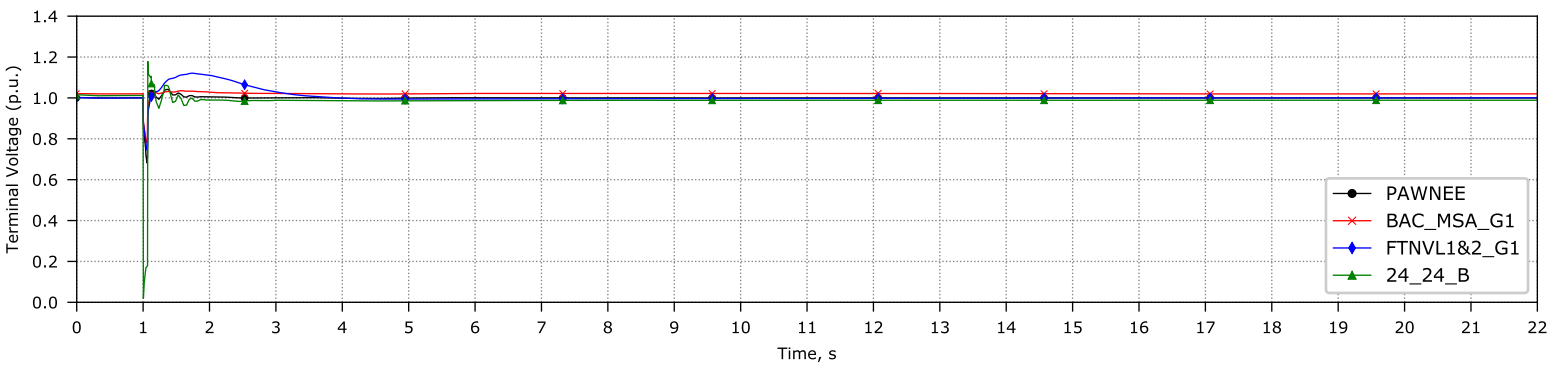
PI-2024-24_Study_GC_P7_164

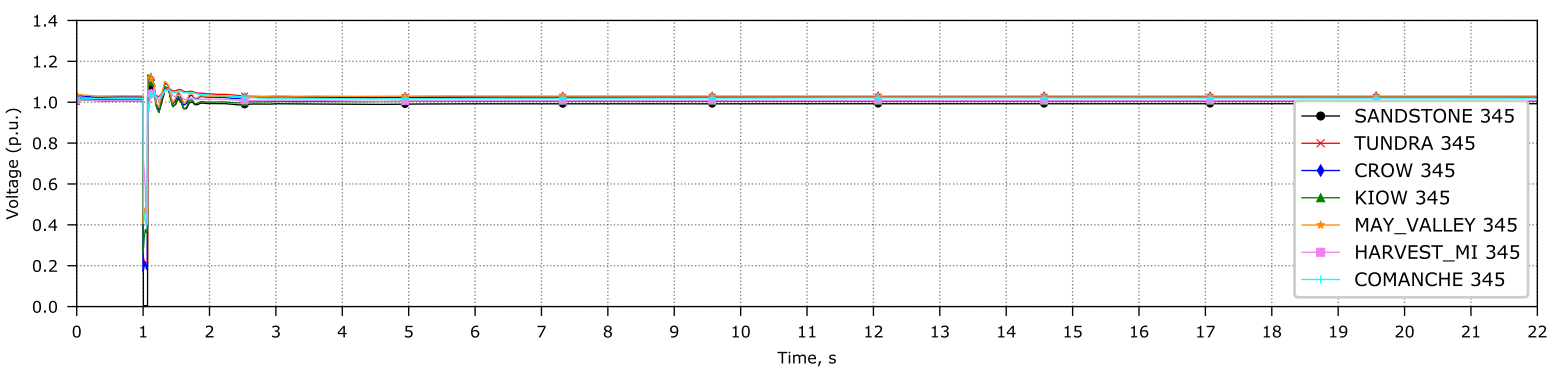




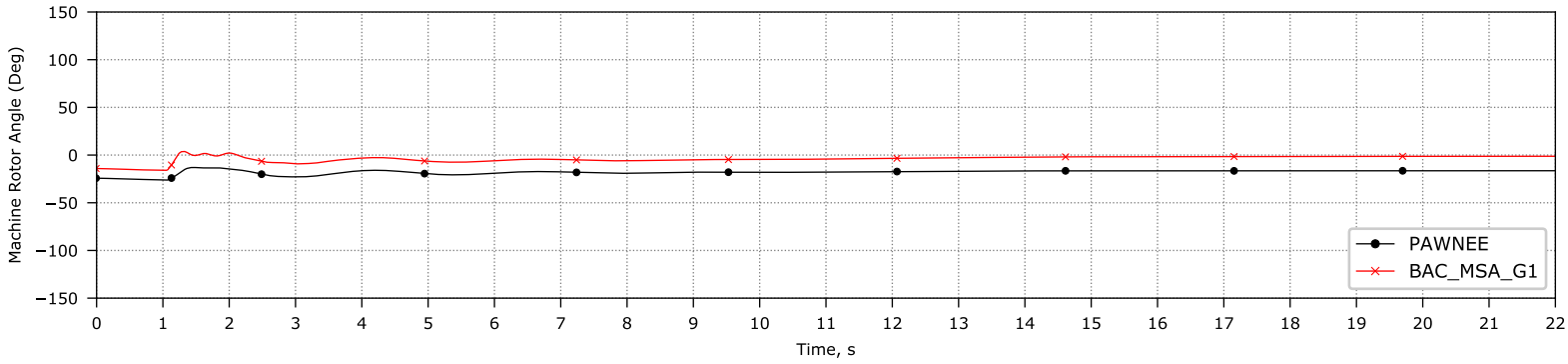


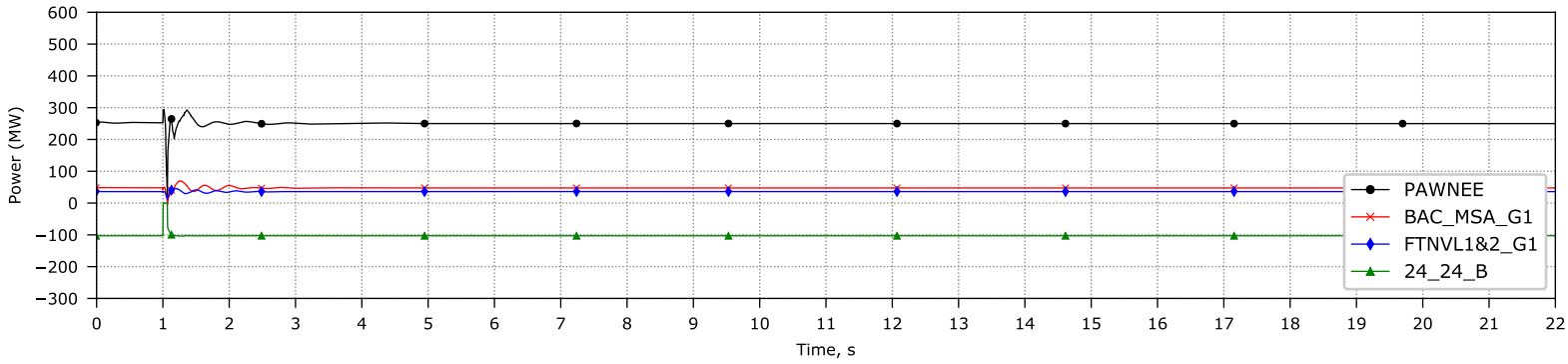


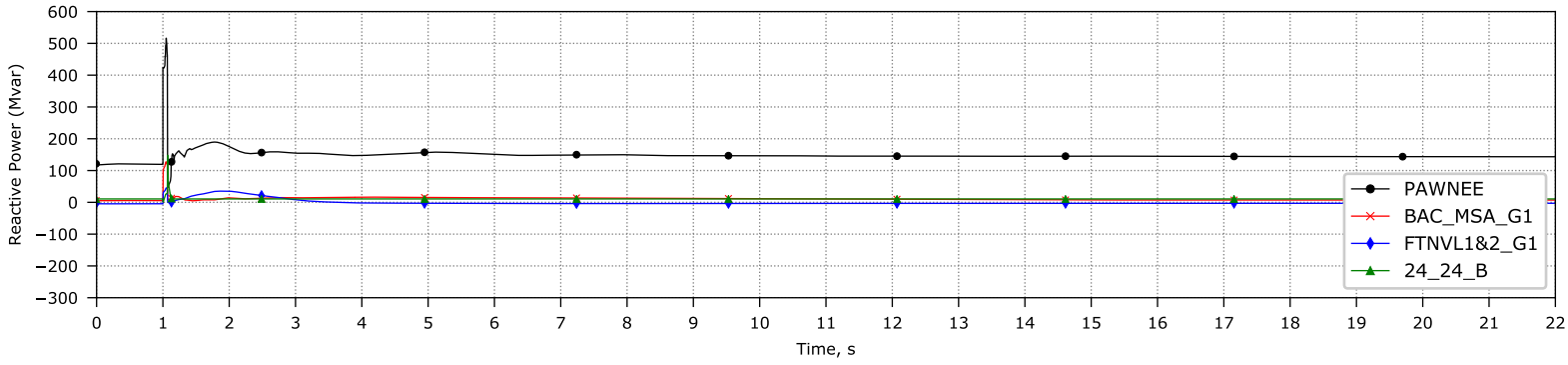


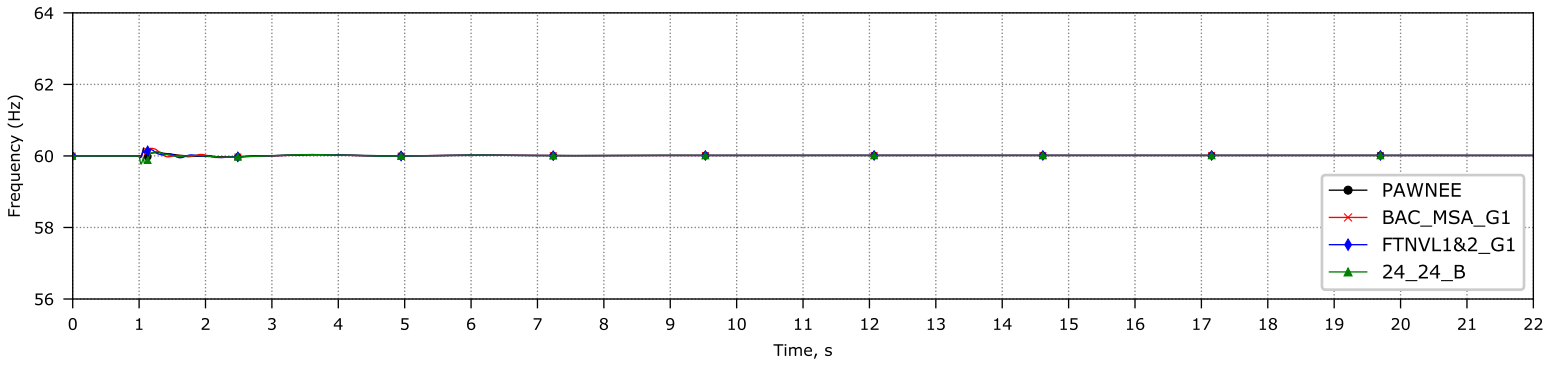


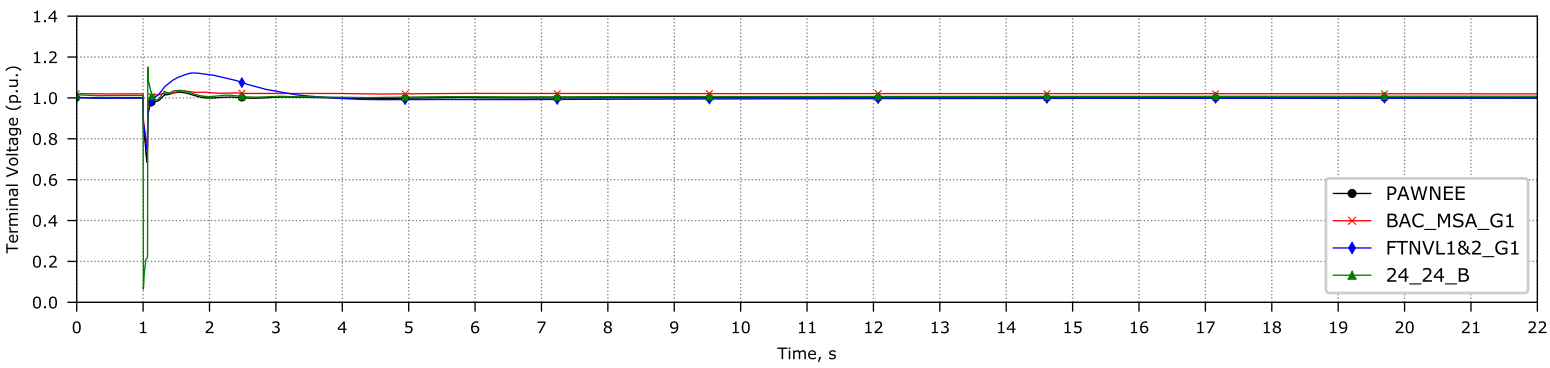
PI-2024-24_Study_GC_P7_165

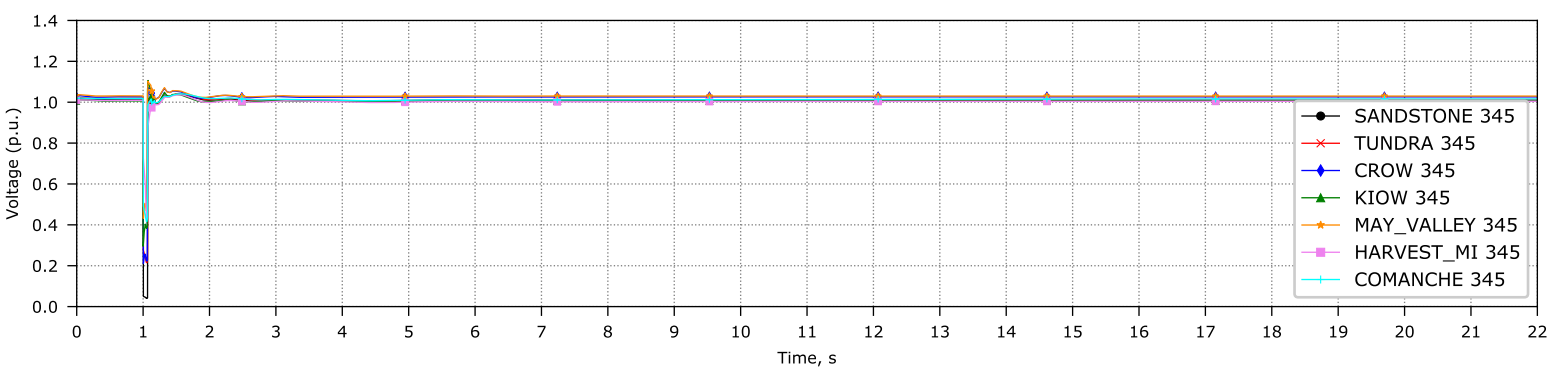




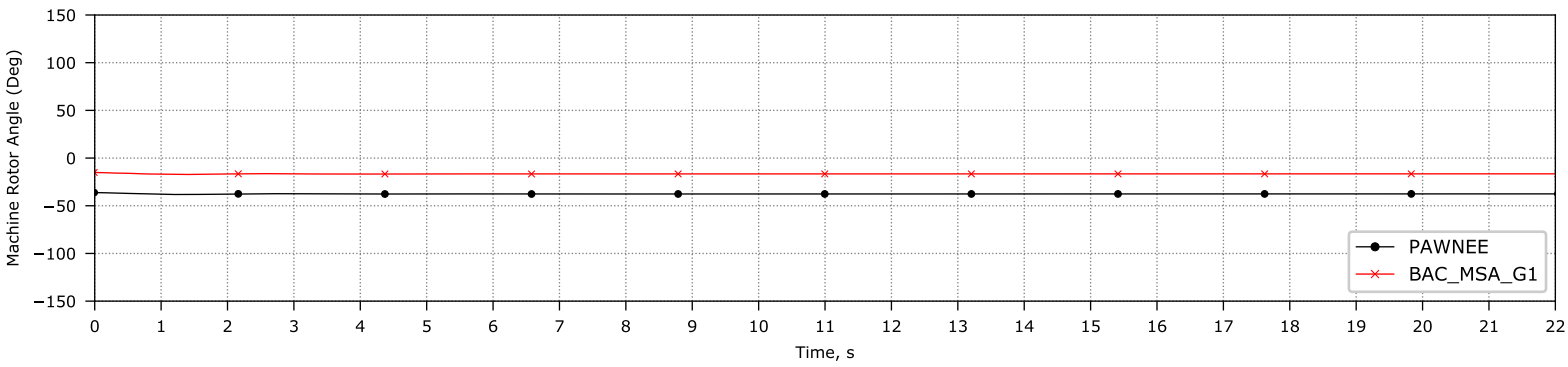


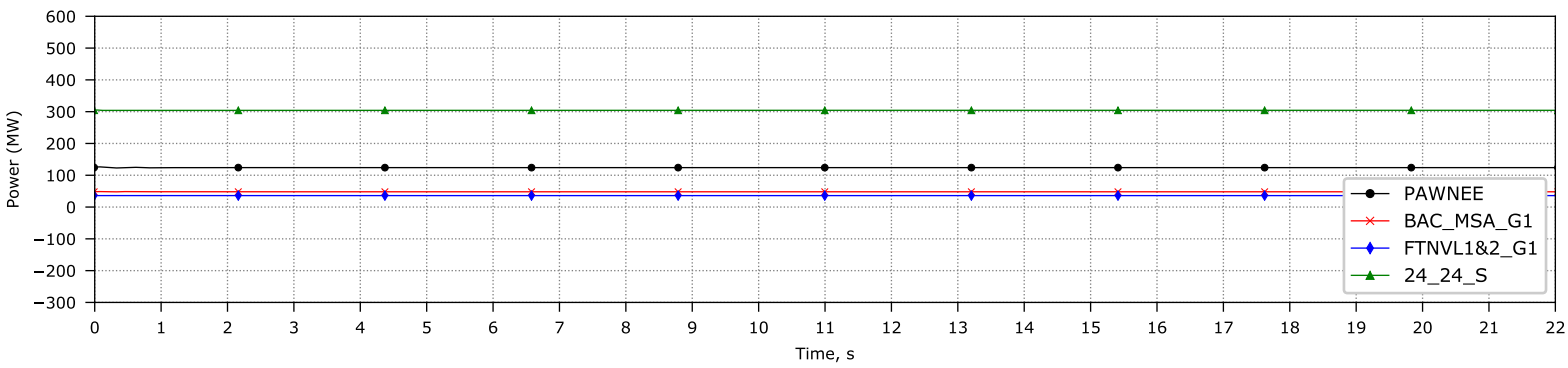


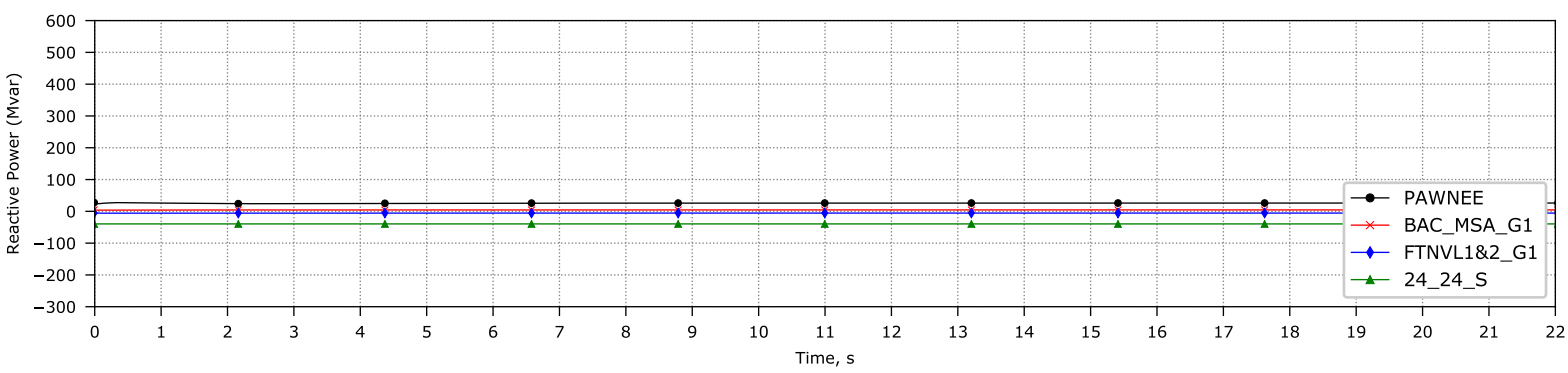


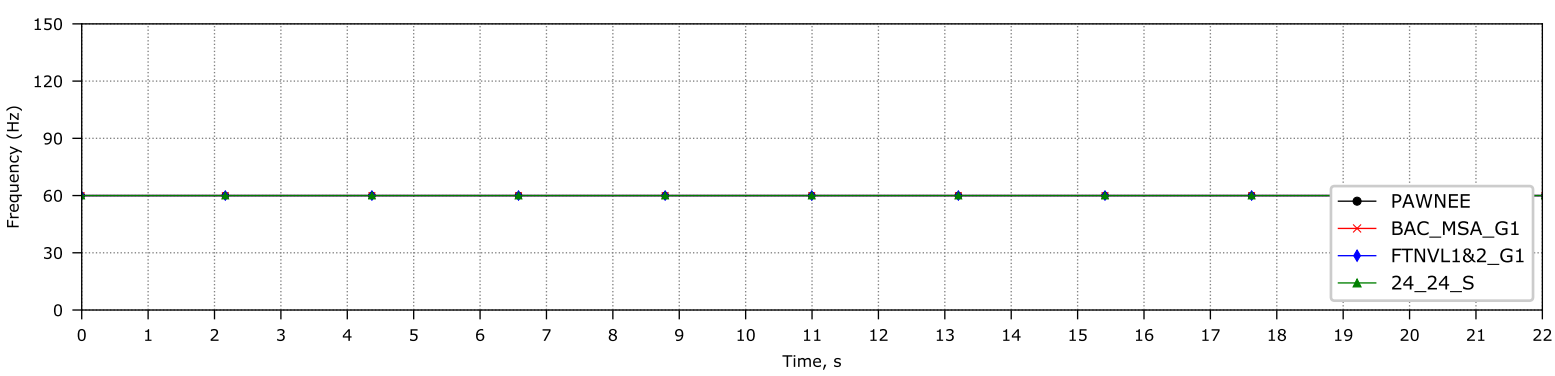


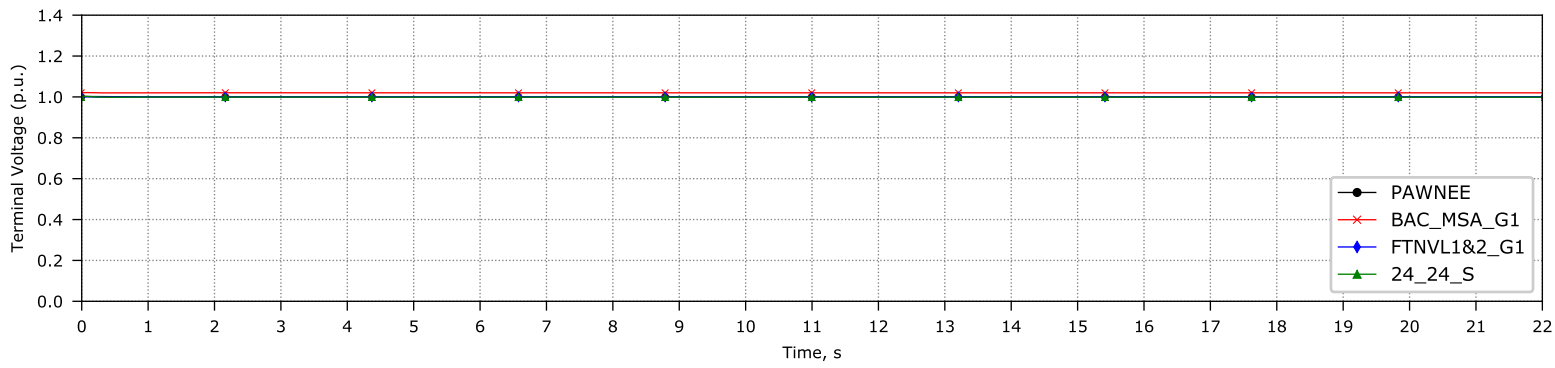
PI-2024-24_Study_GD_flatrun

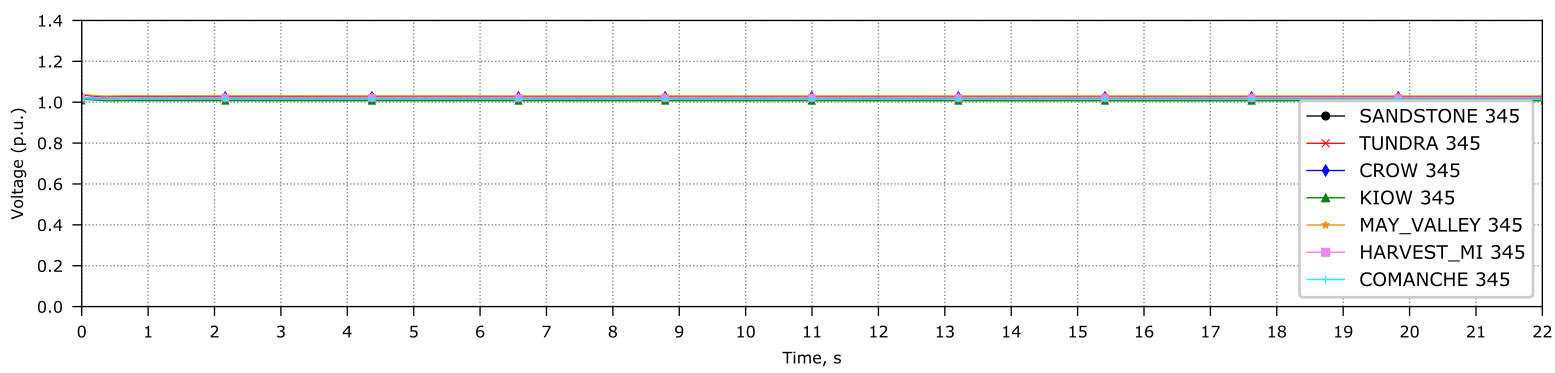




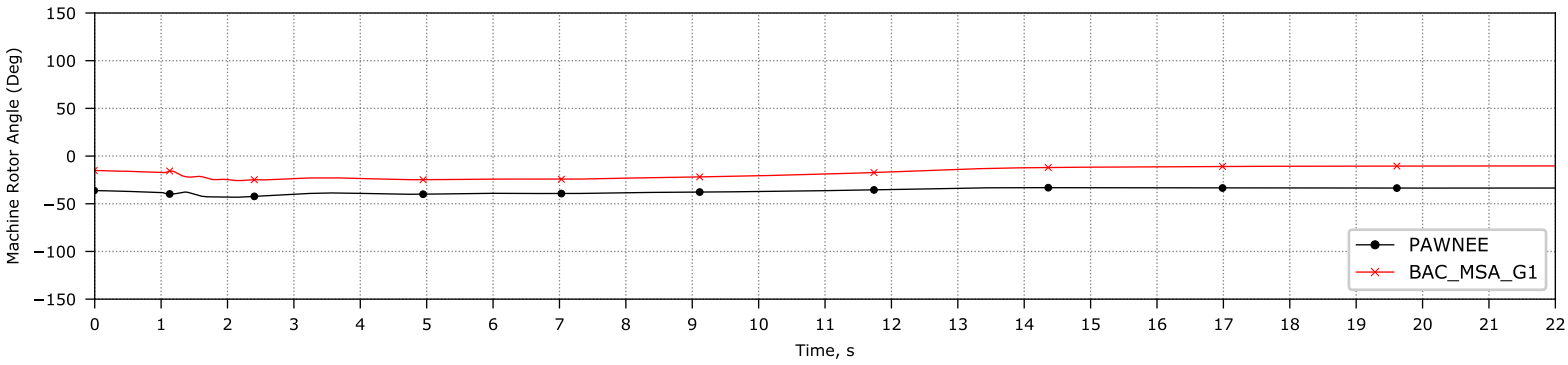


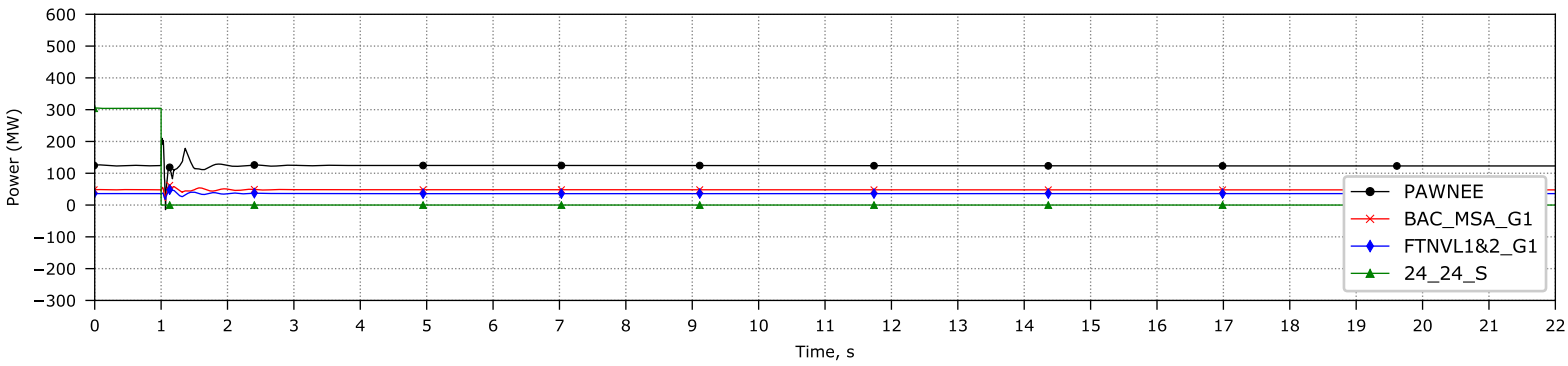


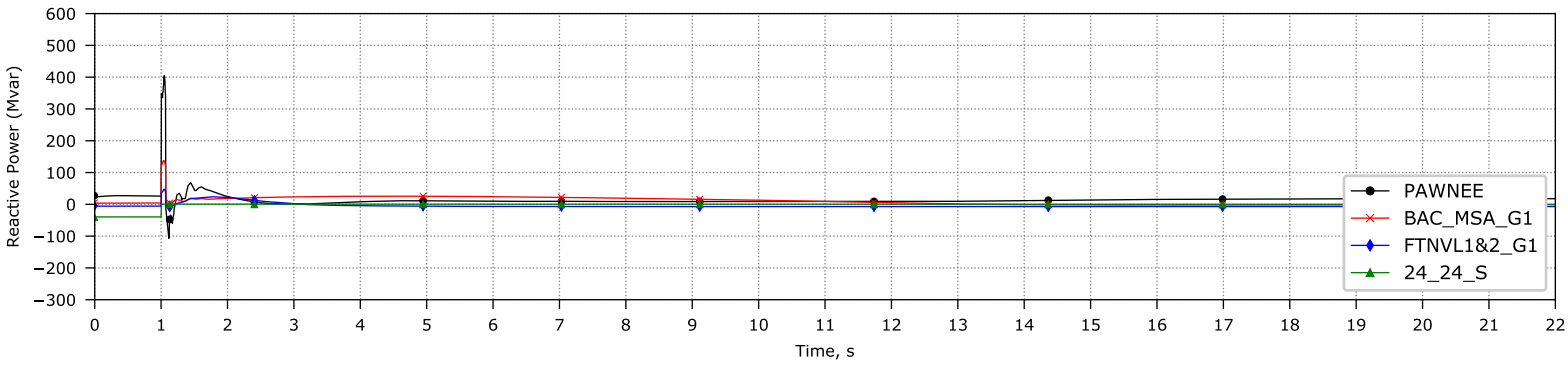


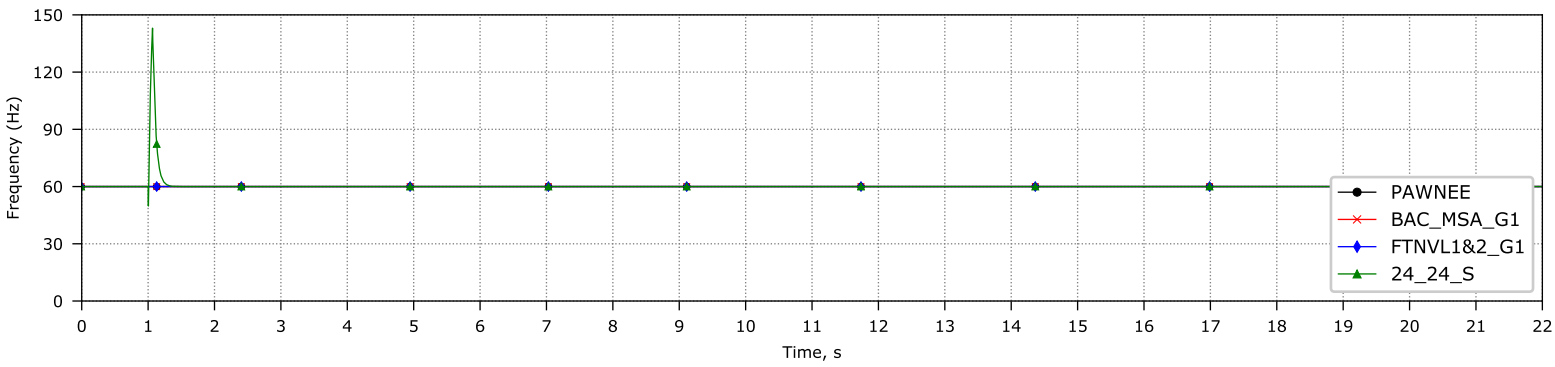


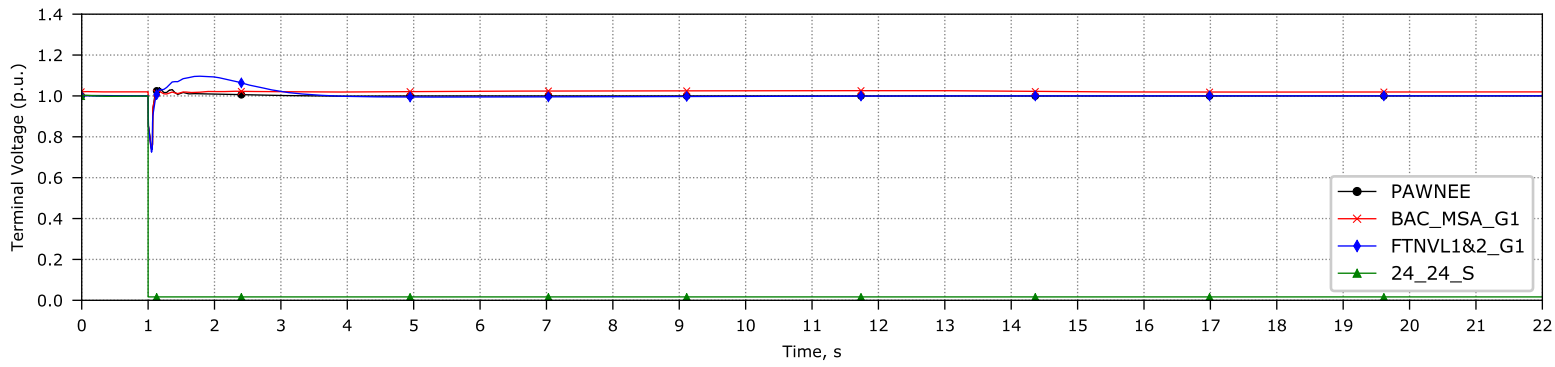
PI-2024-24_Study_GD_PI-2024-24_PV

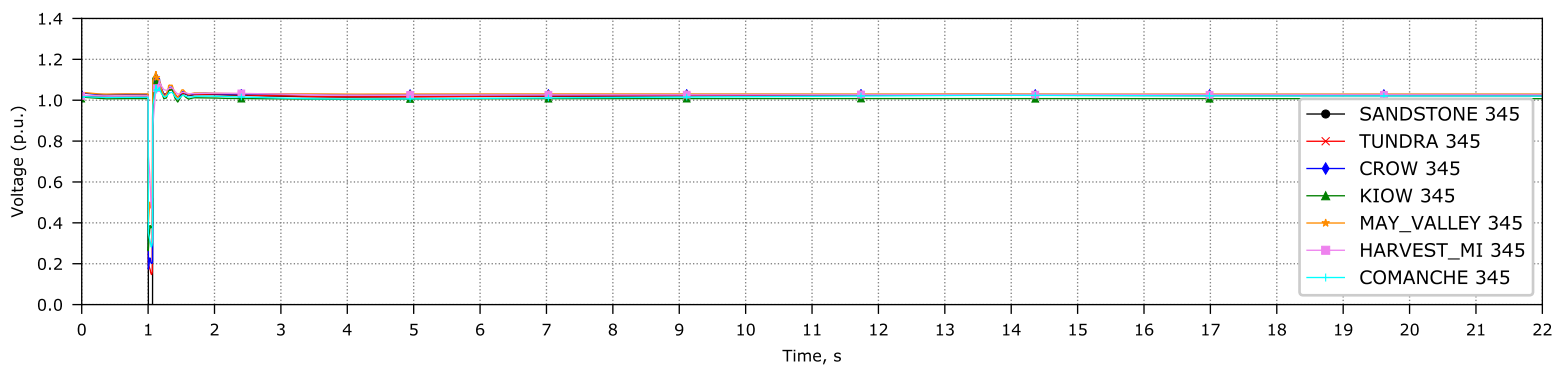




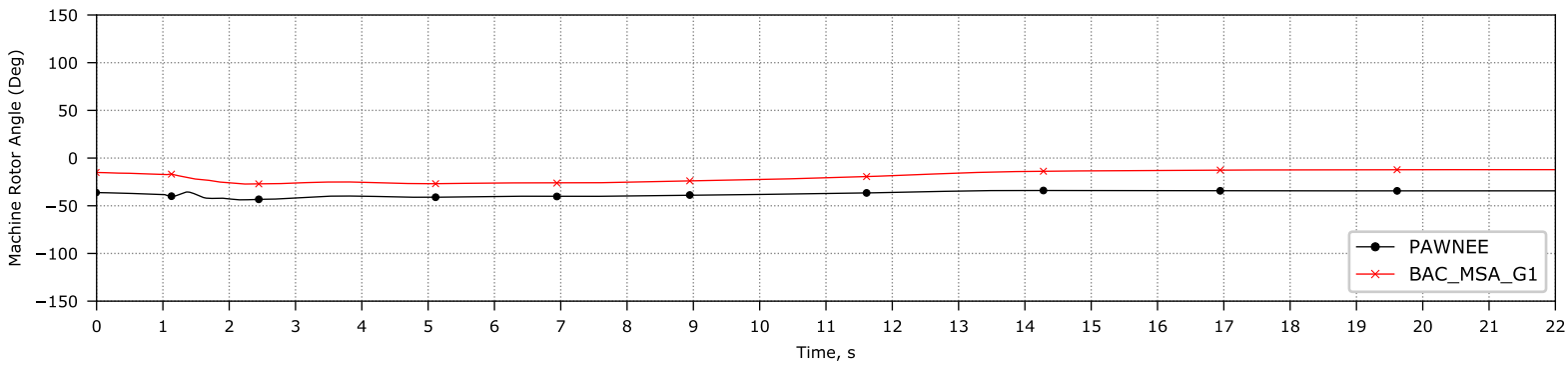


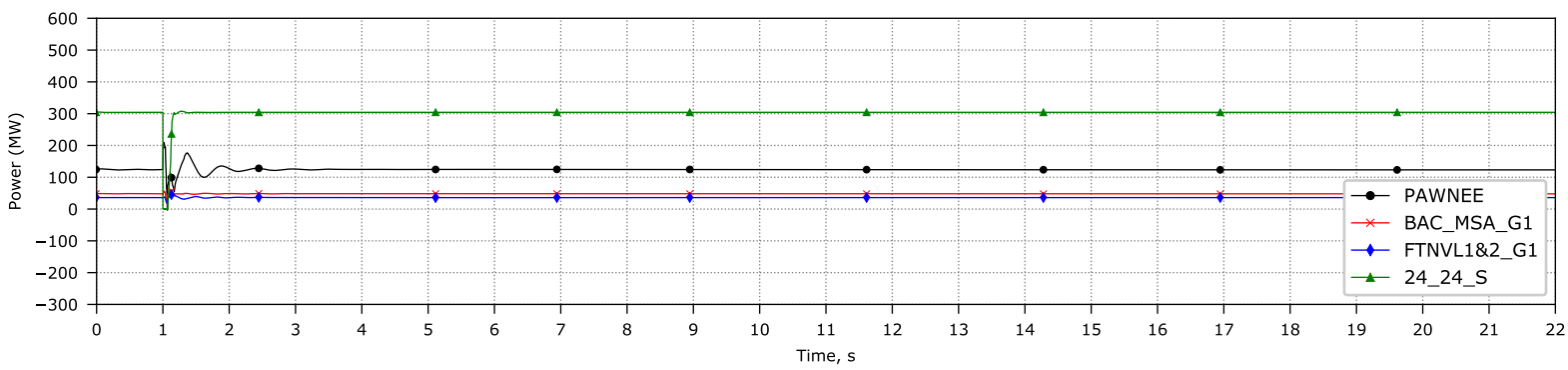


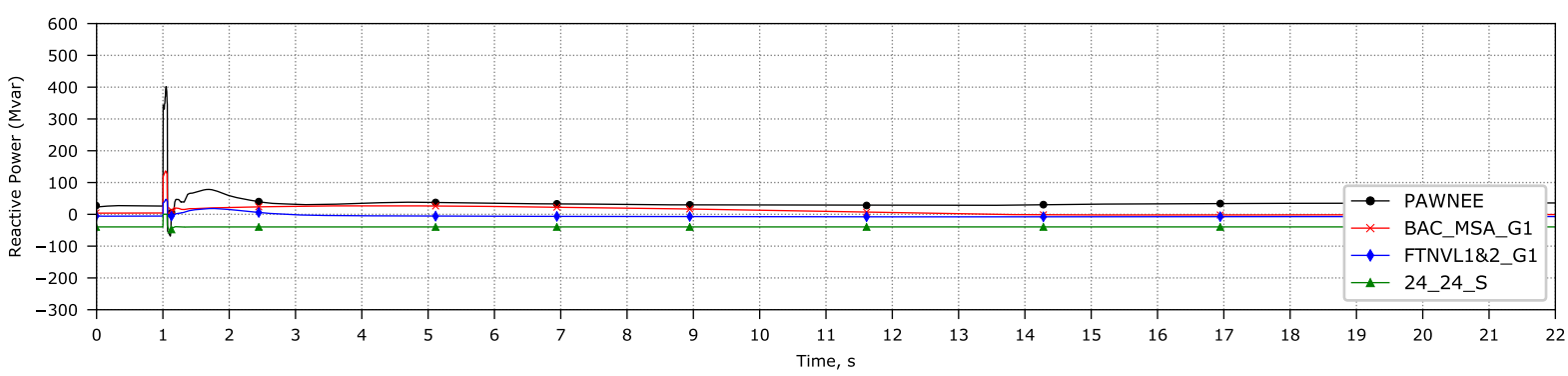


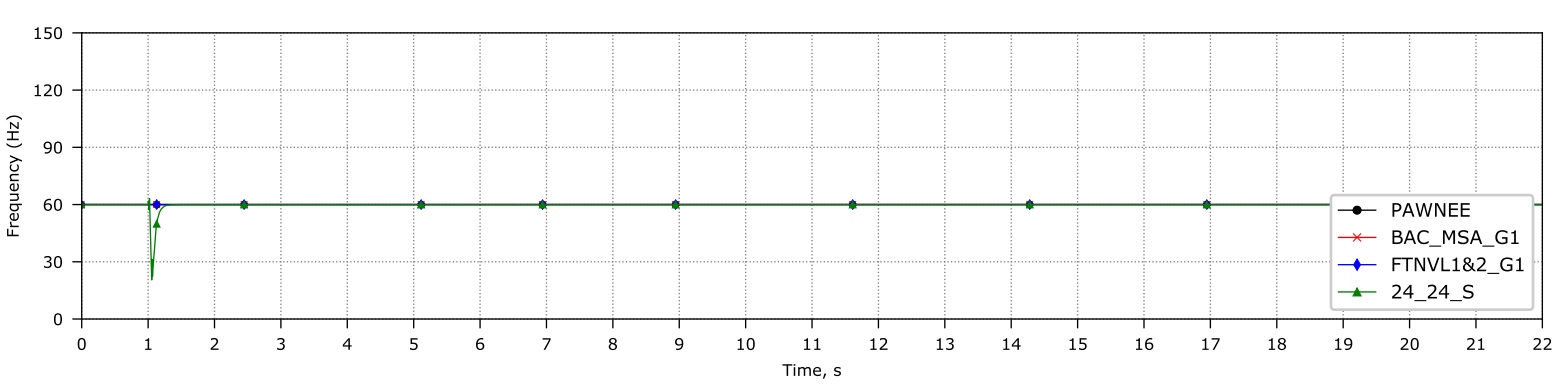


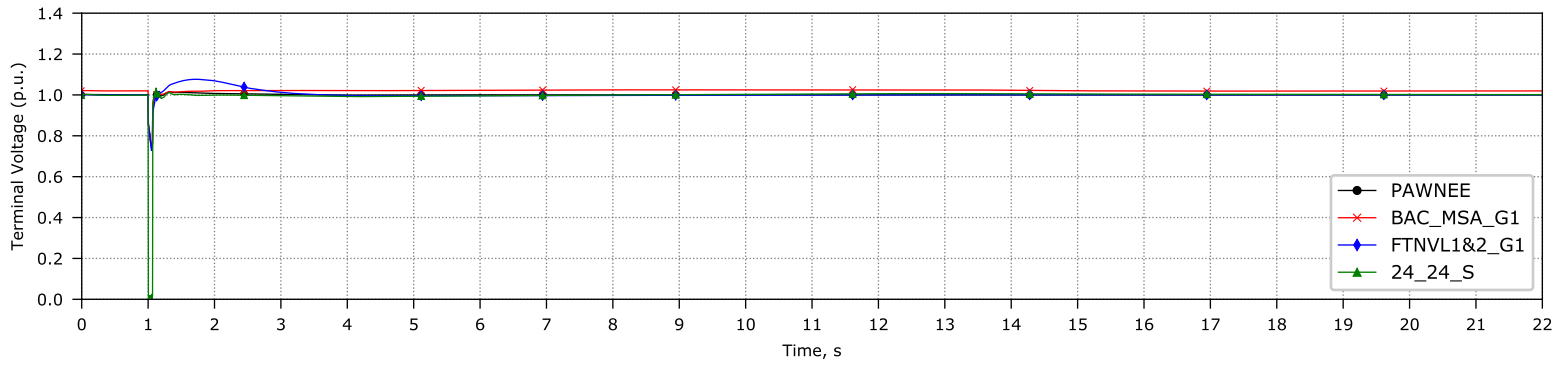
PI-2024-24_Study_GD_May Valley-Sandstone_1

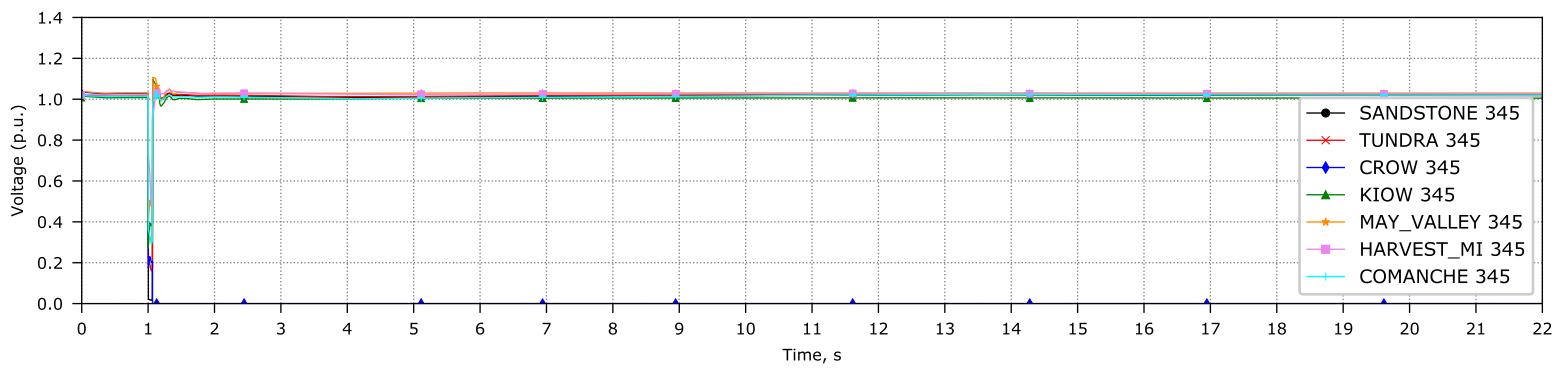




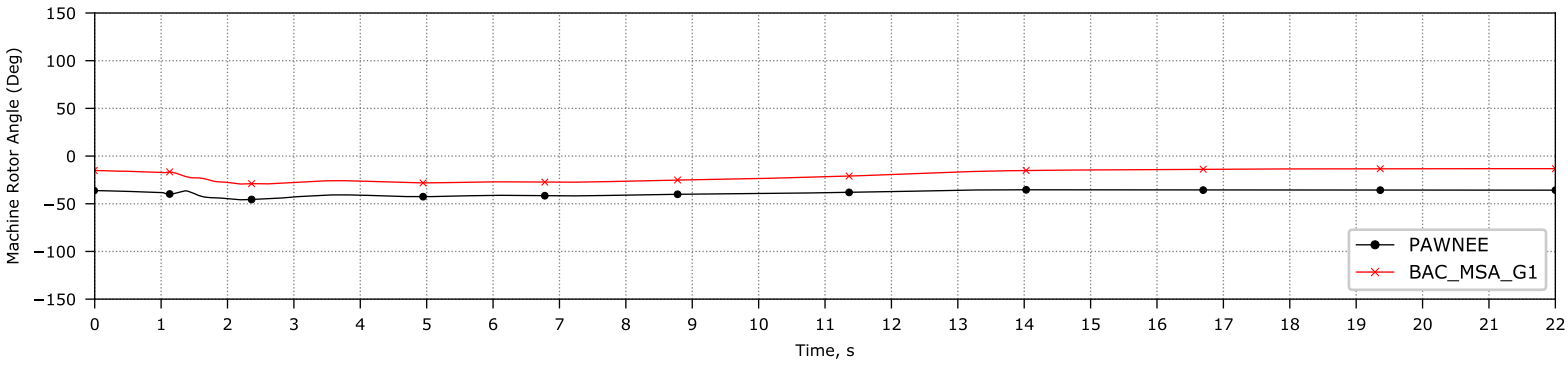


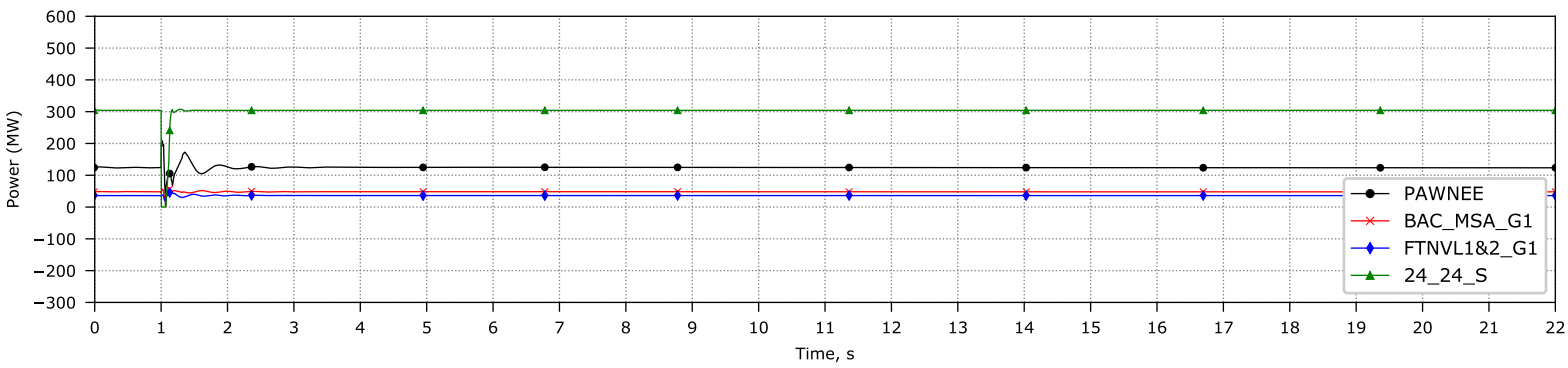


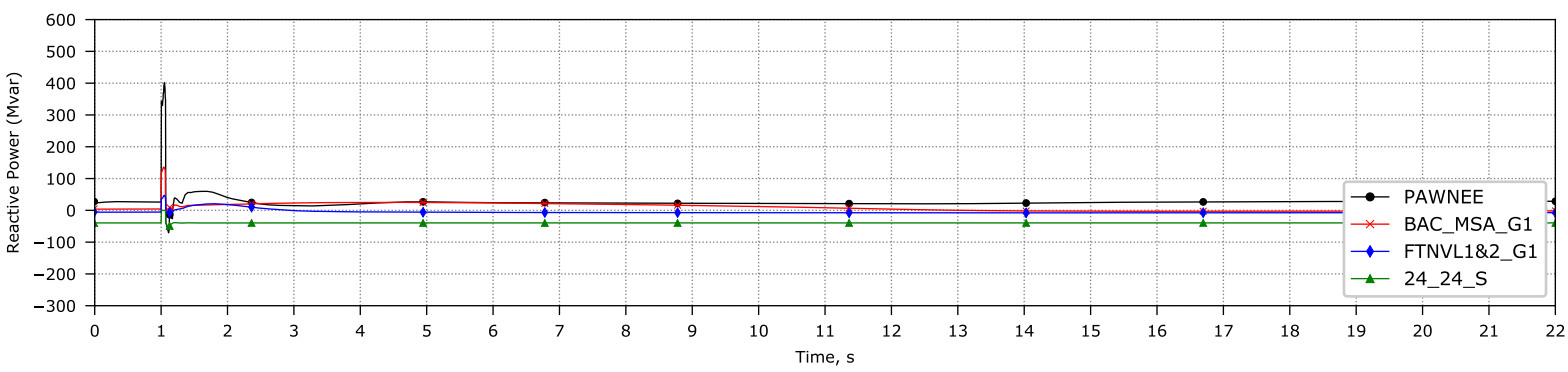


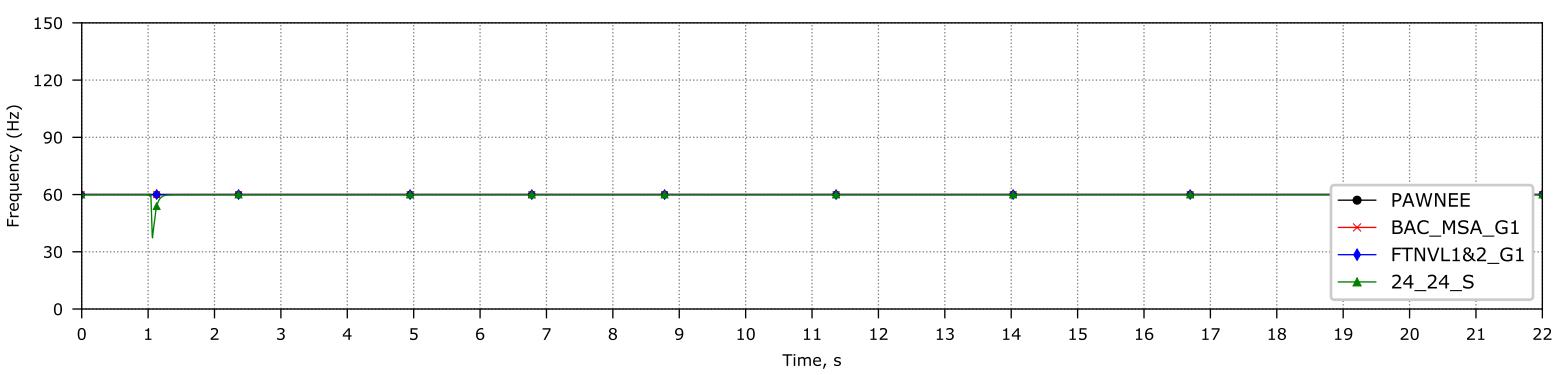


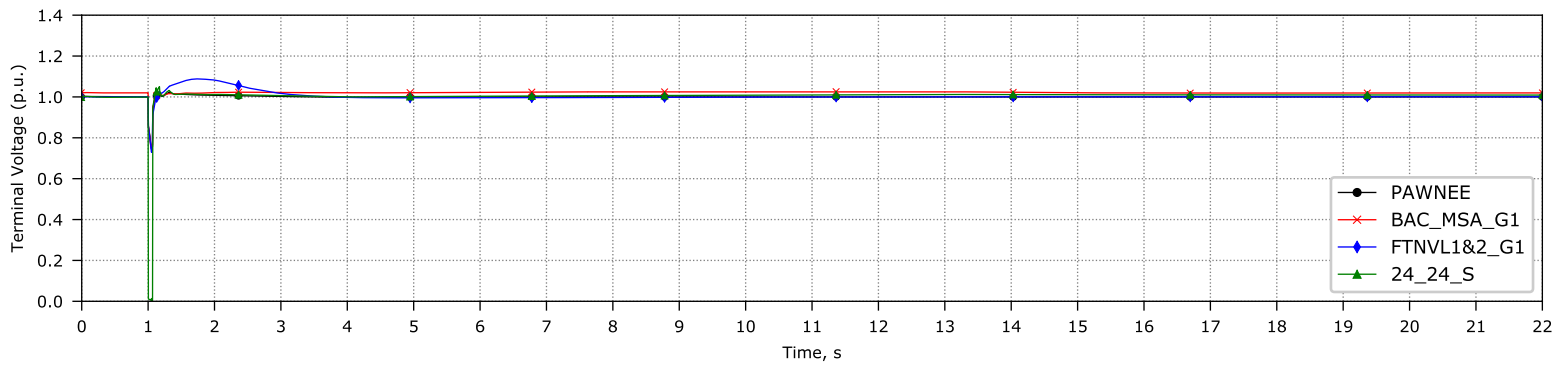
PI-2024-24_Study_GD_May Valley-Sandstone_2

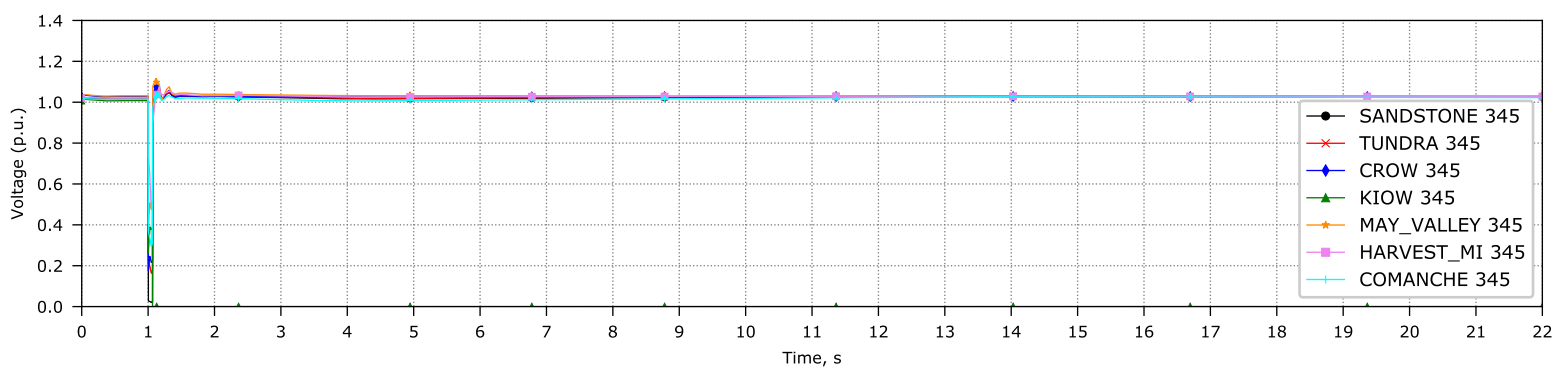




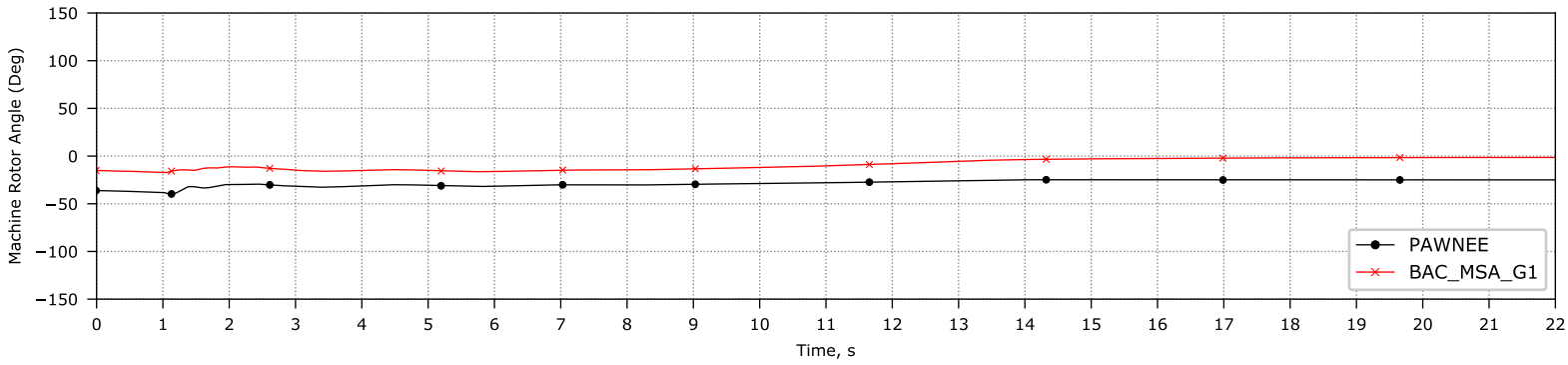


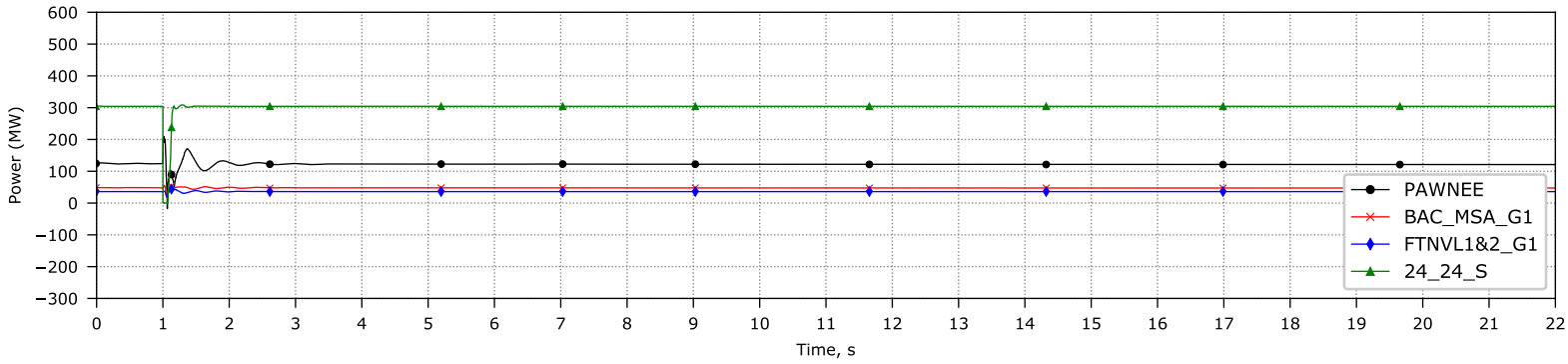


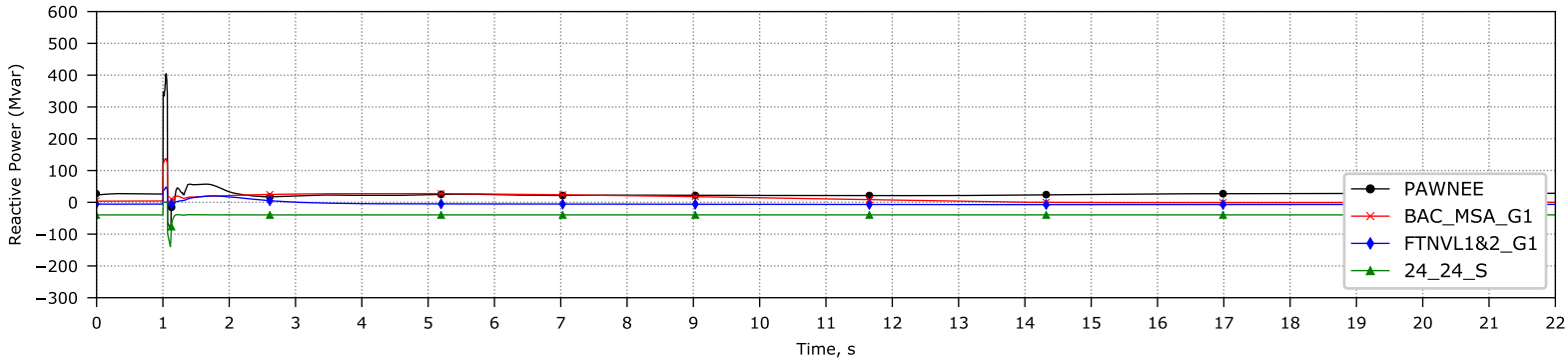


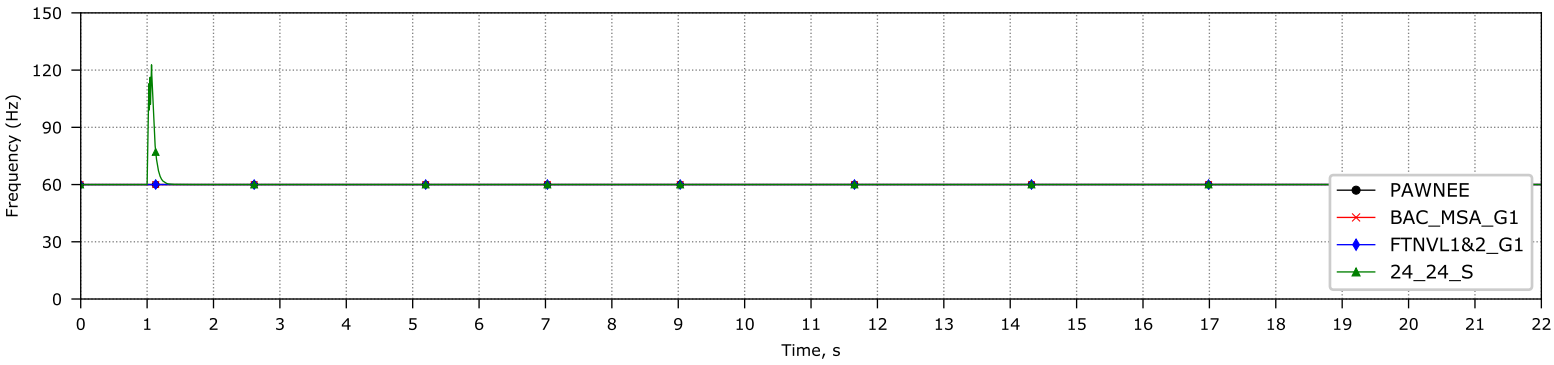


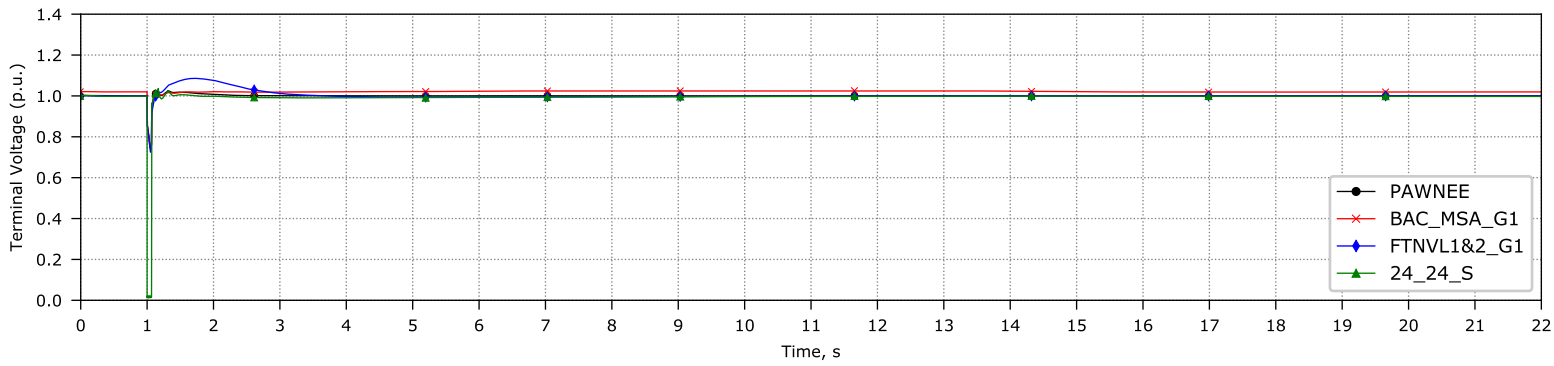
PI-2024-24_Study_GD_Sandstone-Tundra

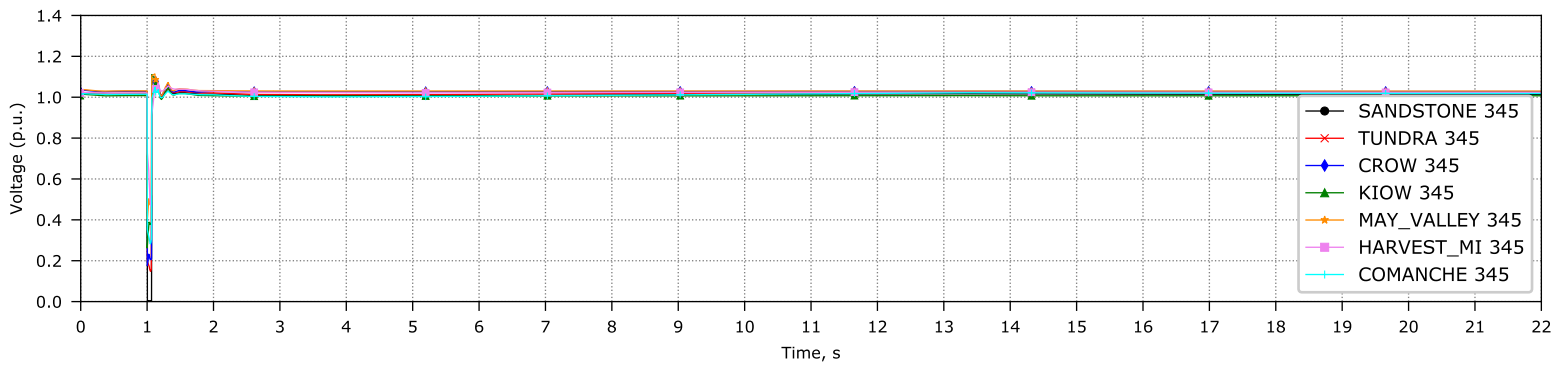




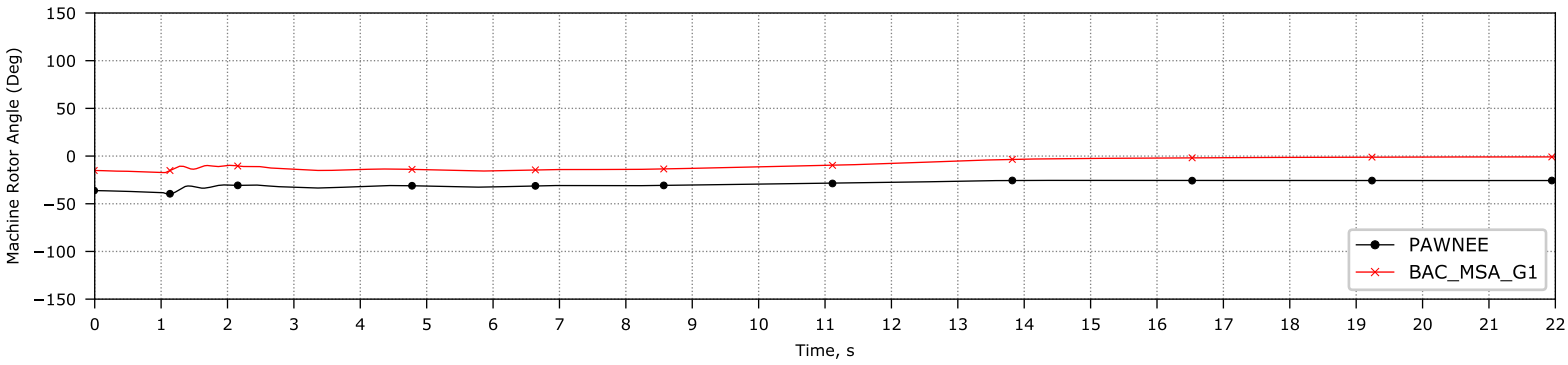


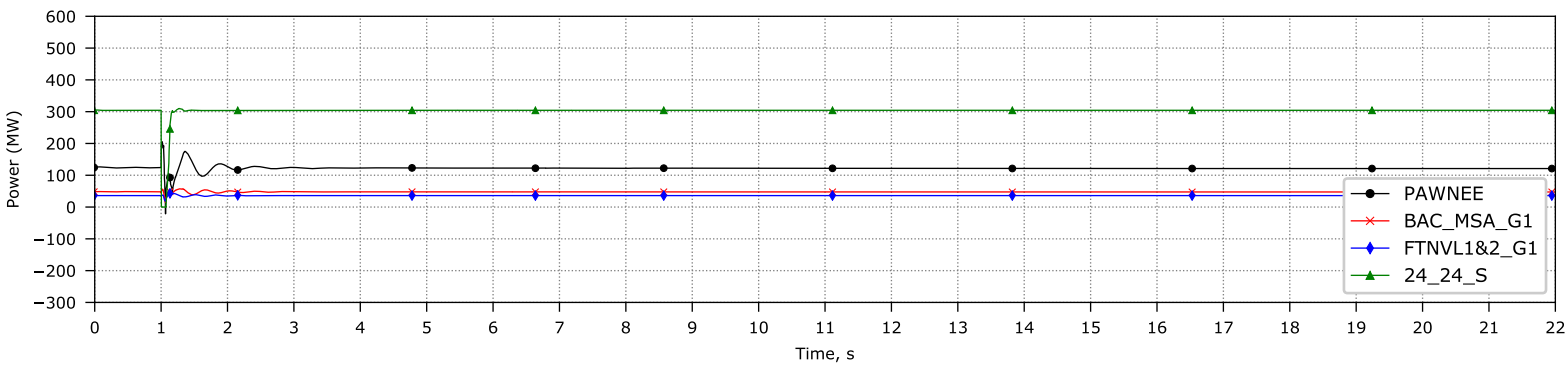


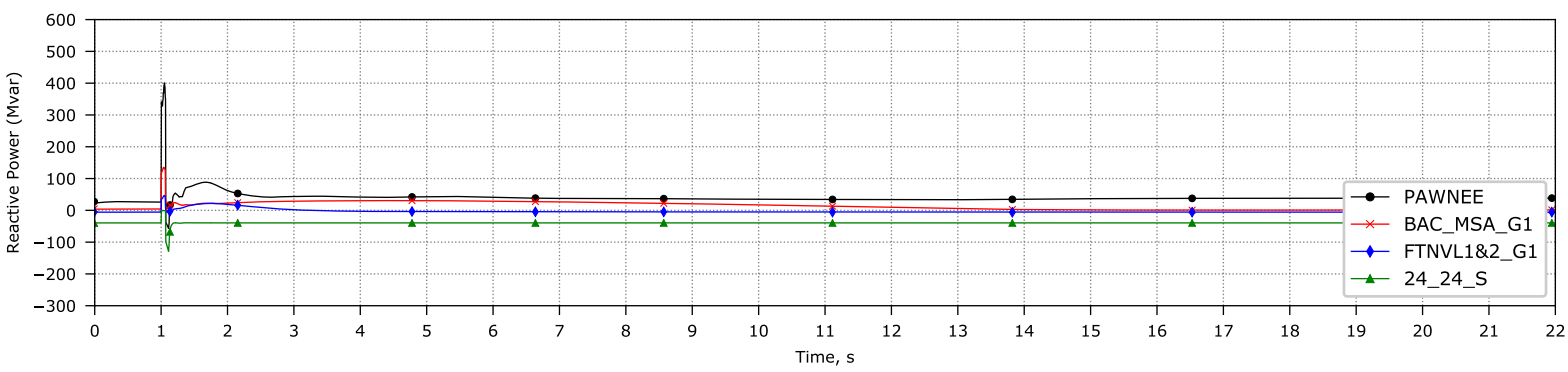


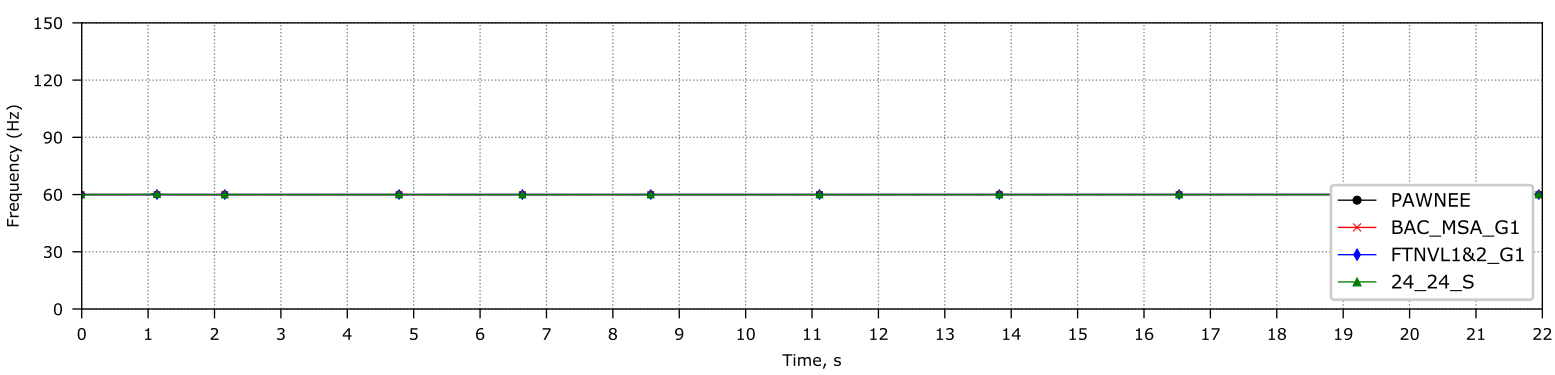


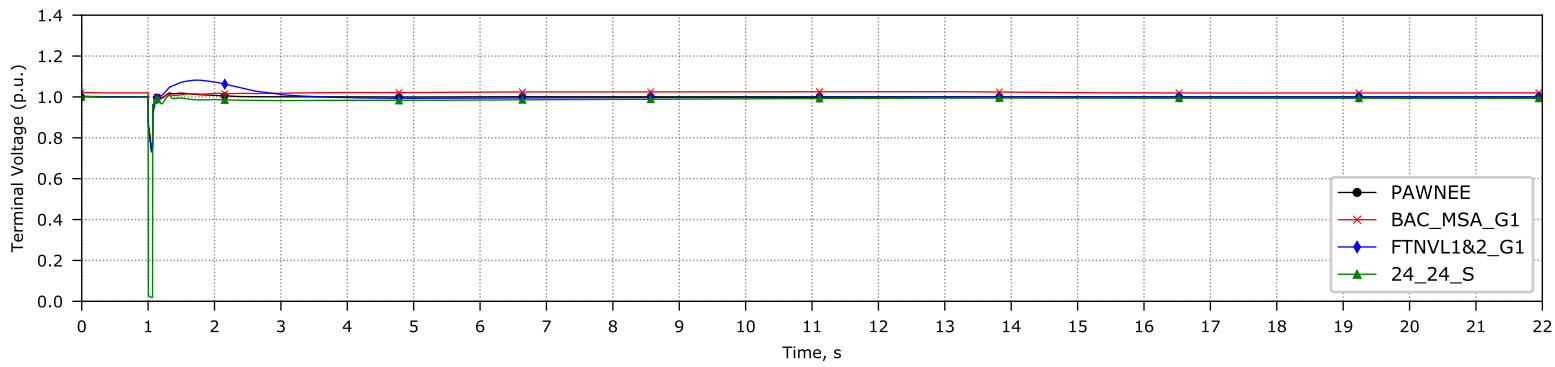
PI-2024-24_Study_GD_Sandstone-Tundra-HMIL

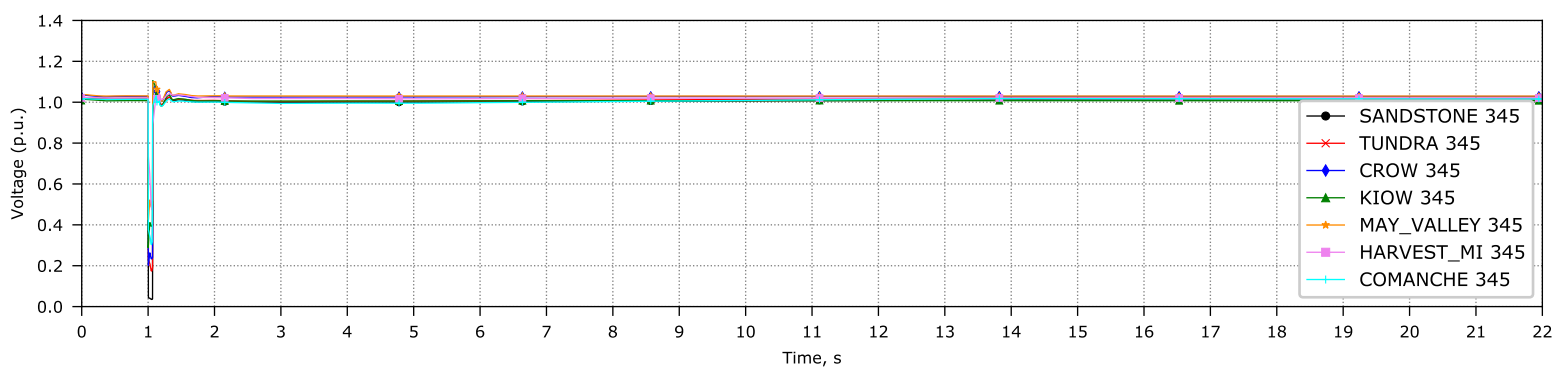












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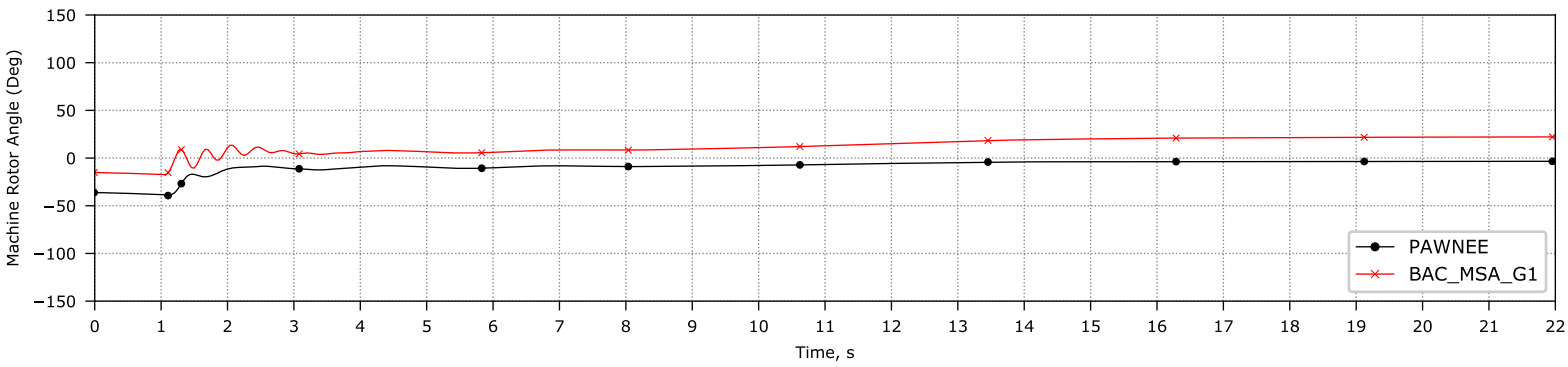

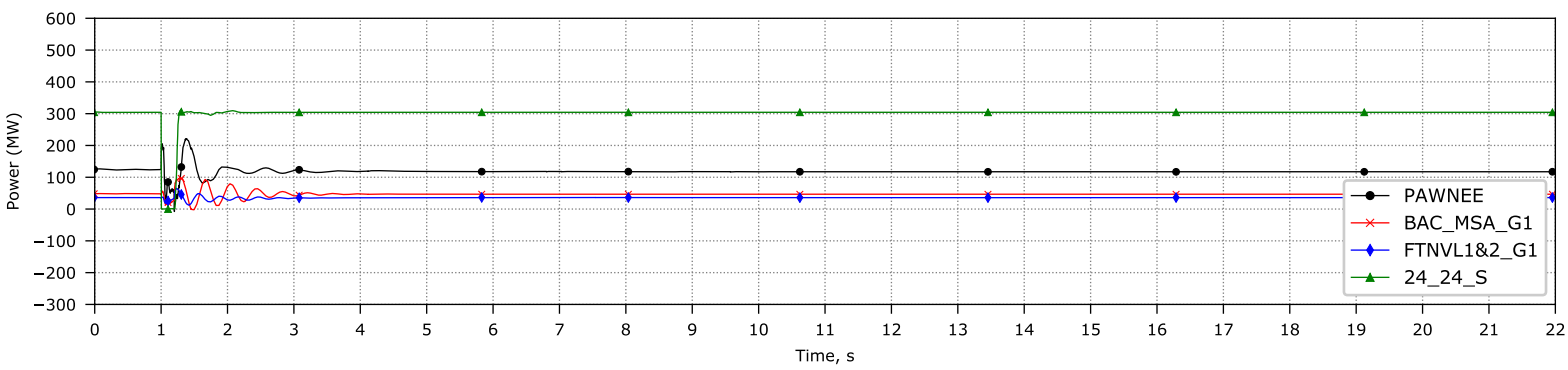

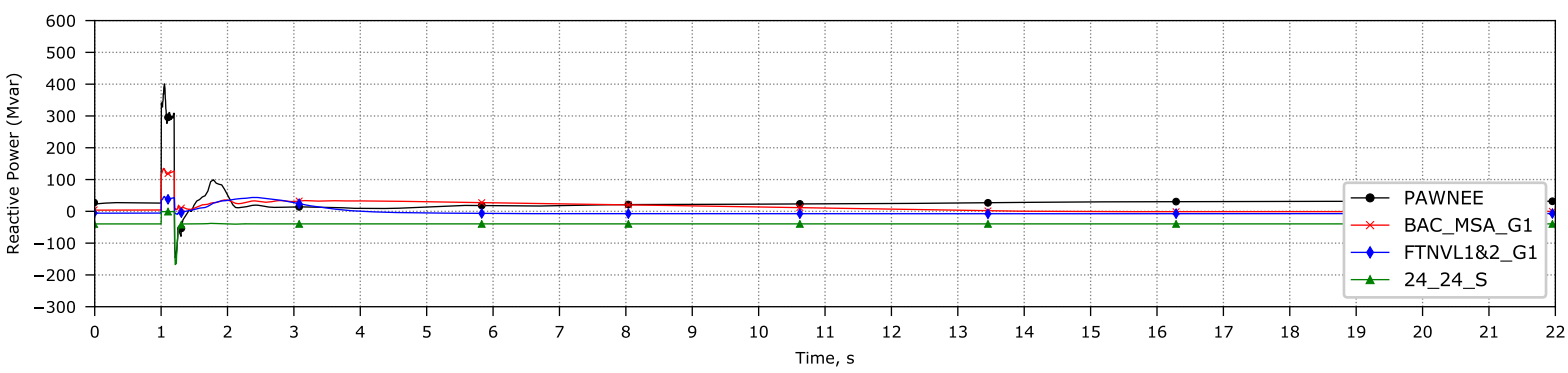

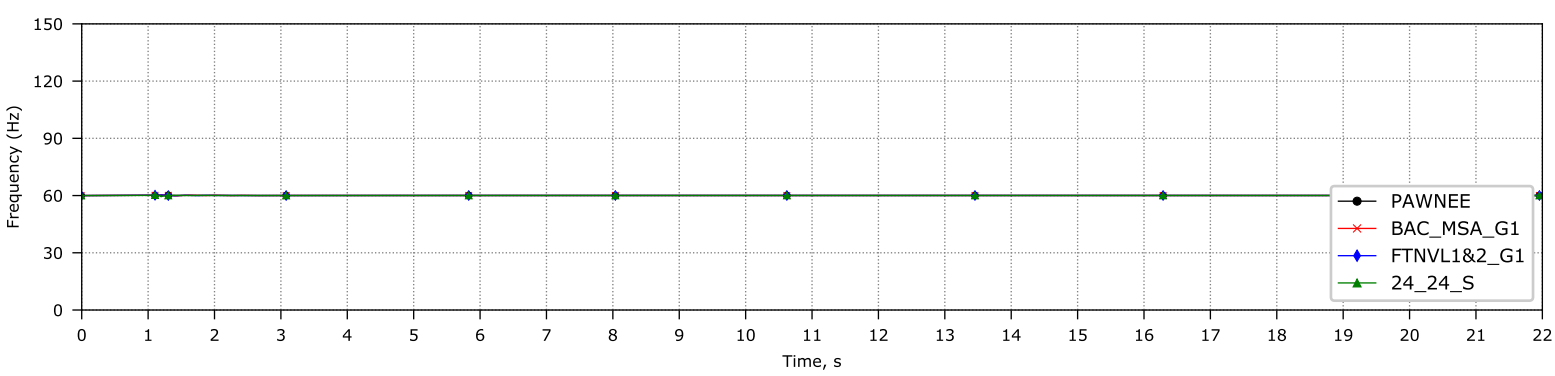

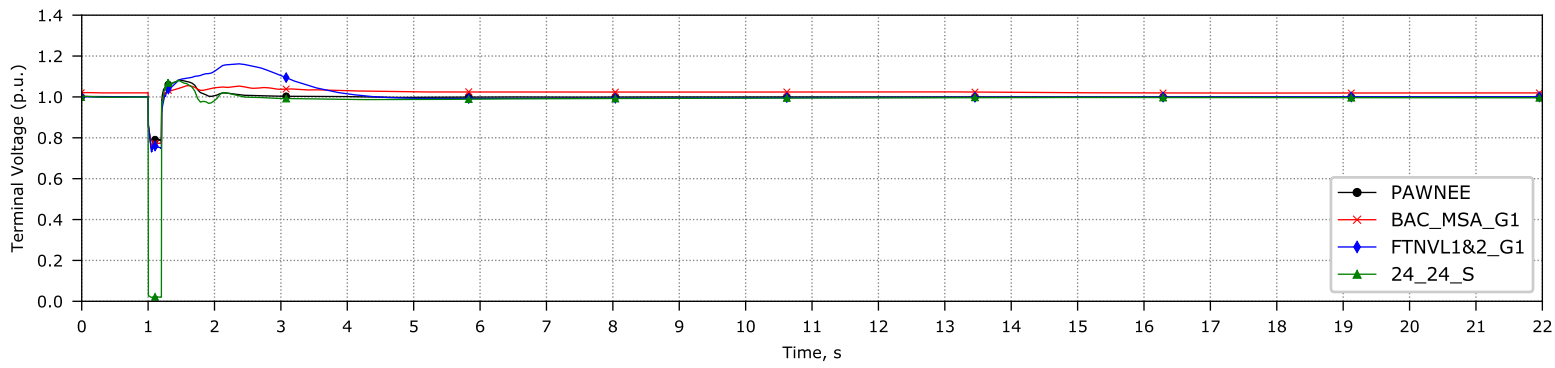

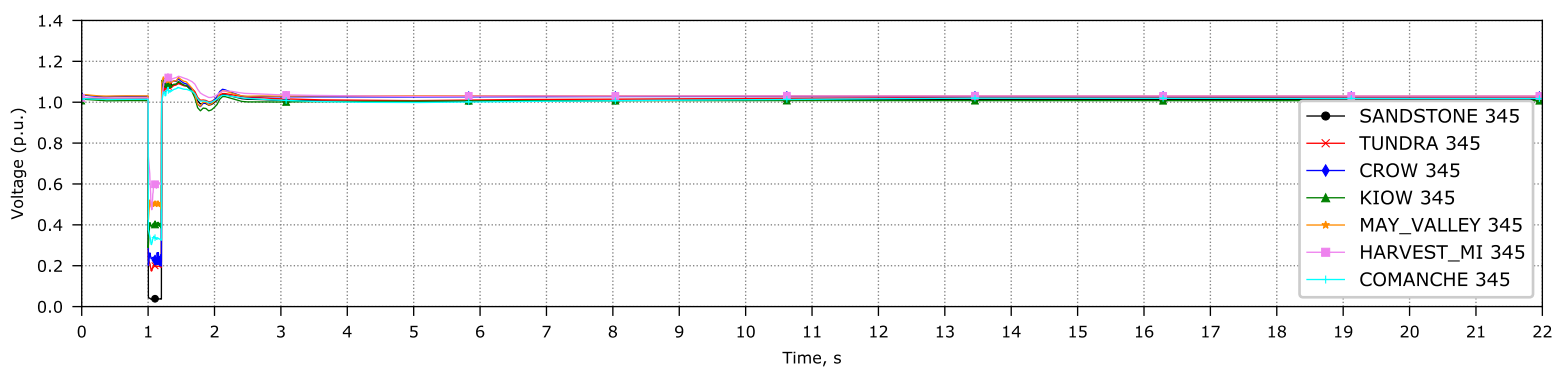

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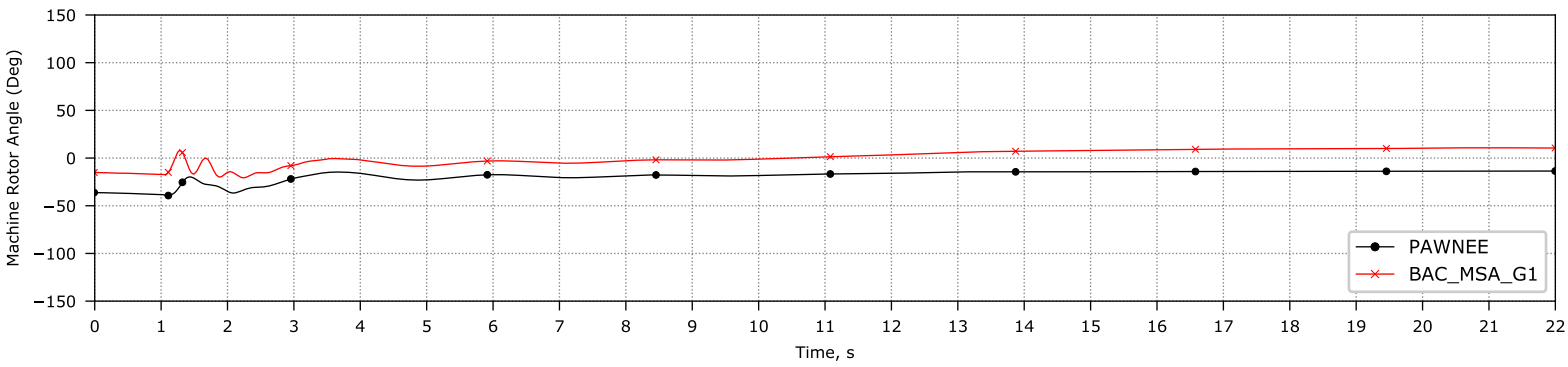

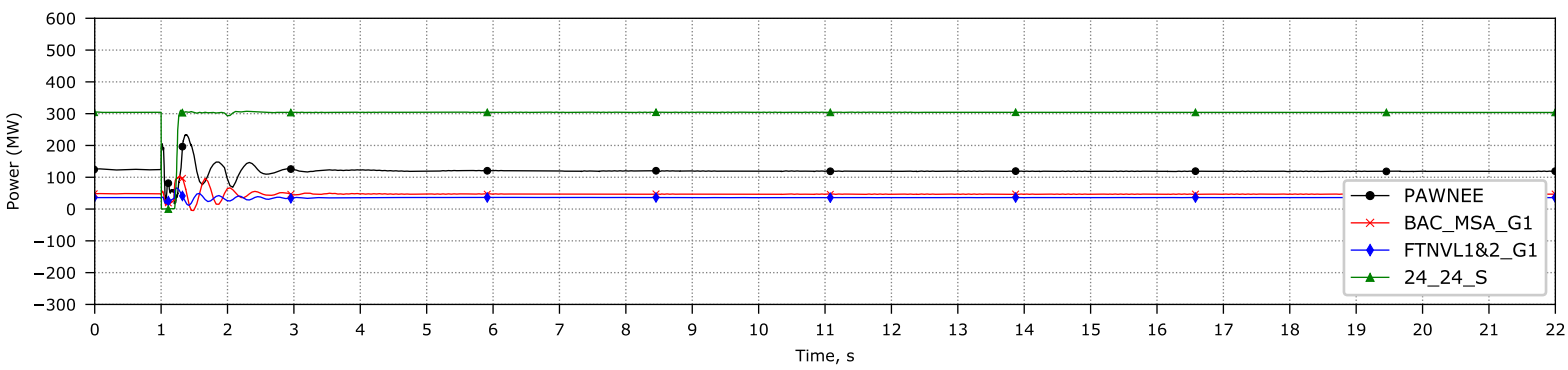

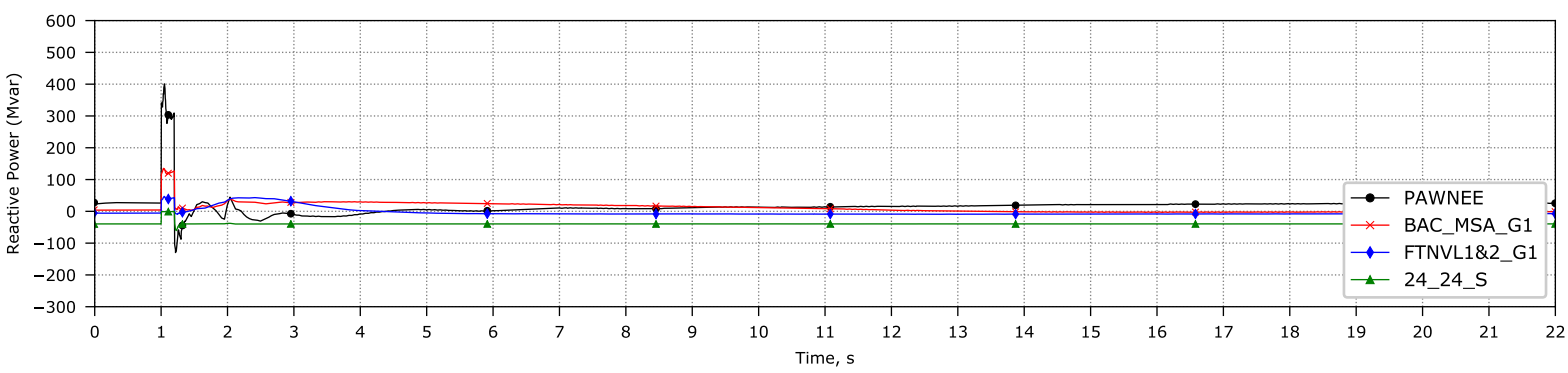

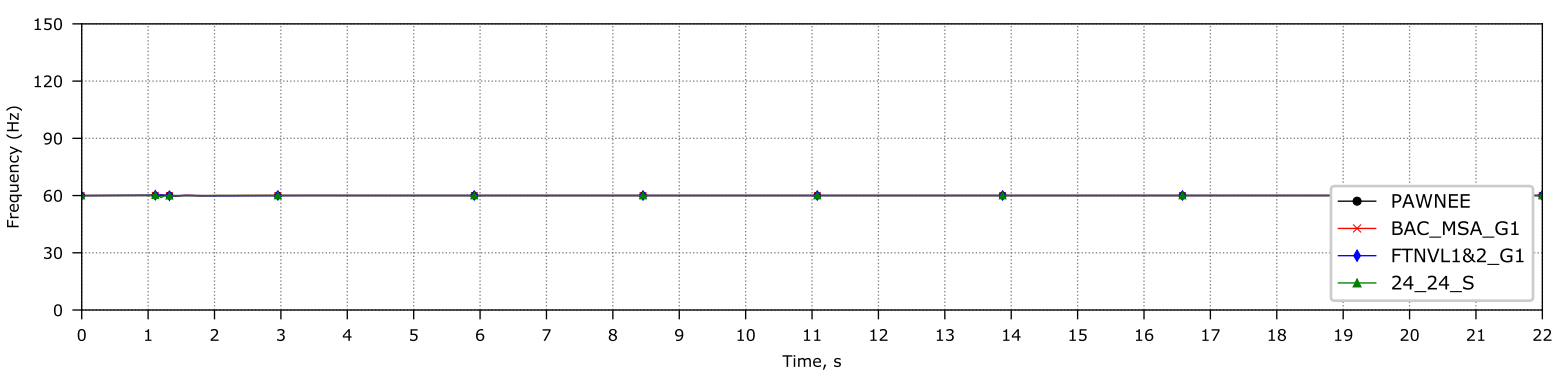

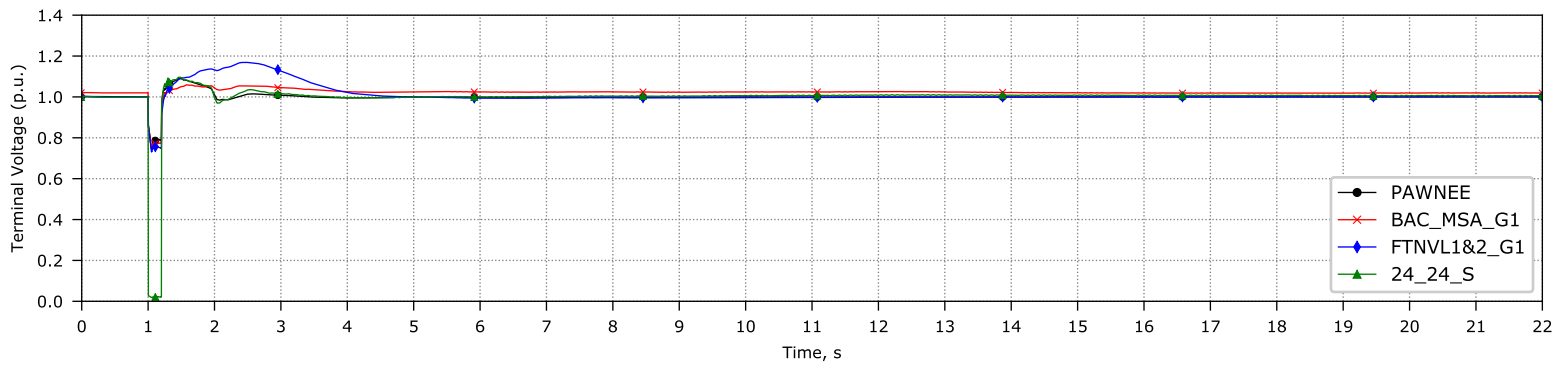

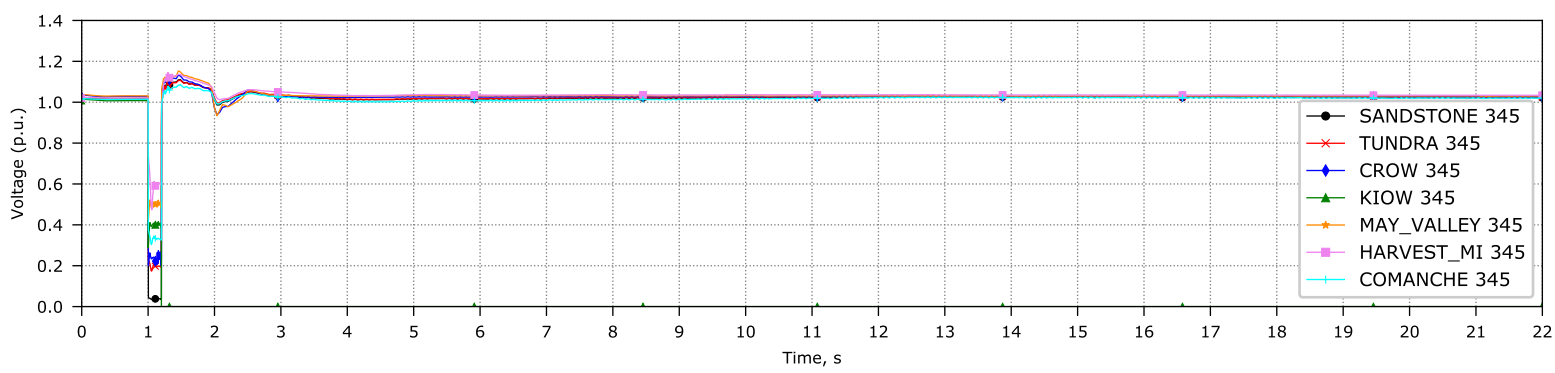

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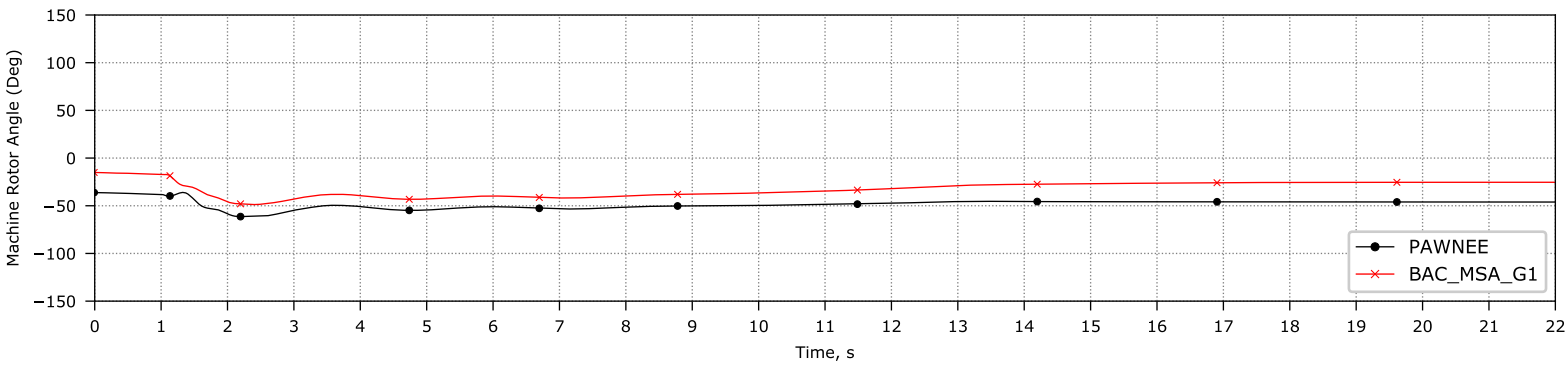

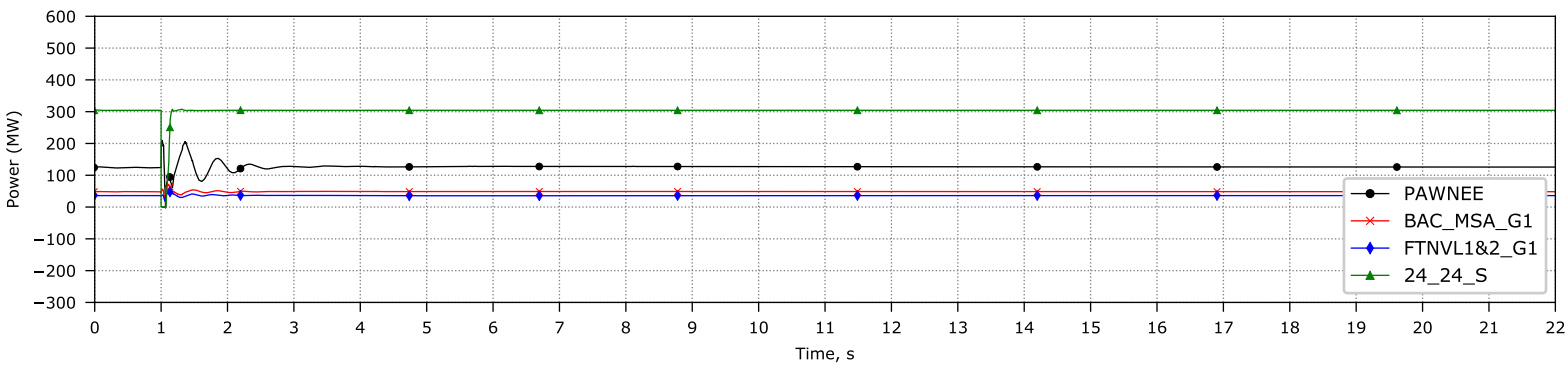

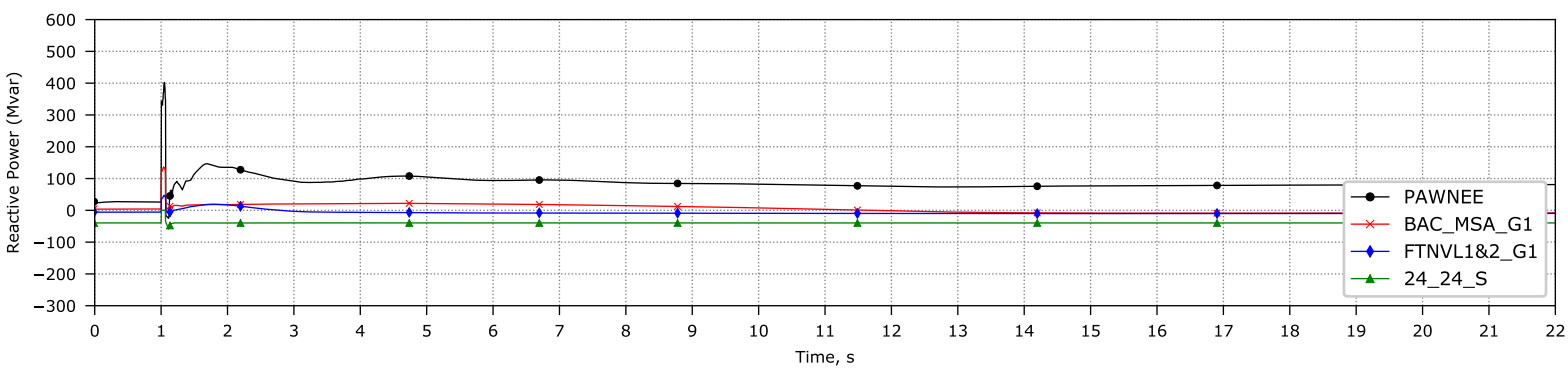

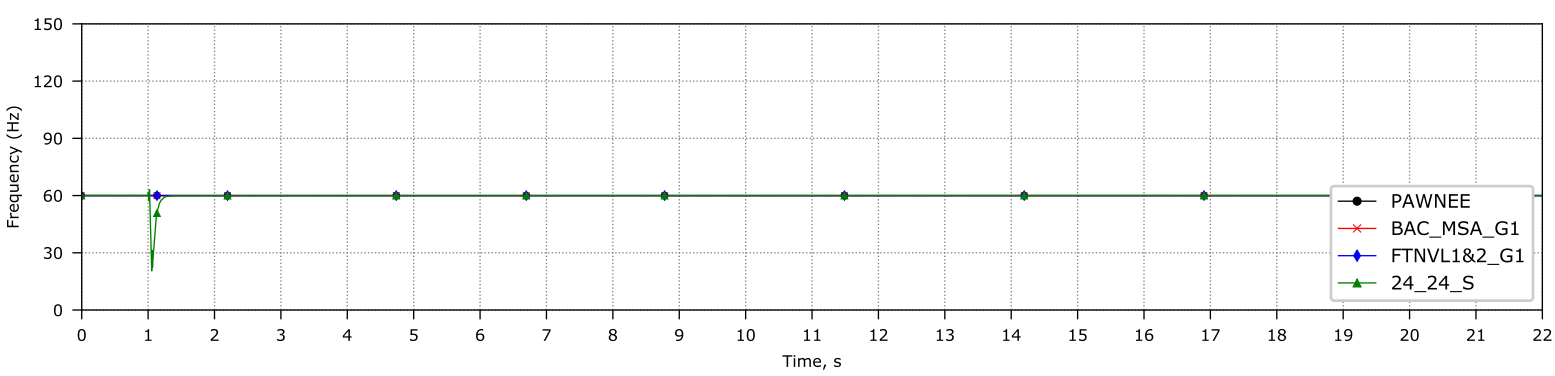

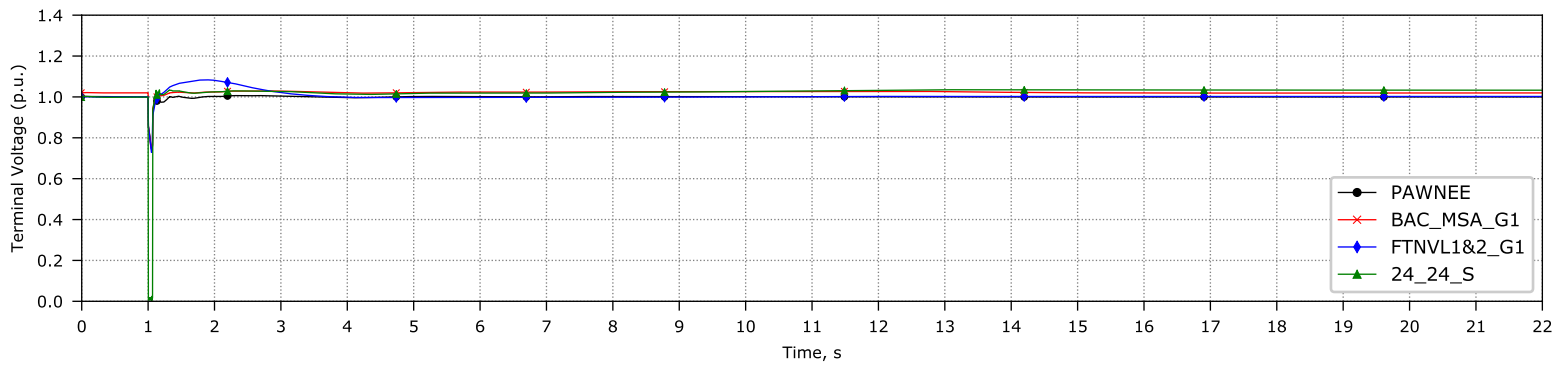

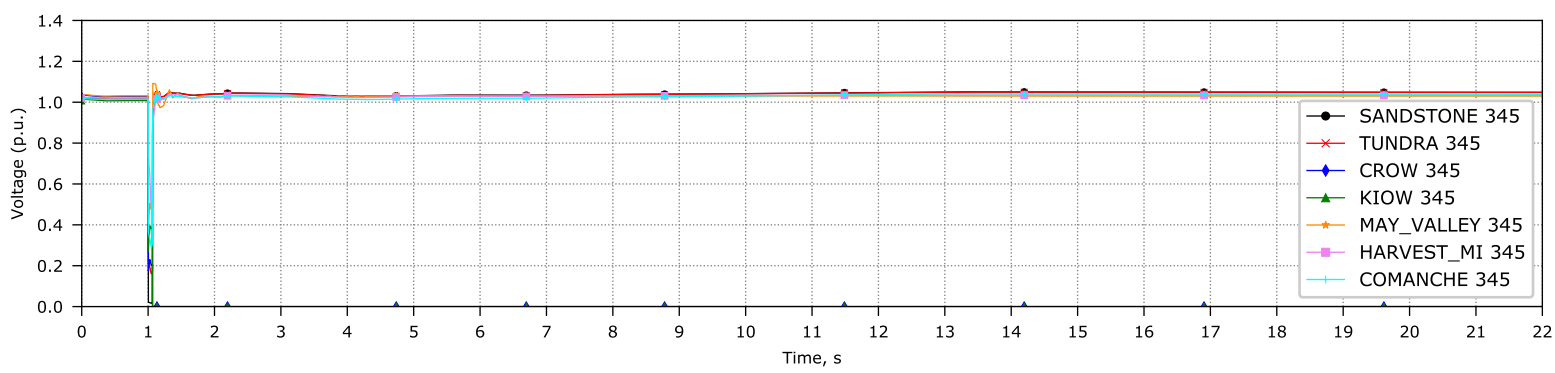

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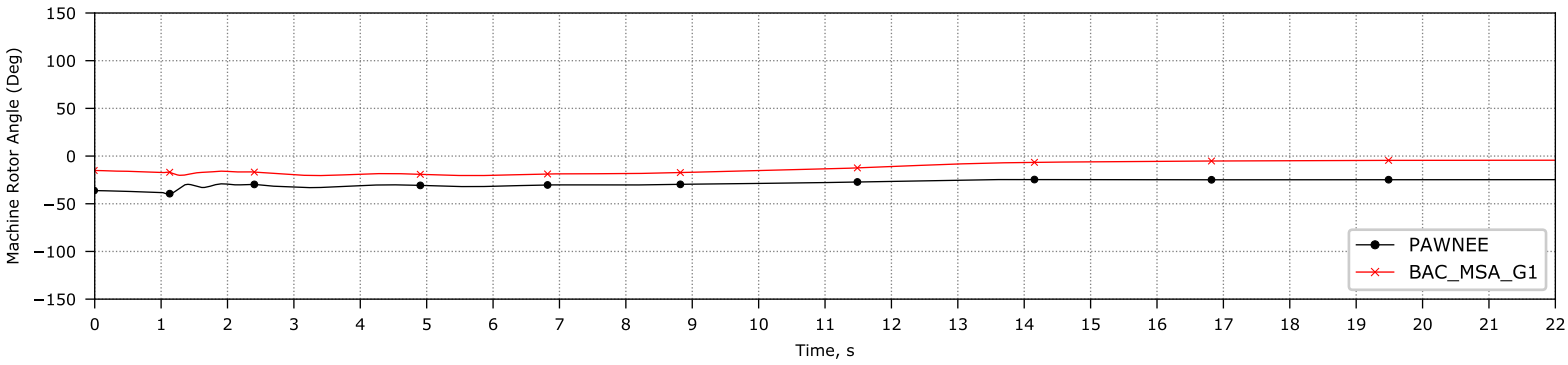

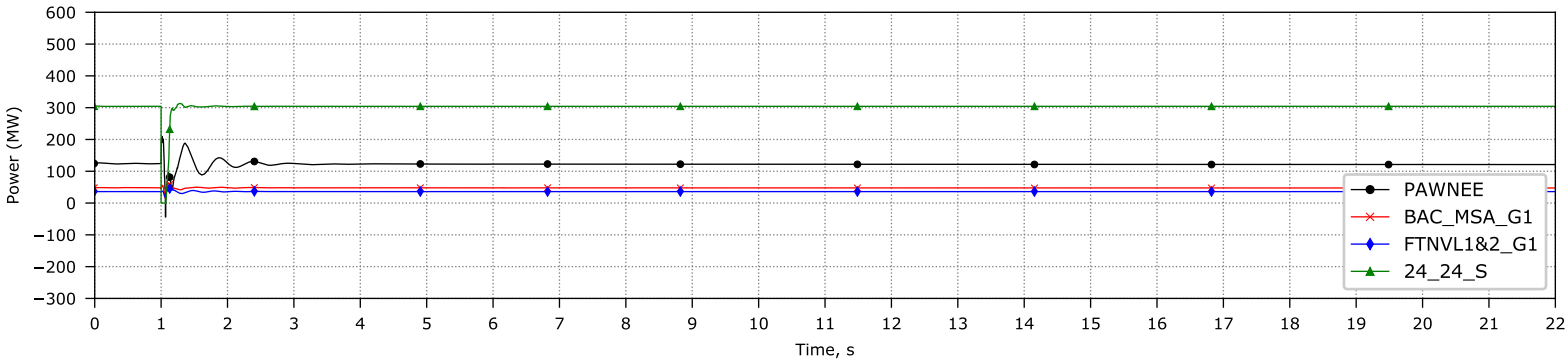

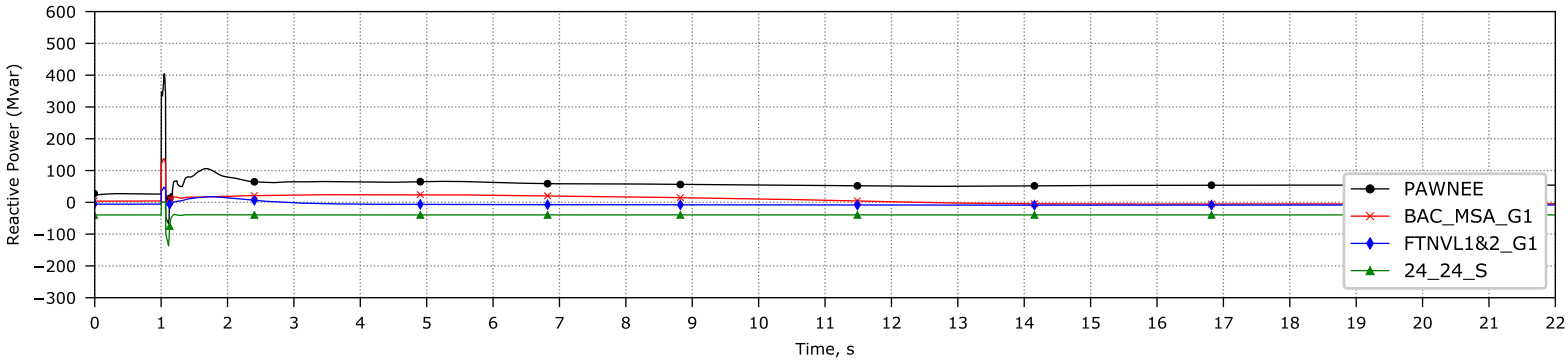

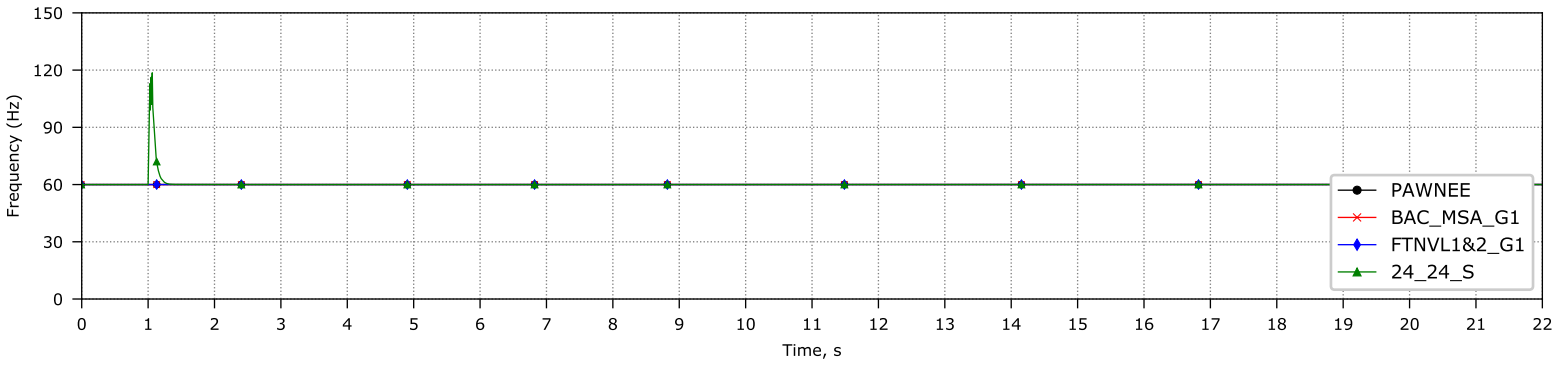

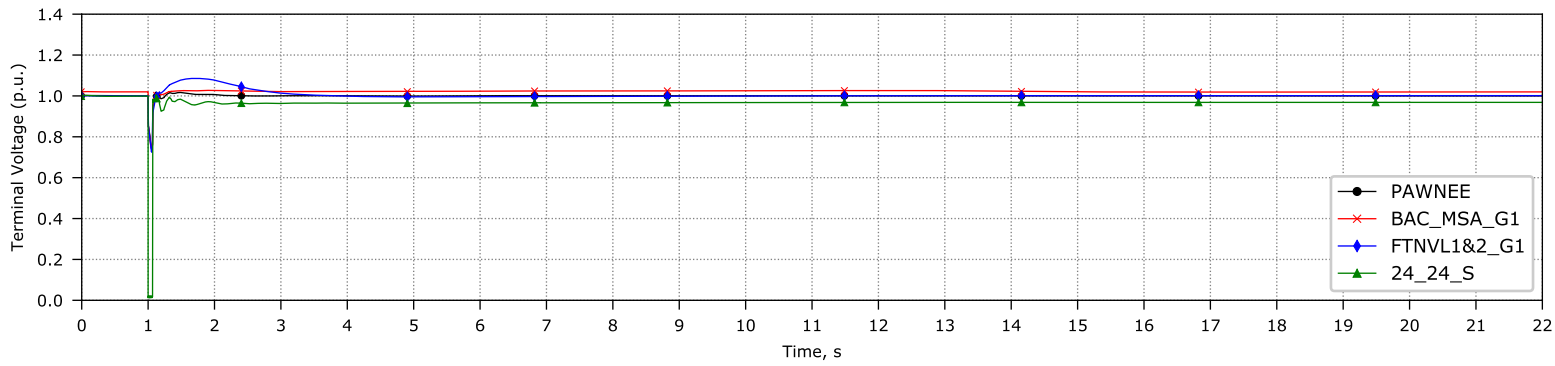

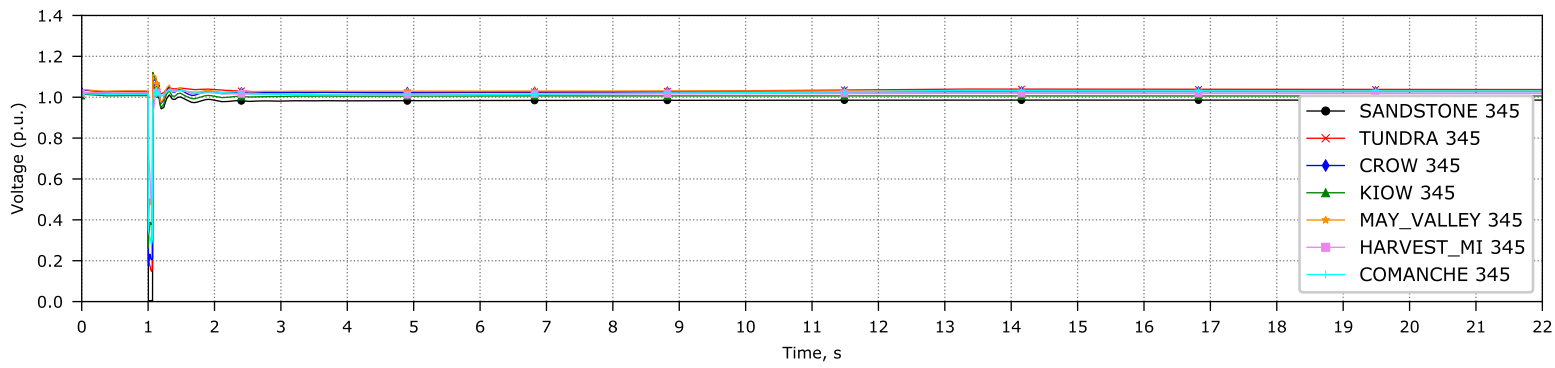

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