Provisional Interconnection Study Report for PI-2024-09

9/30/2024

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1.0 Executive Summary

The PI-2024-09 project is a Provisional Interconnection request for a 578.3 MW Wind Generating Facility with a Point of Interconnection (POI) at the Goose Creek 345 kV substation. PI-2024-09 is a Provisional Interconnection associated with Generation Interconnection Request 5RSC-2024-17 in the 5RSC cluster.

The total cost of the transmission system improvements required for PI-2024-09 to qualify for Provisional Interconnection Service is $10.424 million (Table 11 and Table 12).

The initial maximum permissible output of PI-2024-09 Generating Facility is 578.3 MW. The maximum permissible output of the Generating Facility in the PLGIA[1] would be reviewed quarterly and updated, if there are changes to the system conditions assumed in this analysis, to determine the maximum permissible output.

Security: PI-2024-09 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.

In addition, the Interconnection Customer would assume all risk and liabilities with respect to changes between the PLGIA and the LGIA[2], including changes in output limits and Interconnection Facilities, Network Upgrades, Distribution Upgrades, and/or System Protection Facilities cost responsibility.

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

[1] 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.

[2] 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.

2.0 Introduction

PI-2024-09 is the Provisional Interconnection Service[3] request for a 578.3 MW Wind Generating Facility located in Cheyenne County, Colorado.

- The POI of this project the new Goose Creek 345 kV substation. The Goose Creek 345 kV substation is part of the Colorado Power Pathway project.
- The Commercial Operation Date (COD) to be studied for PI-2024-09 as noted on the Provisional Interconnection Service request form is 5/7/2026.

The geographical location of the transmission system near the POI is shown in Figure 1. Note an approximation was used to overlay the new Colorado's Power Pathway onto the current one-line diagram.

[3] **Provisional Interconnection Service** 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.

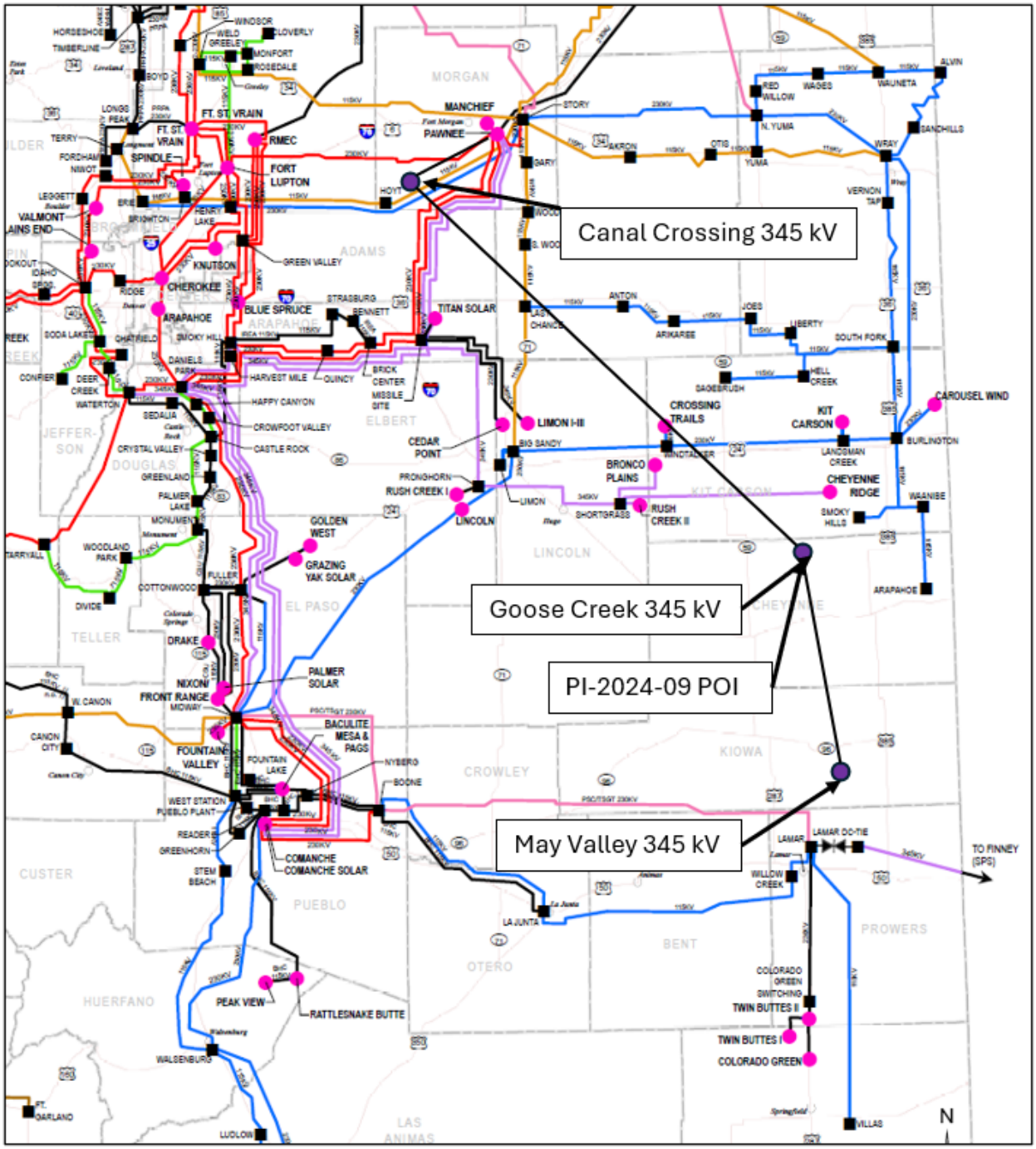

Figure 1: Point of Interconnection of PI-2024-09

3.0 Study Scope

The purpose of this study is to determine the impacts to the PSCo system and the Affected Systems from interconnecting PI-2024-09 for Provisional Interconnection Service. Consistent with the assumption in the study agreement, PI-2024-09 selected Energy Resource Interconnection Service (ERIS)[4].

The scope of this report includes voltage and reactive capability evaluation, steady state (thermal and voltage) analysis, transient stability analysis, short-circuit analysis, and cost estimates for Interconnection Facilities and Station Network Upgrades. The study also identifies the estimated Security[5] and Contingent Facilities associated with the Provisional Service.

3.1 Steady State Criteria

The following Criteria are used for the reliability analysis of the PSCo system and Affected Systems:

P0—System Intact conditions:

Thermal Loading: <=100% of the normal facility rating

Voltage range: 0.95 to 1.05 per unit

P1 & P2-1—Single Contingencies:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8% of pre-contingency voltage

P2 (except P2-1), P4, P5 & P7—Multiple Contingencies:

Thermal Loading: <=100% Emergency facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8% of pre-contingency voltage

[4] **Energy Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission system to be eligible to deliver the Generating Facility's electric output using the existing firm and non-firm capabilities of the Transmission Provider's Transmission System on an as available basis.

[5] **Security** estimates the risk associated with the Network Upgrades and Interconnection Facilities that could be identified in the corresponding LGIA.

3.2 Transient Stability Criteria

The transient voltage stability criteria are as follows:

a. Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events for each applicable Bulk Electric System (BES) bus serving load.
b. Following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds, for all P1 through P7 events.
c. For Contingencies without a fault (P2.1 category event), voltage dips at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds.

The transient angular stability criteria are as follows:

a. P1—No generating unit shall pull out of synchronism. A generator being disconnected from the system by fault clearing action or by a special Protection System is not considered an angular instability.
b. P2–P7—One or more generators may pull out of synchronism, provided the resulting apparent impedance swings shall not result in the tripping of any other generation facilities.
c. P1–P7—The relative rotor angle (power) oscillations are characterized by positive damping (i.e., amplitude reduction of successive peaks) > 5% within 30 seconds.

3.3 Breaker Duty Analysis Criteria

Fault Current after PI addition should not exceed 100% of the Breaker Duty rating. PSCo can only perform breaker duty analysis on the PSCo 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.

3.4 Study Methodology

For PSCo and non-PSCo facilities, thermal violations attributed to the request include all new facility overloads with a thermal loading >100% and increased by 1% or more from the benchmark case overload post the Generator Interconnection Request (GIR) addition.

The voltage violations assigned to the request include new voltage violations which resulted in a further variation of 0.01 per unit.

Since the request is for Provisional Service, if thermal or voltage violations are seen, the maximum permissible Provisional Interconnection before violations is identified. For voltage violations caused by reactive power deficiency at the POI, voltage upgrades are identified.

The Provisional Interconnection request should meet the transient stability criteria stated in Section 3.2. If the addition of the GIR causes any violations, the maximum permissible Provisional Interconnection Service before violations is identified.

3.5 Contingency Analysis

The transmission system on which steady state contingency analysis is run includes the WECC designated areas 70 and 73.

The transient stability analysis is performed for the following worst-case contingencies shown in Table 1.

Table 1 – Transient Stability Contingencies

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)
1	-	P0	Flatrun	-
2	Goose Creek 345 kV	P1	May Valley - Goose Creek 345 kV ckt 1	4
3	Goose Creek 345 kV	P1	Goose Creek - Canal Crossing 345 kV ckt 1	4
4	Goose Creek 345 kV	P1	Goose Creek - Shortgrass 345 kV ckt 1	4
5	Goose Creek 345 kV	P1	Goose Creek - Cheyenne Ridge 345 kV ckt 1 Cheyenne Ridge Wind Generation	4
6	Goose Creek 345 kV	P1	PI-2024-09 Generation	4
7	Daniels Park 345 kV	P4	Daniels Park - Missile Site 345 kV ckt 1 Daniels Pak 345 kV Cap Bank	12
8	Pronghorn 345 kV	P4	Pronghorn - Rush Creek 345 kV ckt Rush Creek Wind Generation Daniels Park 345 kV Cap Bank	12

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)
9	Canal Crossing 345 kV	P4	Goose Creek - Canal Crossing 345 kV ckt 1 Goose Creek - Canal Crossing 345 kV ckt 2 Canal Crossing 345 kV Cap Bank	12

3.6 Study Area

The Eastern Colorado study area includes WECC designated zones 706. As described in Section 3.11 of the BPM, the study pocket East is comprised of the eastern Colorado transmission system with major generation injecting into Pawnee, Beaver Creek and Missile Site substations. The study did not identify any impacts to Affected Systems.

4.0 Base Case Modeling Assumptions

The study was performed using the 2024HS3 WECC base case that has been modified to represent a 2026 heavy summer loading conditions. The following planned transmission projects are modeled in the Base Case:

- Canal Crossing 345 kV substation
- Fort Saint Vrain 345 kV substation
- Goose Creek 345 kV substation
- May Valley 345 kV substation
- Sand 230 kV substation
- Kestrel 230 kV substation
- Coyote 230 kV substation
- Poder 115 kV substation
- Metro Water 115 kV substation
- Pintail 115 kV substation
- DCPL Tap 115 kV substation
- Carl Tap 69 kV substation

The following additional changes were made to the Intermountain Regional Electric Co-Op (CORE) model in the Base Case:

- Citadel 115 kV substation
- Spring Valley 115 kV substation
- Deer Trail 115 kV substation

The Base Case model includes higher-queued and existing PSCo and Affected System generation resources.

4.1 Benchmark Case Modeling

The Benchmark Case was created from the Base Case described in Section 4.0 by changing the study pocket generation dispatch to reflect heavy generation in the Eastern Colorado study pocket. This was accomplished by adopting the stressed generation dispatch given in Table 2.

Table 2 – Generation Dispatch Used to Create the Eastern Colorado Benchmark Case (MW is Gross Capacity)

Bus No.	Bus Name	Base kV	ID	Status	Pgen (MW)	Pmax (MW)
70310	PAWNEE	22	C1	1	523.60	526.00
70314	MANCHEF1	16	G1	1	118.40	131.50
70315	MANCHEF2	16	G2	1	117.90	131.00
70721	SPRNGCAN1_W1	0.57	W1	1	51.80	64.80
70710	PTZLOGN1	34.5	W1	1	160.80	201.00

Bus No.	Bus Name	Base kV	ID	Status	Pgen (MW)	Pmax (MW)
70712	PTZLOGN2	34.5	W2	1	96.00	120.00
70713	PTZLOGN3	34.5	W3	1	63.60	79.50
70714	PTZLOGN4	34.5	W4	1	140.00	175.00
70715	SPRNGCAN2_W2	0.69	W2	1	50.20	62.70
70733	CHEYRGE_W1	0.69	W1	1	43.20	54.00
70736	CHEYRGE_W2	0.69	W2	1	88.00	110.00
70739	CHEYRGW_W1	0.69	W1	1	109.12	136.40
70742	CHEYRGW_W2	0.69	W2	1	105.60	132.00
70670	CEDARPT_W1	0.69	W1	1	99.36	124.20
70671	CEDARPT_W2	0.69	W2	1	100.80	126.00
70767	RUSHCK1_W1	0.69	W1	1	161.12	201.40
70770	RUSHCK1_W2	0.69	W2	1	130.32	162.90
70771	RUSHCK2_W3	0.69	W3	1	166.40	208.00
70635	LIMON1_W	34.5	W1	1	160.80	201.00
70636	LIMON2_W	34.5	W2	1	160.80	201.00
70637	LIMON3_W	34.5	W3	1	160.80	201.00
70753	BRONCO_W1	0.69	W1	1	117.28	146.64
70749	BRONCO_W2	0.69	W2	1	128.96	161.18
70443	ARRIBA_W1	0.69	W1	1	80.08	100.05
70442	ARRIBA_W2	0.69	W2	1	80.80	100.05
Total					3215.74	3857.32

4.2 Study Case Modeling

A Study Case was created from the Benchmark Case by turning on the PI-2024-09 generation. The additional 578.3 MW output from PI-2024-09 was balanced against PSCo generation outside of the Eastern Colorado study pocket.

4.3 Short-Circuit Modeling

This request is for the interconnection of a 578.3 MW wind generating facility (PI-2024-09) to the Goose Creek 345 kV switching station. The output will not exceed 578.3 MW at the POI.

This project assumes the use of one hundred and thirty-four (134) Vestas V162-4.5 MW full converter wind generators rated at 5.3 MVA operating at +/-0.85 pf for PI-2024-09. Each of the generators is connected to a collector transformer, 0.72/34.5 kV, rated at 5.3 MVA. Four 345/34.5/13.8 kV main GSU transformers rated at 113/150/188 MVA step the voltage up from the collector transformer voltage to the POI voltage. The fault current from the interconnection

assumed to be shared equally between the three GSUs. An approximately 26.8-mile-long generation tie line interconnects the project to the Goose Creek 345 kV substation.

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 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.

This Provisional Interconnection has a requested Commercial Operation Date (COD) of 5/7/2026. The Provisional Interconnections that are expected to be in operation at the time of this interconnection were also included in the short circuit model.

5.0 Provisional Interconnection Service Analysis

5.1 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.

Per Section 4.1.1.2 in the BPM, the following voltage regulation and reactive power capability requirements are applicable to synchronous generators:

- Xcel Energy's OATT requires all synchronous Generator Interconnection Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the POI.
- The reactive power analysis performed in this report is an indicator of the reactive power requirements at the POI and the capability of the generator to meet those requirements. The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and the regulating voltage of the POI.

All proposed reactive devices in customer provided models are switched favourably to provide appropriate reactive compensation in each test, therefore identified deficiencies are in addition to any proposed reactive compensation.

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-2024-09 GIR is modeled as follows:

Wind Generator 1: Pmax = 152.8 MW, Pmin = 0 MW, Qmax = 86.7 MVar, Qmin= -54.4 MVar
Wind Generator 2: Pmax = 161.8 MW, Pmin = 0 MW, Qmax = 91.8 MVar, Qmin= -57.6 MVar
Wind Generator 3: Pmax = 134.7 MW, Pmin = 0 MW, Qmax = 76.5 MVar, Qmin= -48.0 MVar
Wind Generator 4: Pmax = 153.0 MW, Pmin = 0 MW, Qmax = 86.7 MVar, Qmin= -54.4 MVar
The summary for the Voltage and Reactive Power Capability Evaluation for PI-2024-09 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. Note during the lagging test the generator terminals and high side of the main power transformer bus exceeds 1.05 p.u. voltage.
- 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-2024-09 are summarized in Table 3.

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Table 3 – Reactive Capability Evaluation for PI-2024-09

Generator 1 Terminals					Generator 2 Terminals					High Side of Main Transformer			
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
152.80	86.70	86.67	-54.40	1.11	161.80	91.80	91.80	-57.57	1.11	587.10	193.10	1.07	0.950
152.80	-11.00	86.67	-54.40	0.96	161.80	-11.00	91.80	-57.57	0.96	586.90	-195.70	0.98	-0.949
0.00	-36.50	86.67	-54.40	0.96	0.00	-36.50	91.80	-57.57	0.96	-1.20	-164.70	1.02	-0.007
Generator 3 Terminals					**Generator 4 Terminals**					**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
134.70	76.50	76.50	-48.00	1.11	153.00	86.70	86.70	-54.40	1.14	576.40	200.90	1.03	0.944
134.70	-11.00	76.50	-48.00	0.97	153.00	-11.00	86.67	-54.40	0.97	574.50	-197.80	0.98	-0.946
0.00	-48.00	76.50	-48.00	0.96	0.00	-36.50	86.67	-54.40	0.96	-1.90	-129.70	1.03	-0.015

5.2 Steady State Analysis

Contingency analysis was performed on the East study pocket Study Case.

The power flow analysis showed that the category P1 contingencies: Missile Site – Pronghorn 345 kV and Smoky Hill – Missile Site 345 kV were divergent in the Study Case. As described in Section 7.4 of the BPM, single contingency issues should be mitigated using redispatch. Therefore, to resolve the divergence without requiring network upgrades or curtailment of the Study GIR's output, PSCo units located near the Study GIR were re-dispatched until the diverged contingency was resolved. The change in output of both units was balanced against PSCo generation outside of the Eastern Colorado study pocket. The following single and multiple contingency analyses are conducted with the dispatch presented in the last column of Table 4.

Table 4 – Generation Dispatch to Resolve the Diverged P1 Contingency

Bus No.	Bus Name	ID	Original Pgen (MW)	Modified Pgen (MW)
70767	RUSHCK1_W1	W1	161.12	0.00
70770	RUSHCK1_W2	W2	130.32	0.00
70636	LIMON2_W	W2	160.80	0.00
70637	LIMON3_W	W3	160.80	0.00

- Results of the system intact analysis on the Study Case are shown in Table 5. System intact analysis showed no voltage violations attributable to PI-2024-09.
- Results of the single contingency analysis on the Study Case are shown in Table 6. Single contingency analysis showed no voltage violations attributable to PI-2024-09.
- Results of the multiple contingency analysis on the Study Case are shown in Table 7. Multiple contingency analysis showed no voltage violations attributable to PI-2024-09.
    - Note two P7 contingencies were divergent as shown in Table 8. 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 5 and Table 6 are alleviated through generation redispatch.

Per TPL-001-5, 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 5 – East Pocket – System Intact Overloads

Ref. No.	Monitored Facility	Contingency Name	kVs	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
1	Monaco_12 (70481) - Sullivan_2 (70365) 230 kV circuit 1	Base Case	230	70	445	106.75	109.80	3.05
2	Greenwood_2 (70189) - Monaco_12 (70481) 230 kV circuit 1	Base Case	230	70	484	105.51	108.35	2.84
3	Leetsdale (70260) - MonroePS (70291) 230 kV circuit 1	Base Case	230	70	398	97.65	104.11	6.46
4	Buckley2 (70046) - Smoky Hill (70396) 230 kV circuit 1	Base Case	230	70	478	94.92	100.35	5.43
5	Story (73192) - Pawnee (70311) 230 kV ckt 1	Base Case	230	73/70	581	83.81	107.60	23.79

Table 6 – East Pocket - Single Contingency Overloads

Ref. No.	Monitored Facility	Contingency Name	kVs	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
1	Monaco_12 (70481) - Sullivan_2 (70365) 230 kV circuit 1	SGL_230_026: Smoky Hill - Buckley - Jewell - Leetsdale (#5285)	230	70	445	137.93	140.29	2.36
2	Greenwood_2 (70189) - Monaco_12 (70481) 230 kV circuit 1	SGL_230_026: Smoky Hill - Buckley - Jewell - Leetsdale (#5285)	230	70	484	134.13	136.25	2.12
3	Harrison_P1 (70215) - Leetsdale_2 (70282) 115 kV circuit 1	SGL_115_085: Cherokee gen drop (70145)	115	70	141	134.08	136.04	1.96

Ref. No.	Monitored Facility	Contingency Name	kVs	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
4	Leetsdale (70260) - Sullivan_2 (70365) 230 kV circuit 1	SGL_230_026: Smoky Hill - Buckley - Jewell - Leetsdale (#5285)	230	70	425	125.16	127.73	2.57
5	Buckley2 (70046) - Smoky Hill (70396) 230 kV circuit 1	SGL_230_048: Greenwood - Monaco - Sullivan (#5717)	230	70	478	122.90	127.00	4.10
6	Story (73192) - Pawnee (70311) 230 kV ckt 1	SGL_345_001: Smokey Hill - Missile Site #7081	230	73/70	581	124.07	126.76	2.69
7	Buckley2 (70046) - Tollgate (70491) 230 kV circuit 1	SGL_230_048: Greenwood - Monaco - Sullivan (#5717)	230	70	484	121.38	125.45	4.07
8	Greenwood_1 (70212) - Greenwood_2 (70189) 230 kV circuit 1	SGL_230_047: Daniels Park - Prairie - Greenwood (#5707)	230	70	687	117.36	118.76	1.40
9	Leetsdale (70260) - MonroePS (70291) 230 kV circuit 1	SGL_230_006: Arapahoe - Daniel Park (#5107)	230	70	398	115.57	118.68	3.11
10	Capitol Hill (70087) - Denver Terminal (70148) 115 kV circuit 1	SGL_115_044: Argo - Cherokee SW (#9413)	115	70	131	115.87	118.67	2.80
11	Denver Terminal (70148) - Elati (70163) 230 kV circuit 1	SGL_230_006: Arapahoe - Daniel Park (#5107)	230	70	307	110.22	113.01	2.79
12	Jewell (70491) - Tollgate (70491) 230 kV circuit 1	SGL_230_048: Greenwood - Monaco - Sullivan (#5717)	230	70	484	102.24	106.40	4.16
13	Fort Lupton (70192) - Pawnee (70311) 230 kV circuit 1	SGL_345_001: Smokey Hill - Missile Site #7081	230	70	478	103.65	104.78	1.13
14	Elati (70163) - MonroePS (70291) 230 kV circuit 1	SGL_230_006: Arapahoe - Daniel Park (#5107)	230	70	398	101.58	104.28	2.70
15	Havana2 (70217) - Chambers (70538) 115 kV circuit 2	SGL_115_053: Cherokee - Derby - Havana - Chambers (#9544)	115	70	159	95.52	103.38	7.86

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Table 7 – East Pocket - Multiple Contingency Overloads

Ref. No.	Monitored Facility	Contingency Name	kVs	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
1	Leetsdale (70260) - MonroePS (70291) 230 kV circuit 1	BF_004a: Arapahoe 230 kV	230	70	398	150.96	155.98	5.02
2	Buckley2 (70046) - Smoky Hill (70396) 230 kV circuit 1	BF_064c: Greenwood Bus Tie	230	70	478	148.88	154.53	5.65
3	Elati (70163) - MonroePS (70291) 230 kV circuit 1	BF_004a: Arapahoe 230 kV	230	70	398	136.26	141.15	4.89
4	Buckley2 (70046) - Tollgate (70491) 230 kV circuit 1	BF_064c: Greenwood Bus Tie	230	70	554	128.46	133.34	4.88
5	Jewell (70491) - Leetsdale (70260) 230 kV circuit 1	BF_064c: Greenwood Bus Tie	230	70	478	118.29	123.98	5.69
6	Jewell (70491) - Tollgate (70491) 230 kV circuit 1	BF_064c: Greenwood Bus Tie	230	70	555	111.52	116.44	4.92
7	Story (73192) - Pawnee (70311) 230 kV ckt 1	BF_057b: Fort Lupton 230 kV Breaker 5522	230	73/70	589	106.06	111.85	5.79
8	Denver Terminal (70148) - Elati (70163) 230 kV circuit 1	BF_004a: Arapahoe 230 kV	230	70	440	107.45	111.75	4.30
9	Harrison_P1 (70215) - Leetsdale_2 (70282) 115 kV circuit 1	BF_050a: Elati 230 kV Breaker 5283	115	70	14	103.19	107.02	3.83
10	Greenwood_1 (70212) - Greenwood_2 (70189) 230 kV circuit 1	BF_045s: Daniels Park 230 kV Breaker 5707	230	70	796	101.29	102.50	1.21

Ref. No.	Monitored Facility	Contingency Name	kVs	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
11	Havana2 (70217) - Chambers (70538) 115 kV circuit 2	BF_031i: Chambers 230 kV Breaker 9236	115	70	17	93.41	100.51	7.10
12	East_1 (70162) - East_2 (70171) 115 kV circuit 1	P7_29: Lines 5185 and 5187	115	70	119.5	163.51	167.20	3.69
13	Monaco_12 (70481) - Sullivan_2 (70365) 230 kV circuit 1	P7_150: Lines 5167 and 5285	230	70	445	136.84	138.92	2.08
14	Leetsdale (70260) - Sullivan_2 (70365) 230 kV circuit 1	P7_150: Lines 5167 and 5285	230	70	425	124.03	126.32	2.29
15	Clark (70112) - Jordan (70241) 230 kV circuit 1	P7_58: Lines 5707 and 5111	230	70	364	120.37	124.29	3.92
16	Greenwood_2 (70189) - Monaco_12 (70481) 230 kV circuit 1	P7_150: Lines 5167 and 5285	230	70	553	116.51	118.15	1.64
17	Capitol Hill (70087) - Denver Terminal (70148) 115 kV circuit 1	P7_11: Lines 9413 and 9541	115	70	145	111.96	114.38	2.42

Table 8 – Diverged P7 Contingencies

Diverged Contingency	Contingency Description	Benchmark Case	Study Case
P7_135	Daniels Park - Missile Site 345 kV circuit 1 Smoky Hill - Missile Site 345 kV circuit 1	Diverged	Diverged
P7_160	Canal Crossing - Goose Creek 345 kV circuit 1 Canal Crossing - Goose Creek 345 kV circuit 2	Converged	Diverged

5.3 Transient Stability Results

The following results were obtained for the disturbances analysed:

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

The results of the contingency analysis are shown in Table 9. The transient stability plots are shown in Appendix A in Section 10.0 of this report. Note the results presented include a change to the Vup parameter from 1.1 p.u. to 1.2 p.u. This change was made to resolve unsatisfactory reactive power and voltage response. It is up to the customer to confirm if this setting change is within their turbine's capability.

The response observed during the category P4 contingency shown in Ref. No. 9 in Table 9 may require either a Remedial Action Scheme (RAS) or Corrective Action Plan (CAP). Mitigation has not been determined at this time.

Table 9 – Transient Stability Analysis Results

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)	Post-Fault Voltage Recovery	Angular Stability
1	-	P0	Flatrun	-	Stable	Stable
2	Goose Creek 345 kV	P1	May Valley - Goose Creek 345 kV ckt 1	4	Stable	Stable
3	Goose Creek 345 kV	P1	Goose Creek - Canal Crossing 345 kV ckt 1	4	Stable	Stable
4	Goose Creek 345 kV	P1	Goose Creek - Shortgrass 345 kV ckt 1	4	Stable	Stable
5	Goose Creek 345 kV	P1	Goose Creek - Cheyenne Ridge 345 kV ckt 1 Cheyenne Ridge Wind Generation	4	Stable	Stable
6	Goose Creek 345 kV	P1	PI-2024-09 Generation	4	Stable	Stable
7	Daniels Park 345 kV	P4	Daniels Park - Missile Site 345 kV ckt 1 Daniels Pak 345 kV Cap Bank	12	Stable	Stable
8	Pronghorn 345 kV	P4	Pronghorn - Rush Creek 345 kV ckt Rush Creek Wind Generation	12	Stable	Stable
9	Canal Crossing 345 kV	P4	Goose Creek - Canal Crossing 345 kV ckt 1 Goose Creek - Canal Crossing 345 kV ckt 2 Canal Crossing 345 kV Cap Bank	12	Stable	Stable

5.4 Short-Circuit and Breaker Duty Analysis Results

The fault currents at the POI for three-phase and phase-to-ground faults can be found in Table 10 below, along with the Thevenin impedance at the POI. Both the base case and the case with the GIR added are shown.

Table 10 – Short-Circuit Parameters at PI-2024-09 POI (Goose Creek 345 kV switching station)

	Before the PI Addition	After the PI Addition
Three Phase		
Three Phase Current	8460A	7160 A
Positive Sequence Impedance	2.15398+ j22.5968 ohms	2.15398+ j22.5968 ohms
Negative Sequence Impedance	2.18224 + j22.5892 ohms	2.18224 + j22.5892 ohms
Zero Sequence Impedance	0.92032 + j8.92331 ohms	1.09289 + j8.11144 ohms
Phase-to-Ground		
Single Line to Ground Current	20660 A	22460 A
Positive Sequence Impedance	4.16772 + j48.2257 ohms	4.16772 + j48.2257 ohms
Negative Sequence Impedance	4.35505 + j48.1722 ohms	4.35505 + j48.1722 ohms
Zero Sequence Impedance	0.92032 + j8.92331 ohms	1.09289 + j8.11144 ohms

A breaker duty study on the PSCo transmission system did not identify any circuit breakers that became over-dutied because of adding the wind generation PI-2024-09.

5.5 Affected Systems

No Affected Systems were identified.

5.6 Summary of Provisional Interconnection Analysis

All system intact and single contingency thermal violations were alleviated through generation redispatch, therefore, the maximum allowable output of the GIR without requiring any additional System Network Upgrades is 578.3 MW.

6.0 Cost Estimates

The total cost of the required Upgrades for PI-2024-09 to interconnect for Provisional Interconnection Service at the Goose Creek 345 kV switching station is estimated to be **$10.424 million**. Note that cost estimates for system Network Upgrades on Affected Systems would not be provided by PSCo.

- **Cost of Transmission Provider's Interconnection Facilities (TPIF) is $3.894 million** (Table 11)
- **Cost of Station Network Upgrades is $6.530 million** (Table 12)
- **Cost of System Network Upgrades is $0**

The list of improvements required to accommodate the Provisional Interconnection Service of PI-2024-09 are given in Table 11, and Table 12.

Table 11 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Million)
PSCo's Goose Creek 345 kV switching station	Interconnection of 5RSC-2024-17 (PI-2024-9) at the Goose Creek 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	$3.644
PSCo's Goose Creek 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 new switching station from the PCO. Single span, dead end structure, 3 conductors, insulators, hardware, jumpers and labor.	$0.250
Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities		**$3.894**

Table 12 – Station Network Upgrades

Element	Description	Cost Est. (Million)
PSCo's Goose Creek 345 kV switching station	Interconnection of 5RSC-2024-17 (PI-2024-9) at Goose Creek 345 kV Switching Station. The new equipment includes: • (1) 345 kV dead end structure • (2) 345 kV 3000 A SF6 circuit breakers • (5) 345 kV 3000 A disconnect switches • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$6.122
PSCo's Goose Creek 345 kV switching station	Install required communication in the EEE at the Goose Creek 345 kV Switching Station	$0.358
PSCo's Goose Creek 345 kV switching station	Siting and Land Rights land acquisition and permitting, no land purchase costs included	$0.050
Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities		**$6.530**

PSCo has developed cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of PI-2024-09 for Provisional Interconnection Service. The estimated costs provided in this report are based upon the following assumptions:

- The estimated costs are in 2024 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 Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer substation. PSCo will be provided with indications, readings and data from the LF/AGC 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

6.1 Schedule

This section provides proposed milestones for the interconnection of PI-2024-09 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 of October 17,2025. This is not 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 13.

Table 13 – Proposed Milestones for PI-2024-09

Milestone	Responsible Party	Estimated Completion Date
LGIA Execution	Interconnection Customer and Transmission Provider	November 2024
In-Service Date for Transmission Provider Interconnection Facilities and Station Network Upgrades required for interconnection	Transmission Provider	June 1, 2026
In-Service Date & Energization of Interconnection Customer's Interconnection Facilities	Interconnection Customer	June 1, 2026
Initial Synchronization Date	Interconnection Customer	July 1, 2026
Begin trial operation & testing	Interconnection Customer and Transmission Provider	August 1, 2026
Commercial Operation Date	Interconnection Customer	December 15, 2026

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 12 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.

7.0 Summary of Provisional Interconnection Service Analysis

The total estimated cost of the PSCo transmission system improvements required for PI-2024-09 to qualify for Provisional Interconnection Service is $10.424 million.

The initial maximum permissible output of PI-2024-09 Generating Facility is 578.3 MW. The maximum permissible output of the Generating Facility in the PLGIA would be reviewed quarterly and updated if there are changes to system conditions compared to the system conditions previously used to determine the maximum permissible output.

Security: PI-2024-09 is a request for 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.

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

8.0 Contingent Facilities

Contingent Facilities identified for PI-2024-09 include the TPIF and Station Network Upgrades identified in Table 11 and Table 12, respectively.

9.0 Preliminary One-Line Diagram and General Arrangement for PI-2024-09

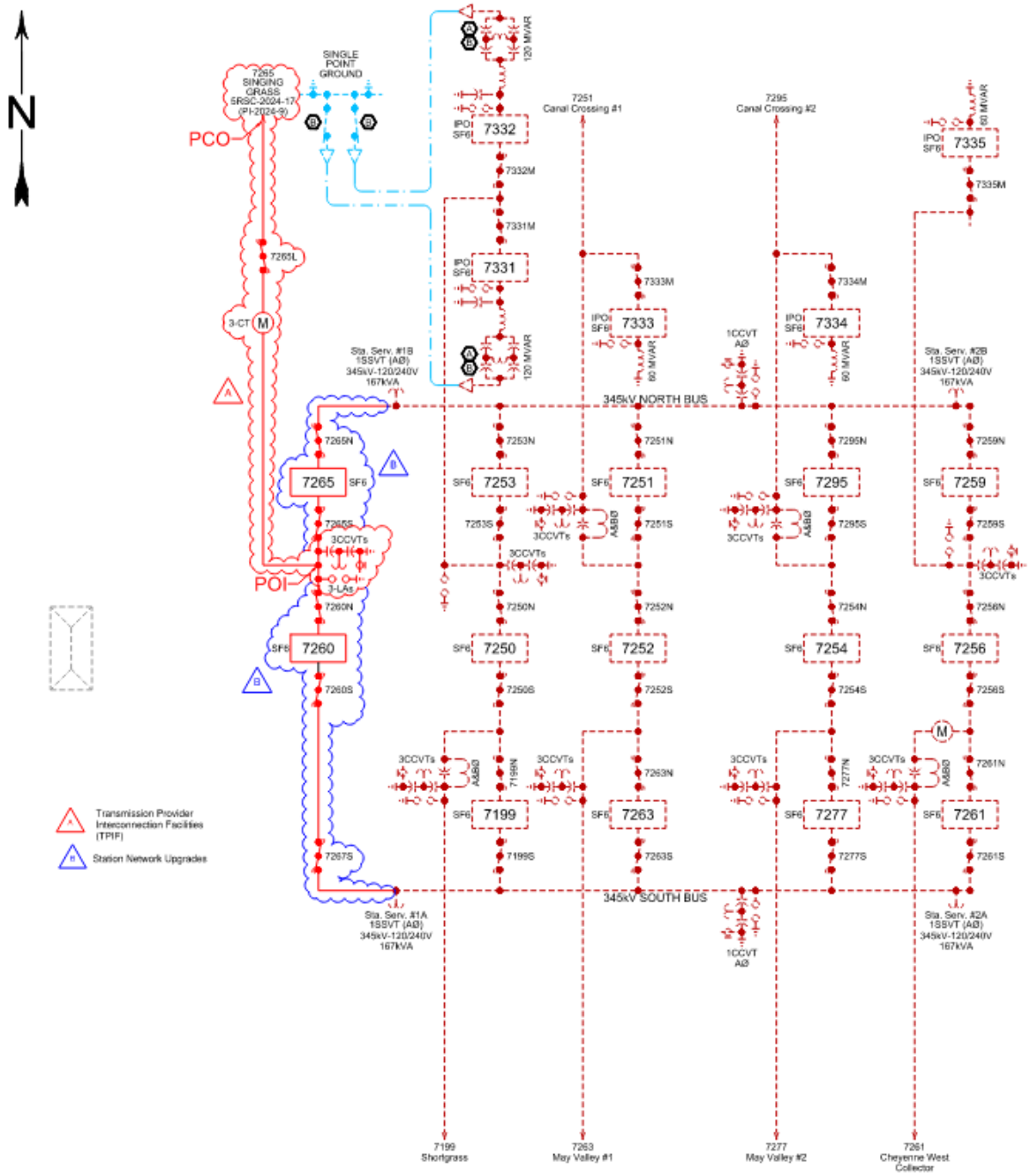


Figure 2: Preliminary One-Line of PI-2024-09 at the Goose Creek 345 kV switching station

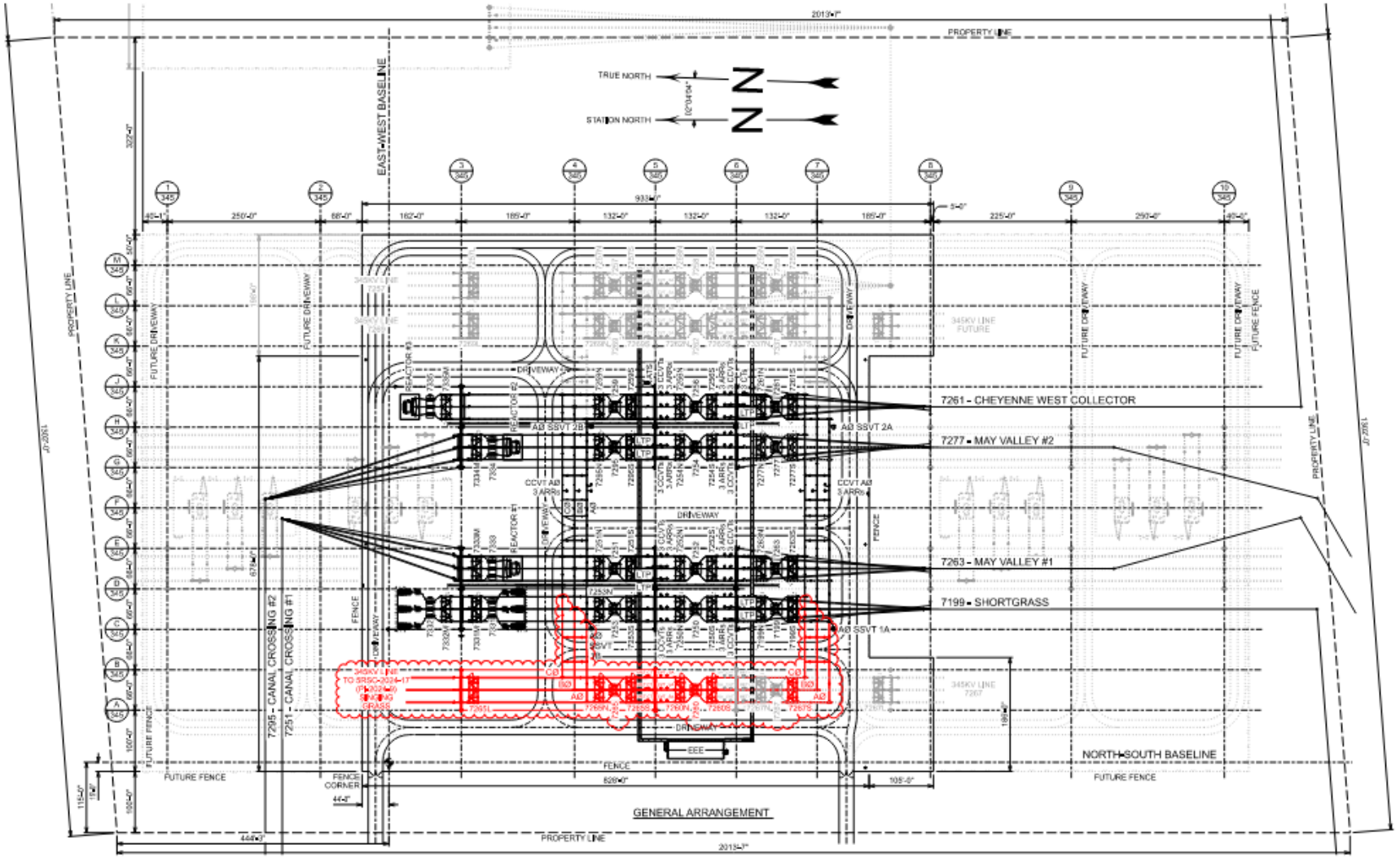


Figure 3: Preliminary General Arrangement for PI-2024-09 at the Goose Creek 345 kV switching station

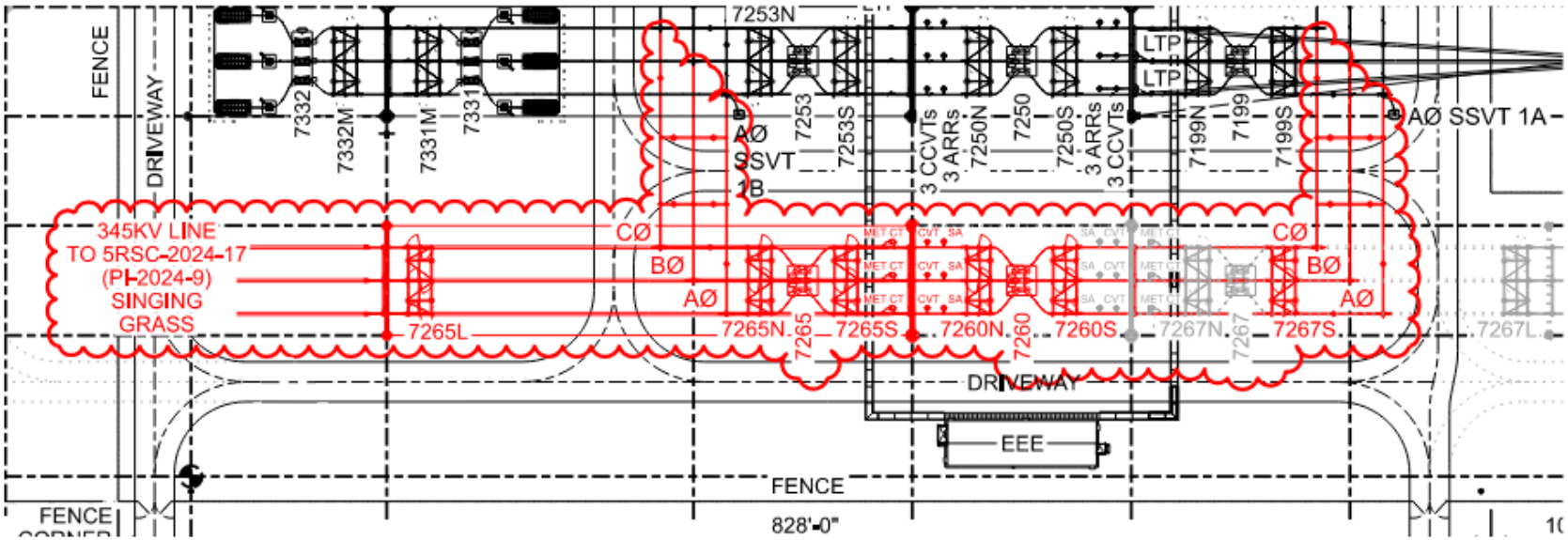
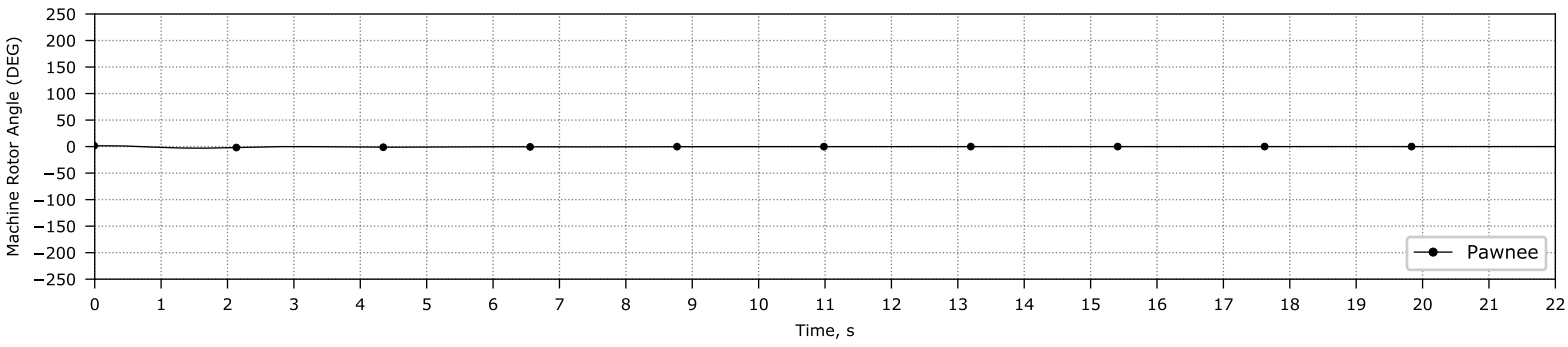


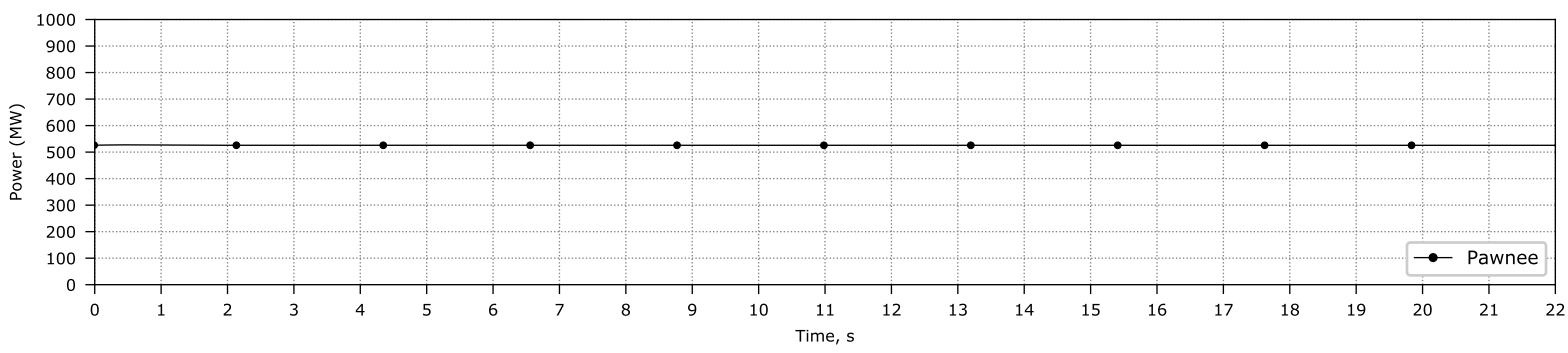
Figure 4: **Preliminary General Arrangement Enlargement for PI-2024-09 at the Goose Creek 345 kV switching station**

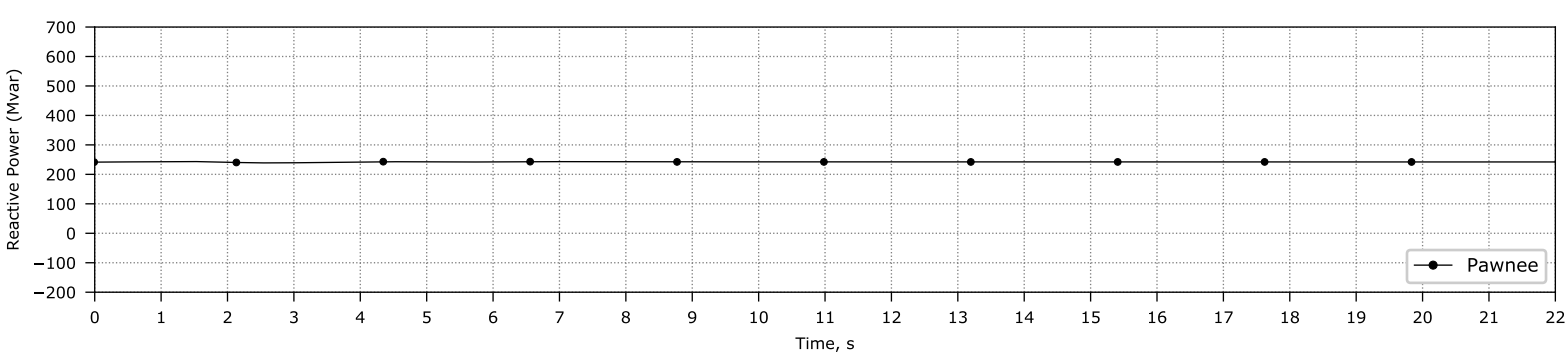
10.0 Appendices

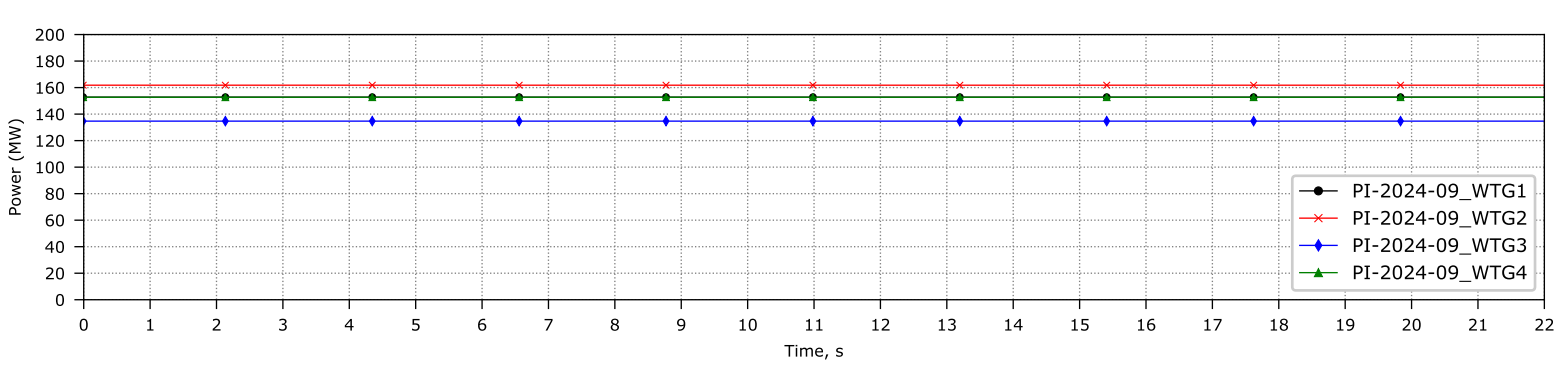
Appendix A: Transient Stability Plots	PI-2024-09_Transient Stability Plots_Final.pc

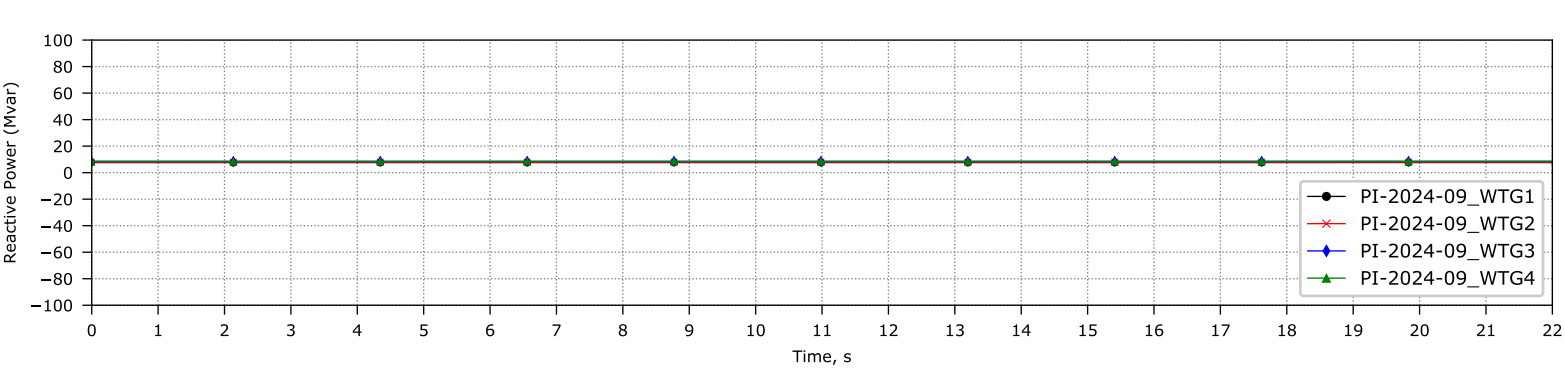
PI-2024-09_Study_East_flatrun

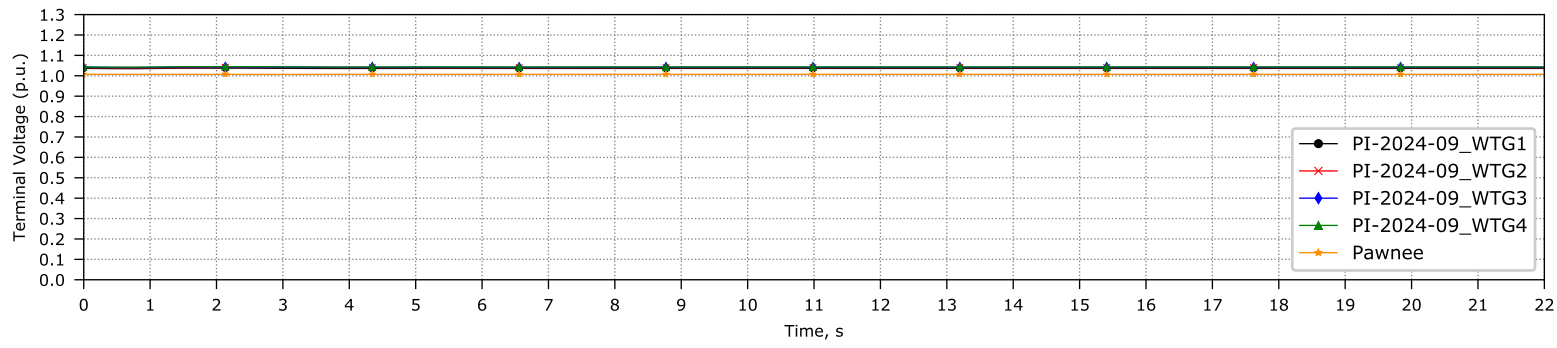


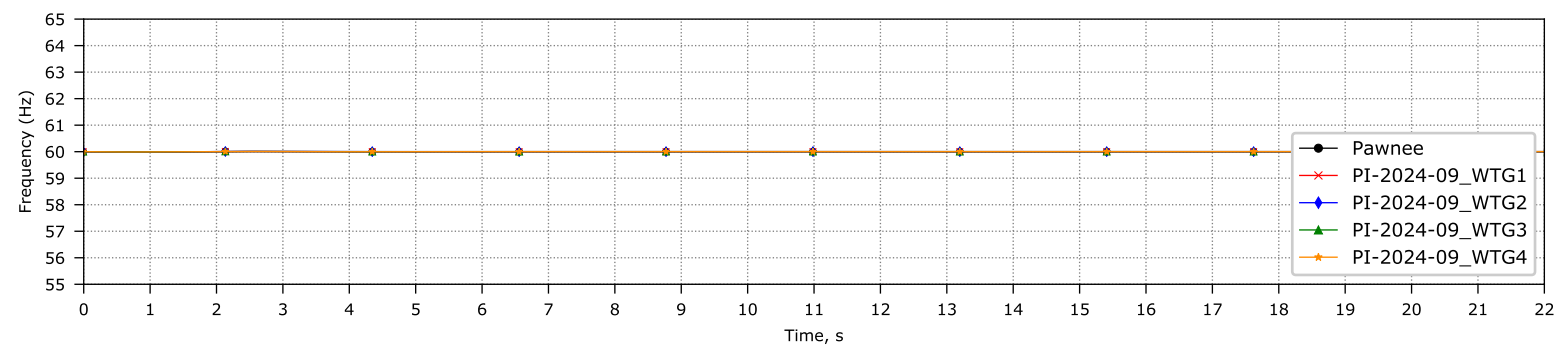


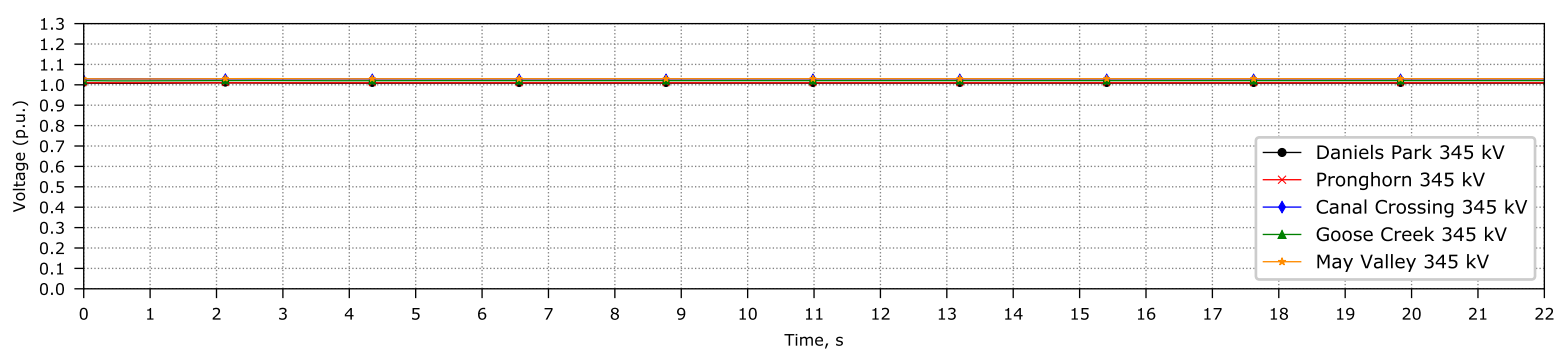




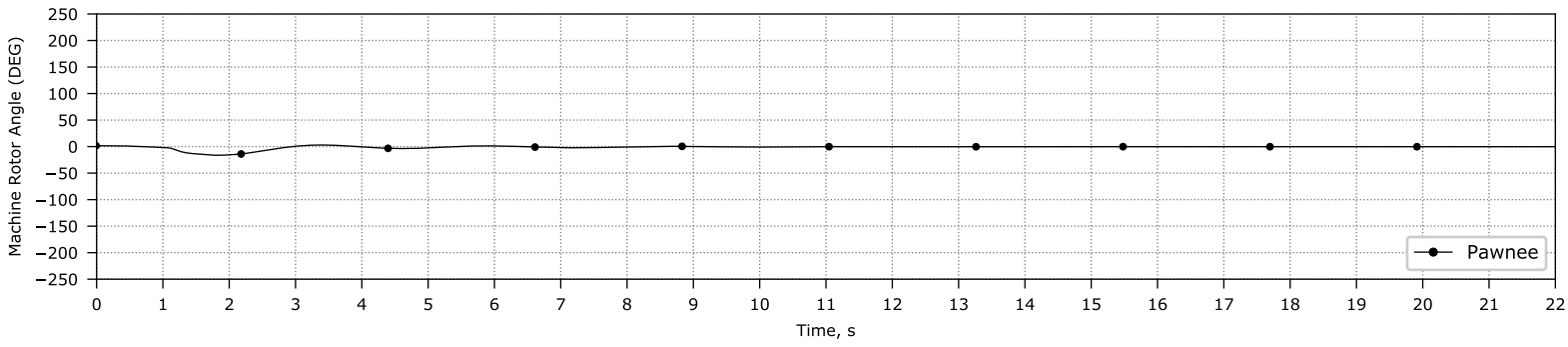


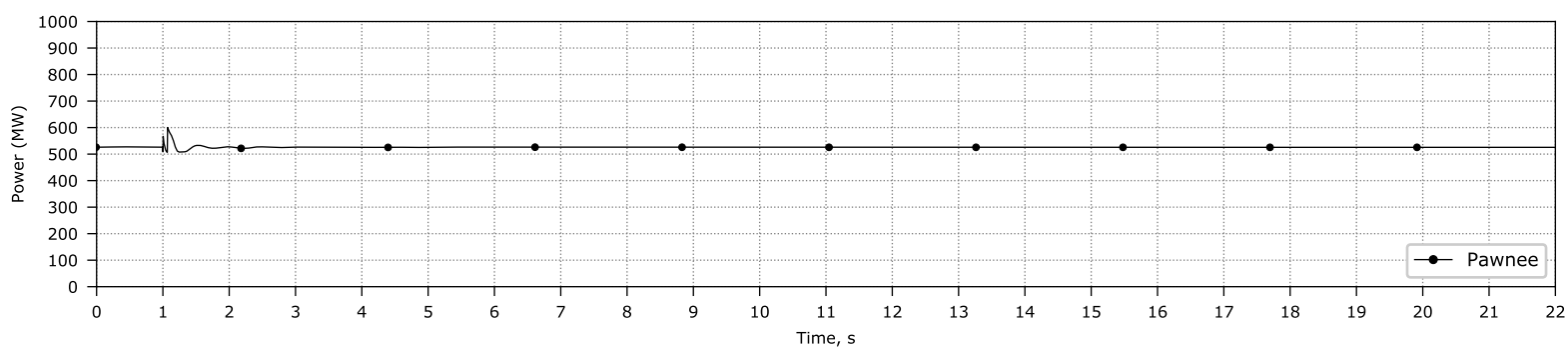


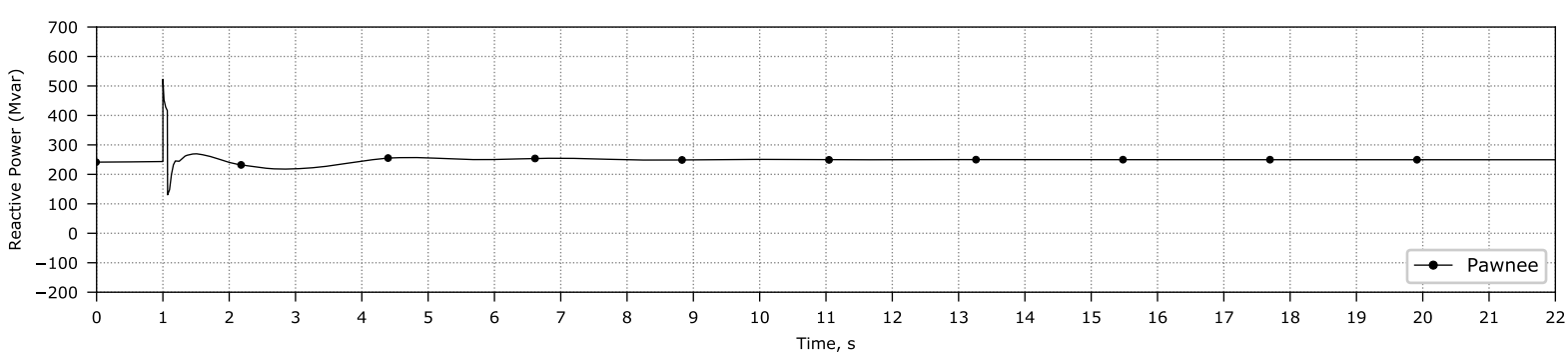


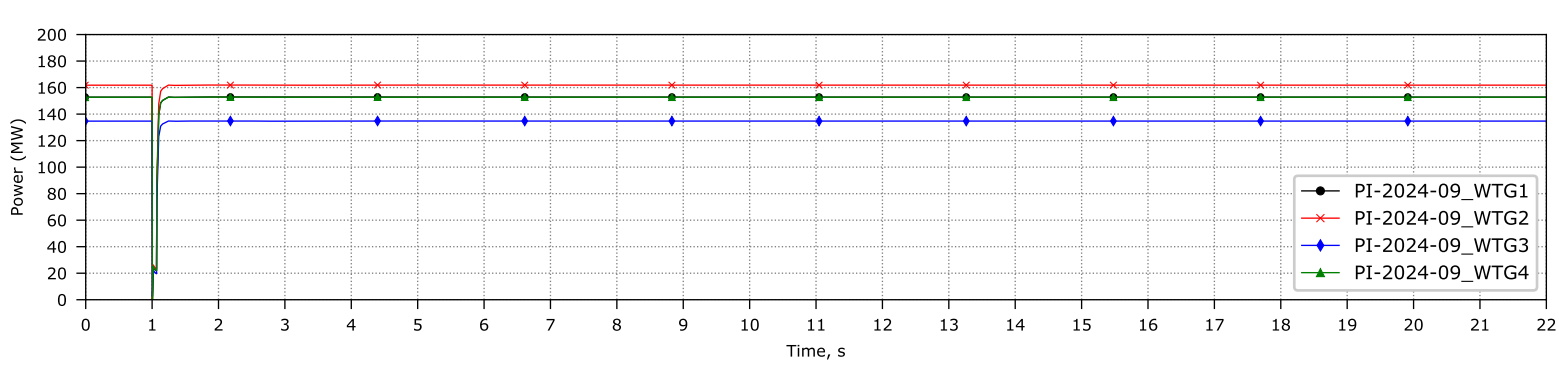


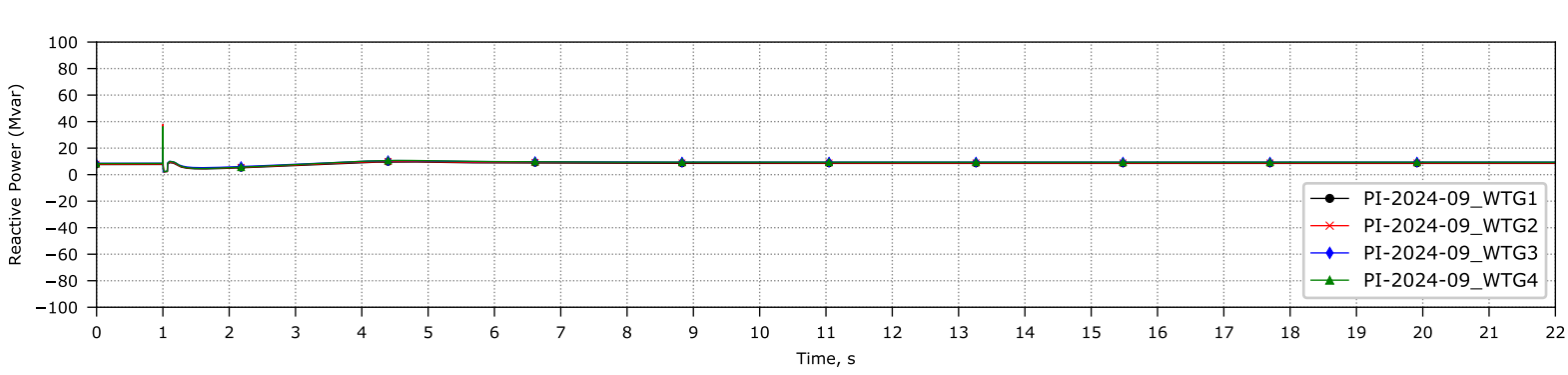
PI-2024-09_Study_East_MayV-GooseCrk-1_345kV

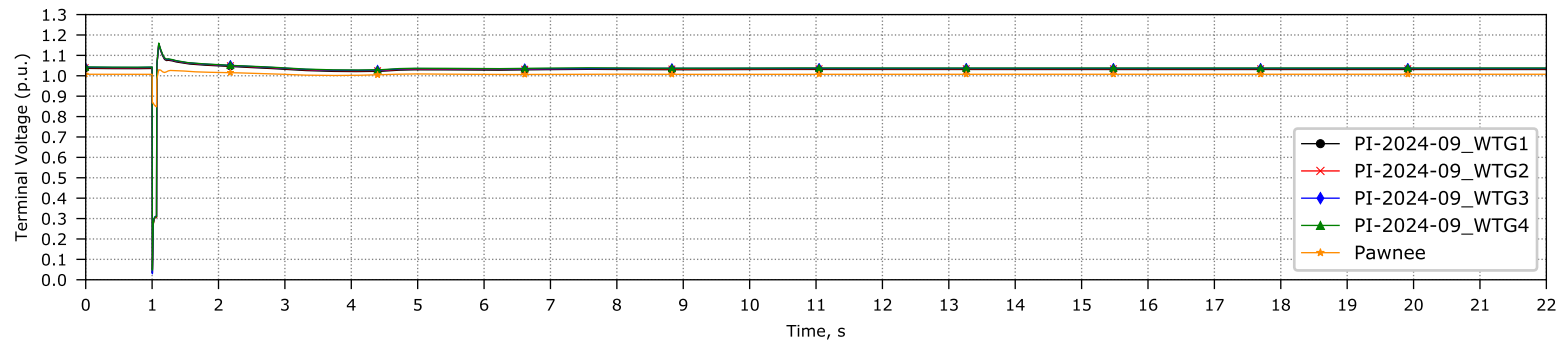


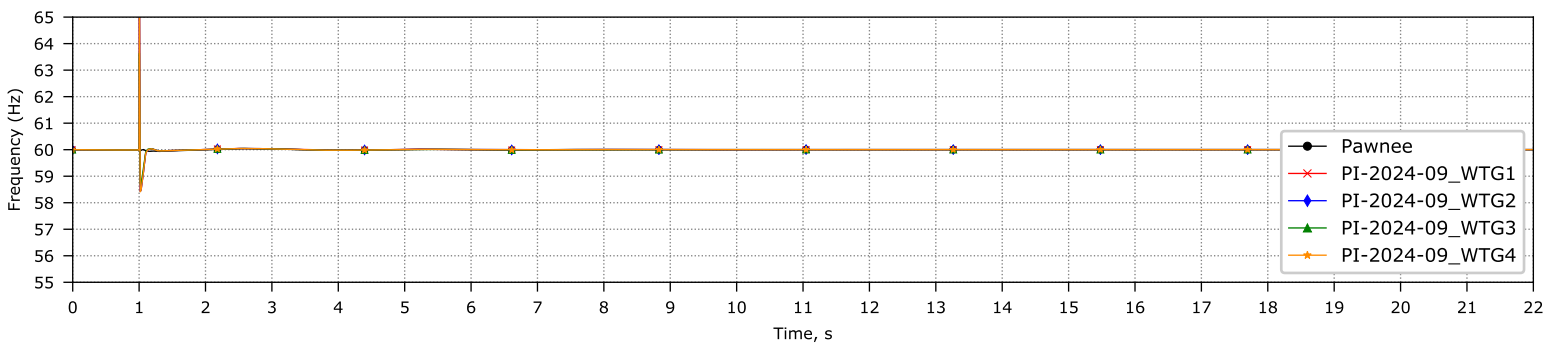


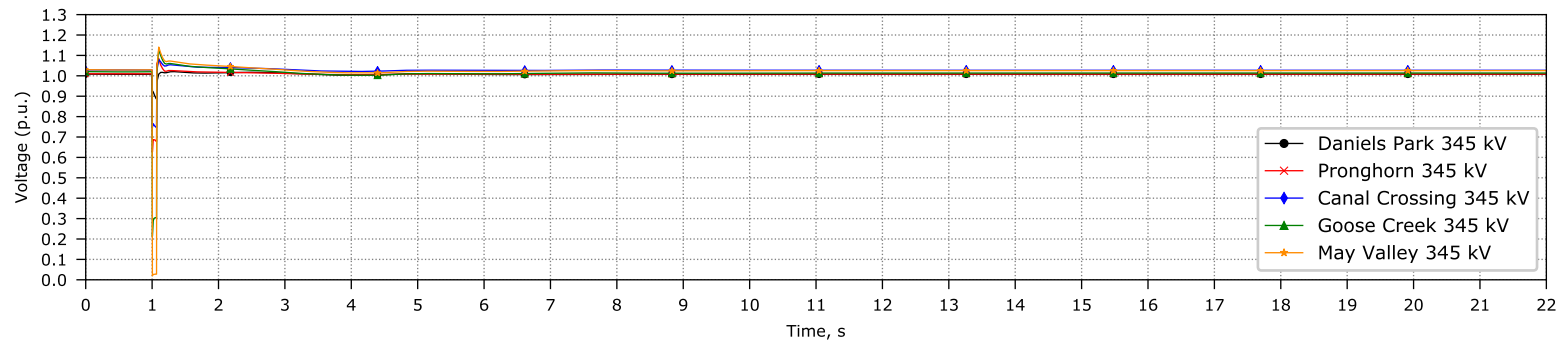




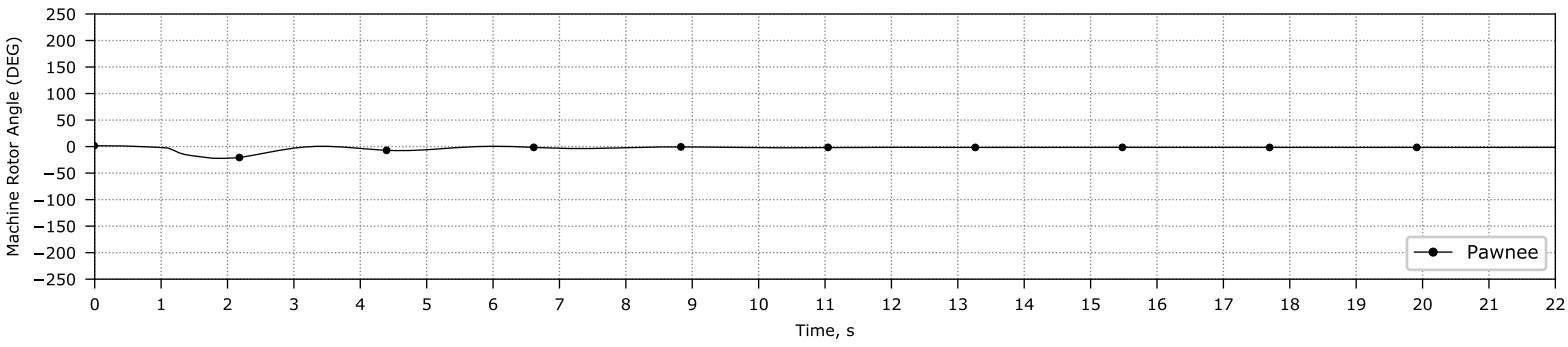


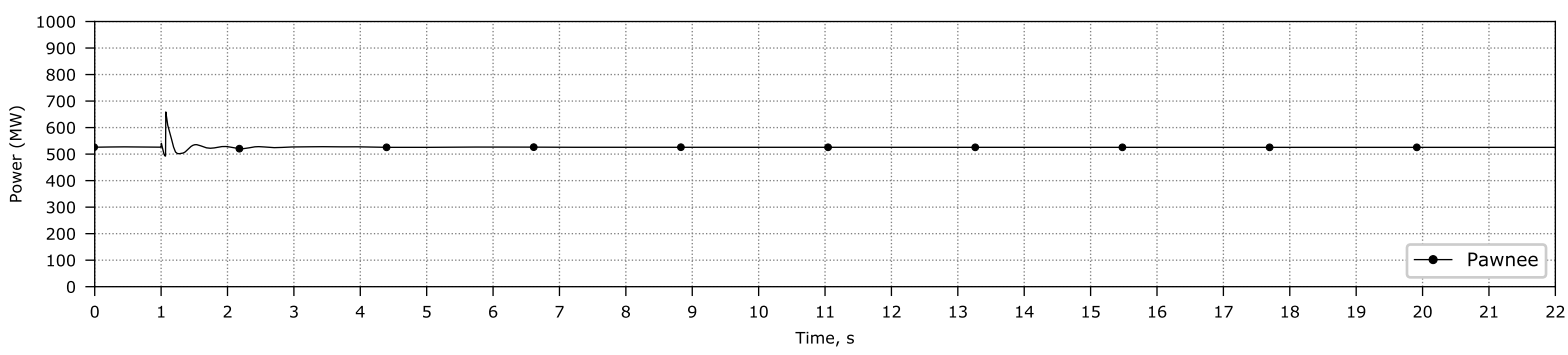


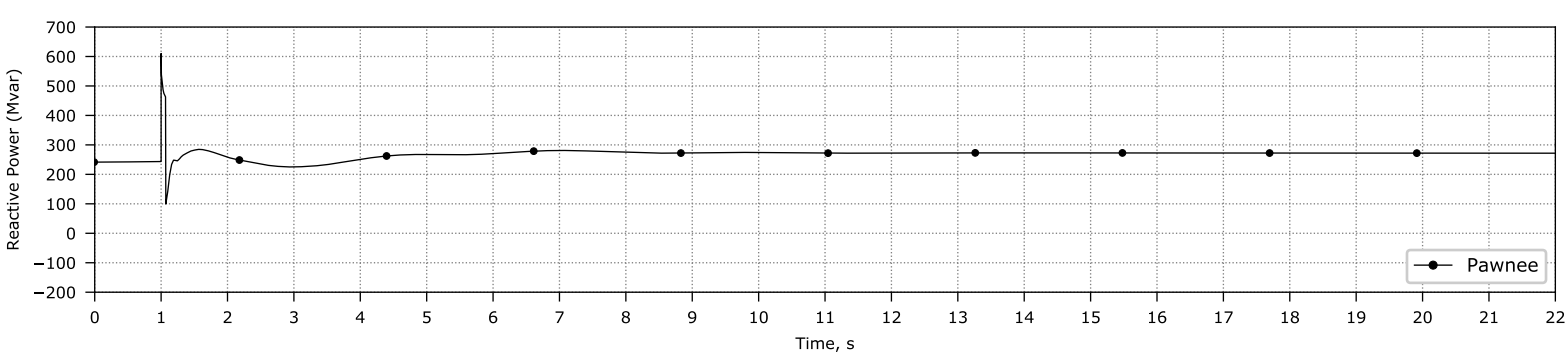


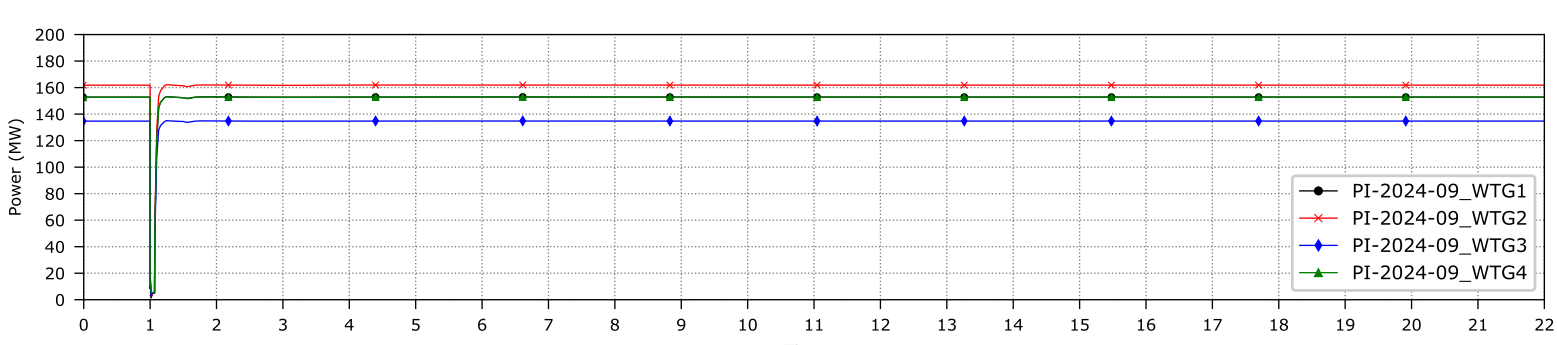


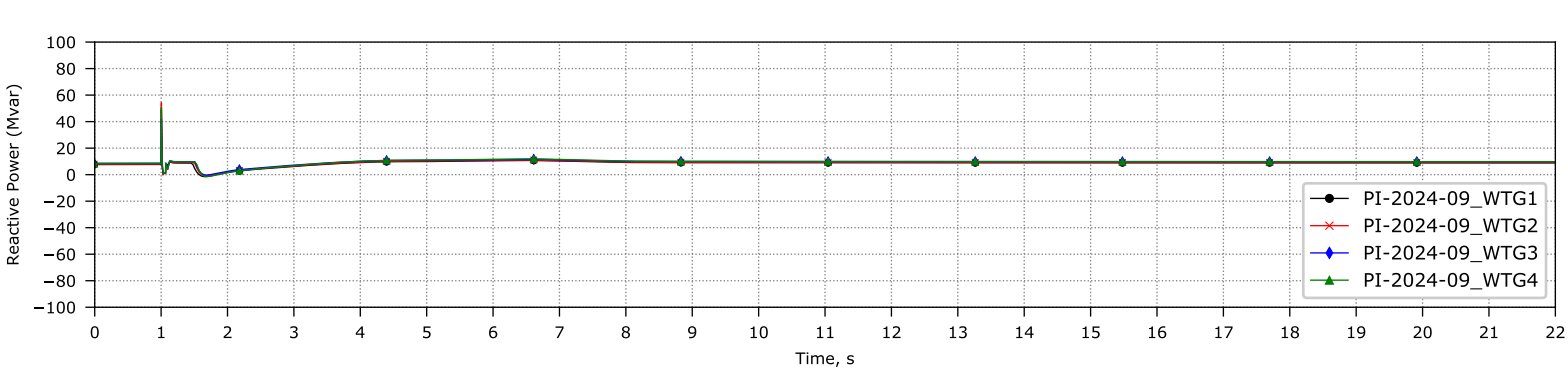
PI-2024-09_Study_East_GooseCrk-CanalXing-1_345kV

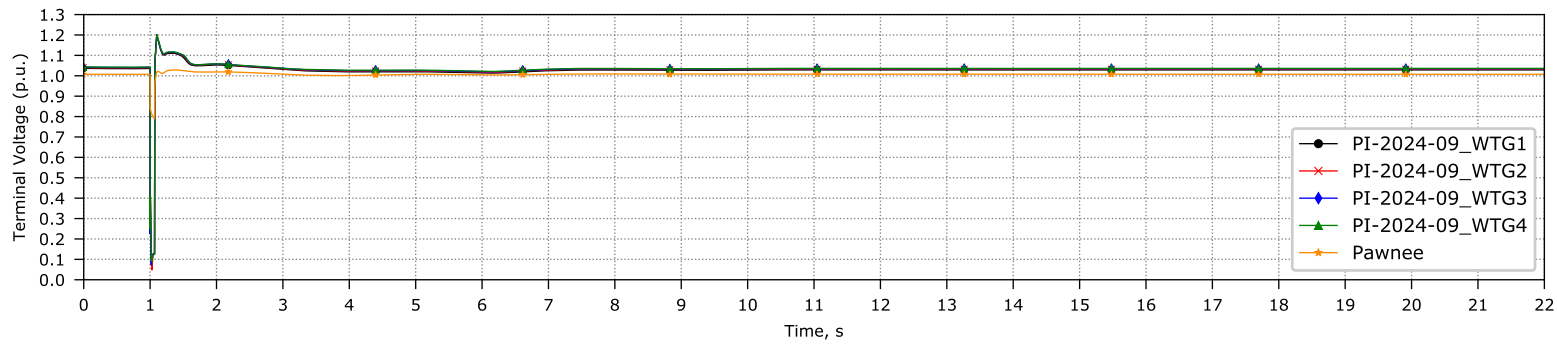


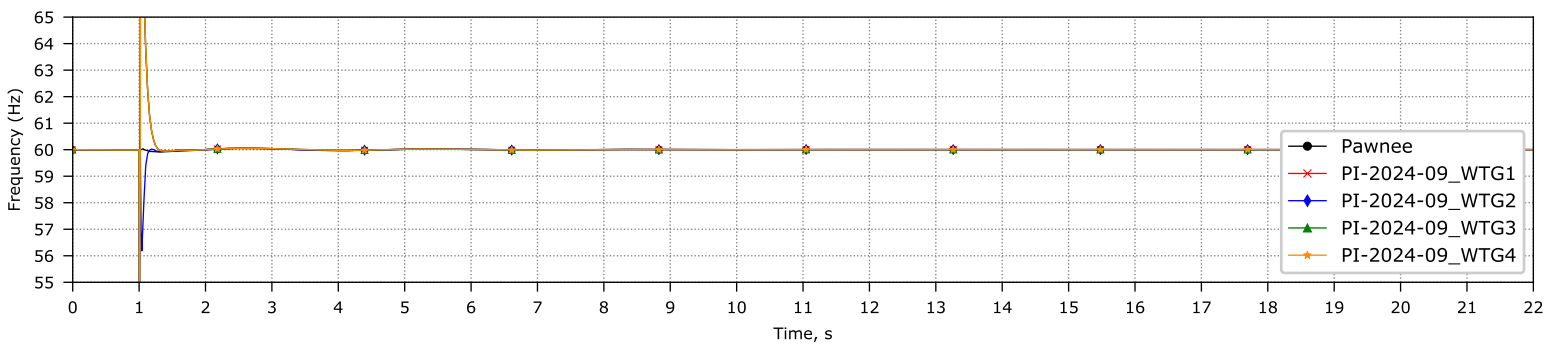


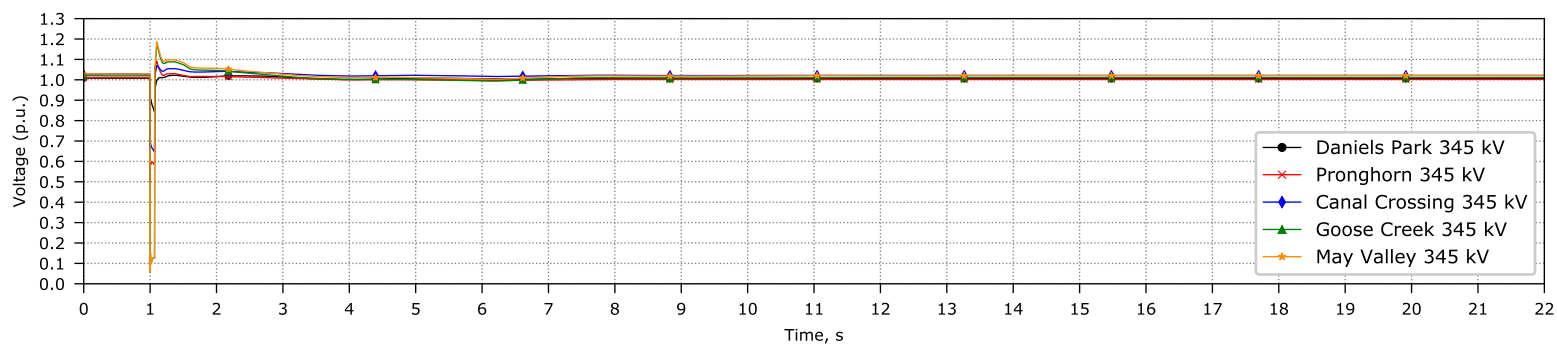












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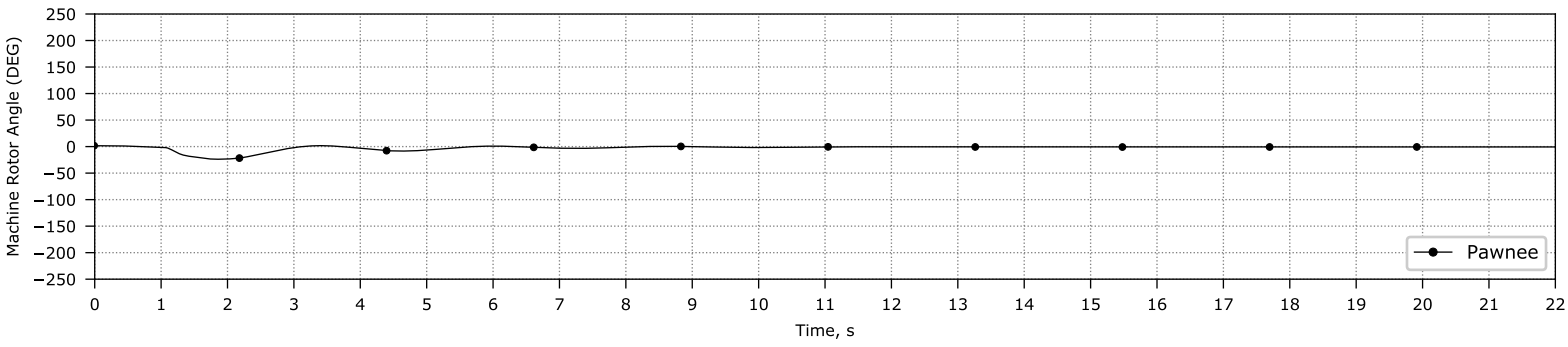
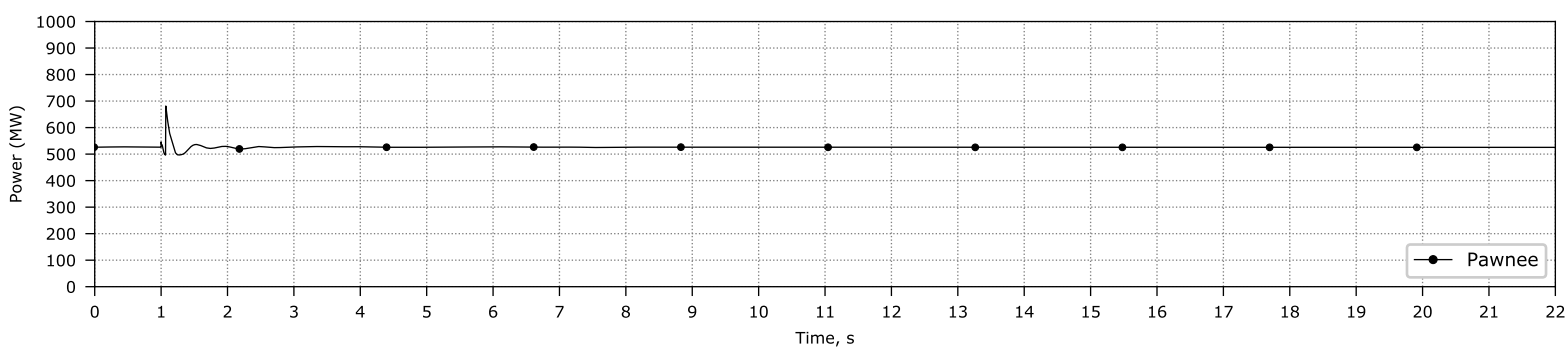
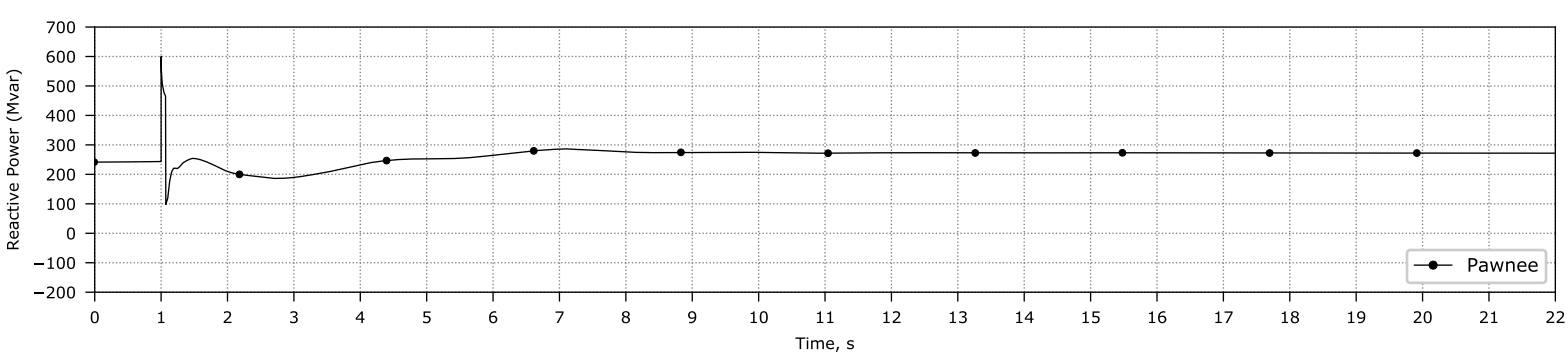
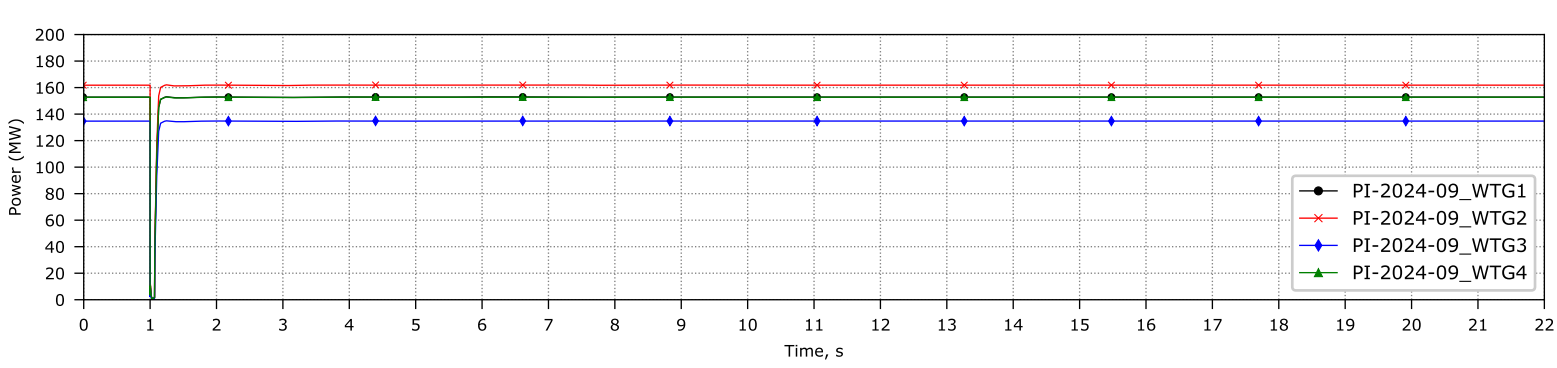
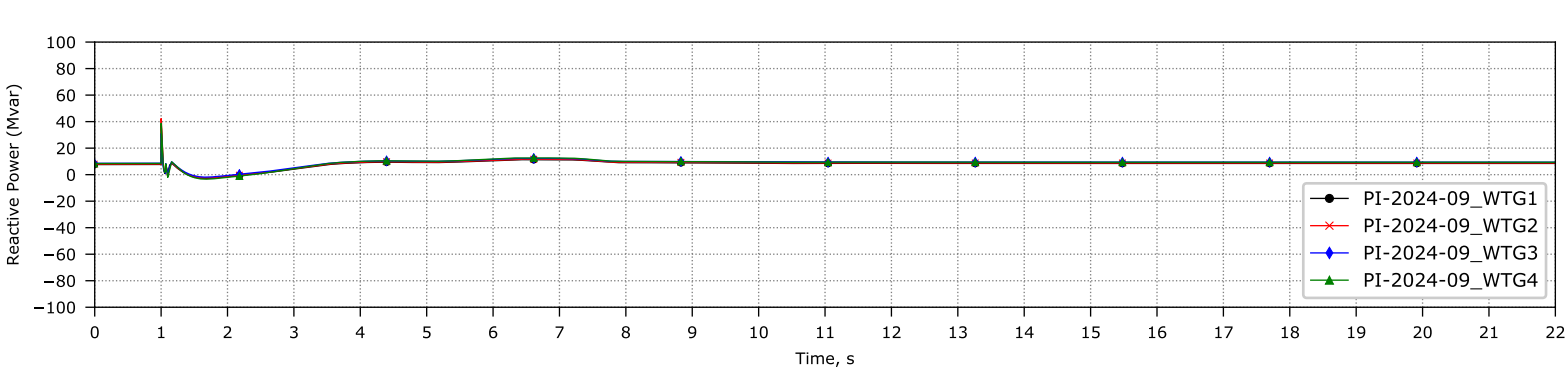
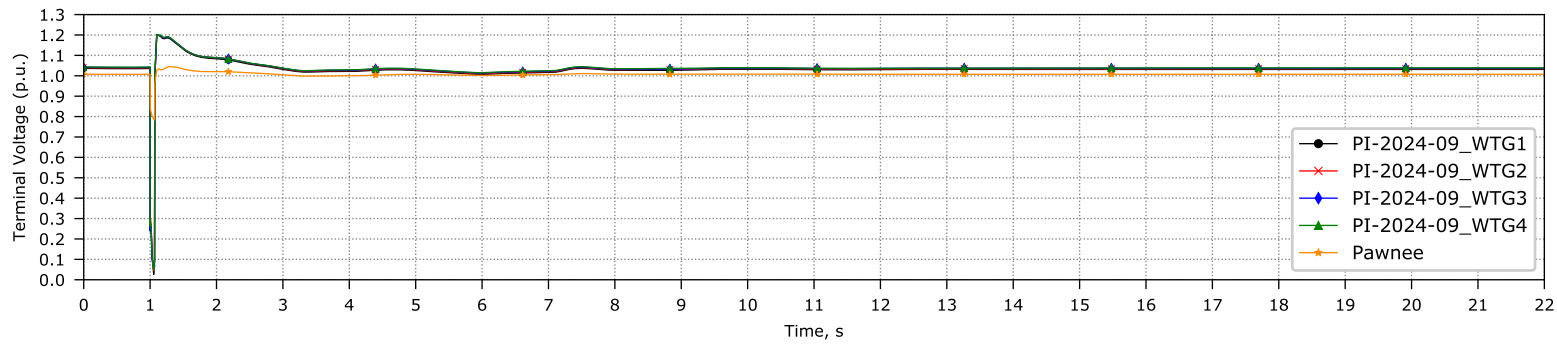


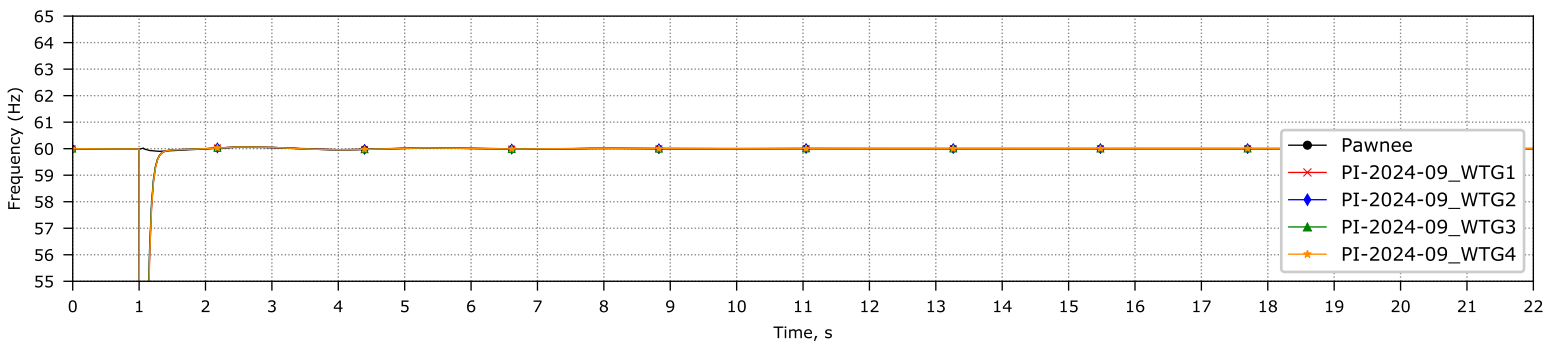


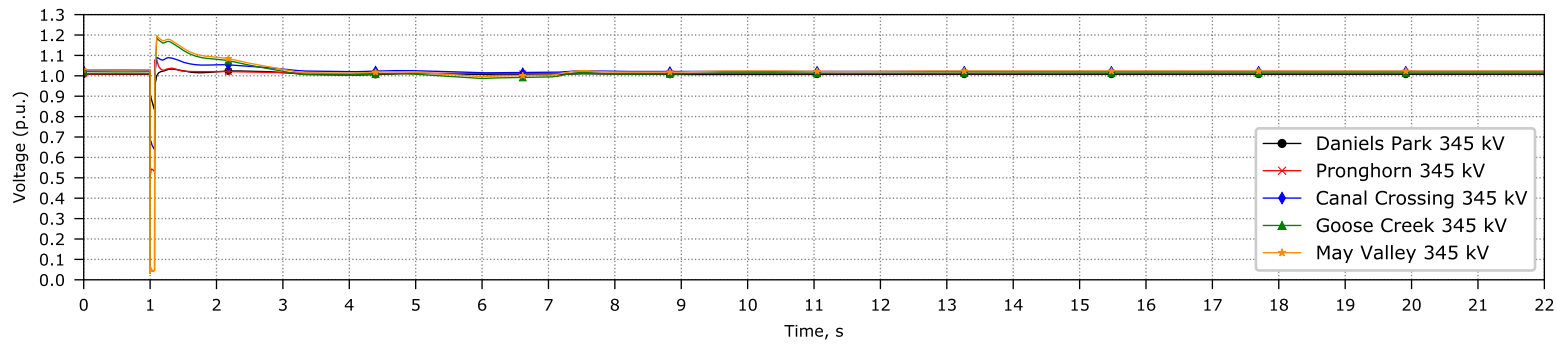




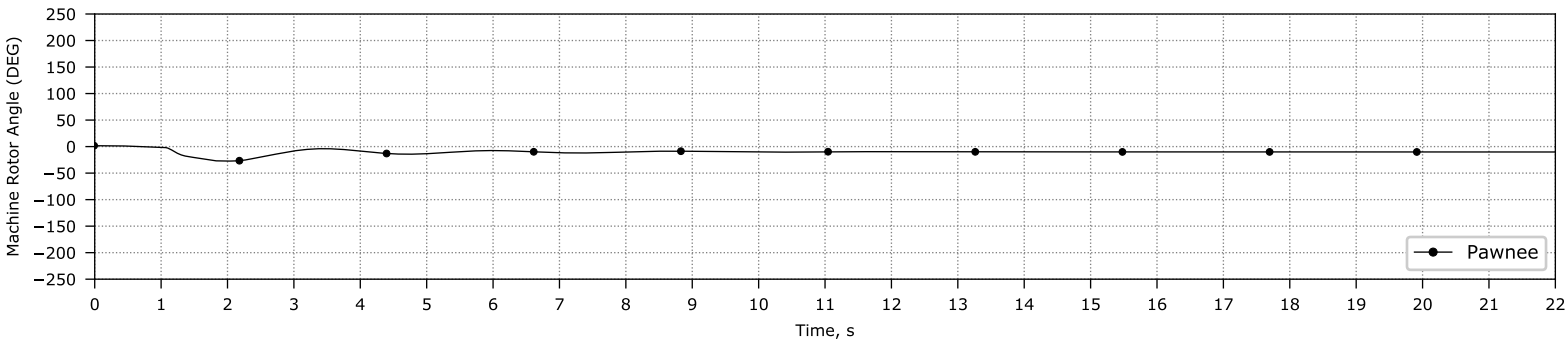


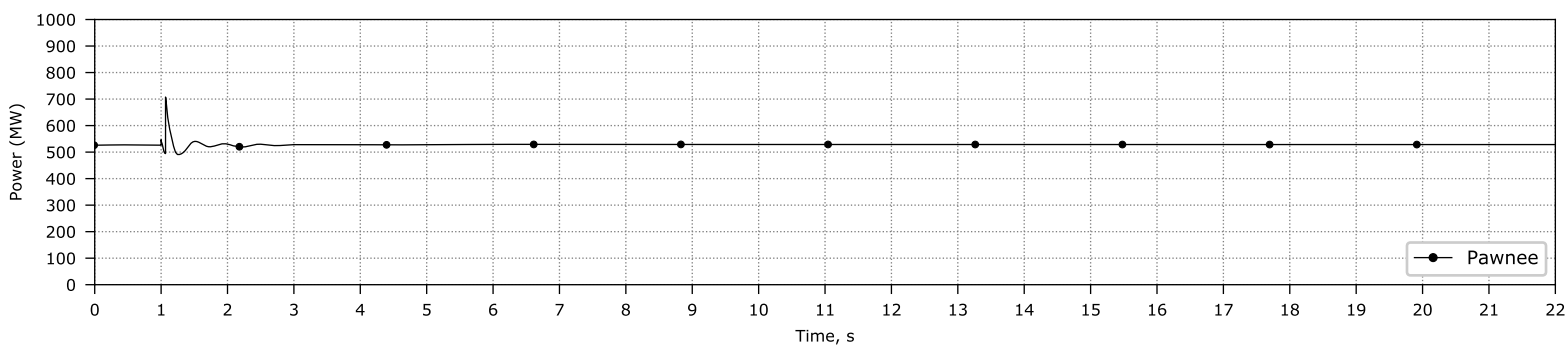


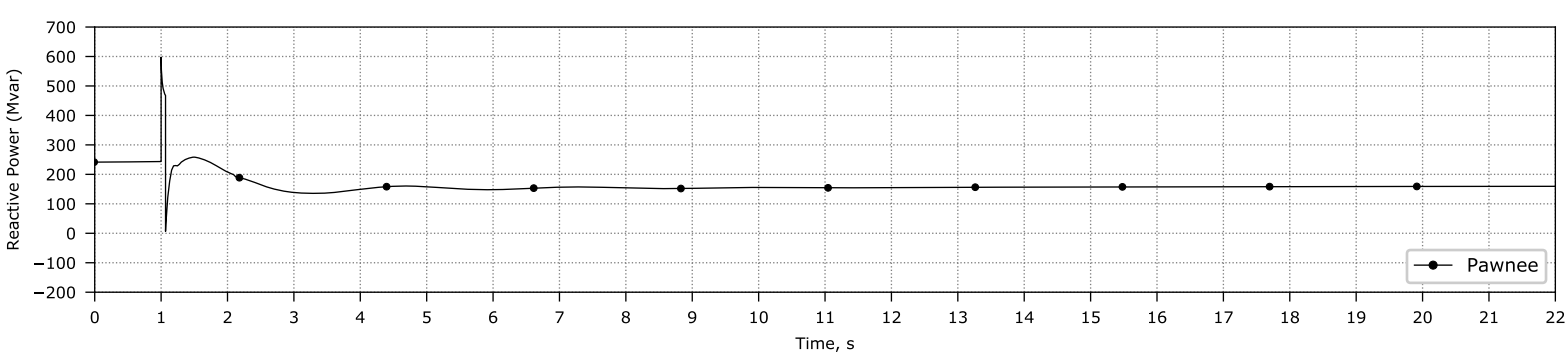


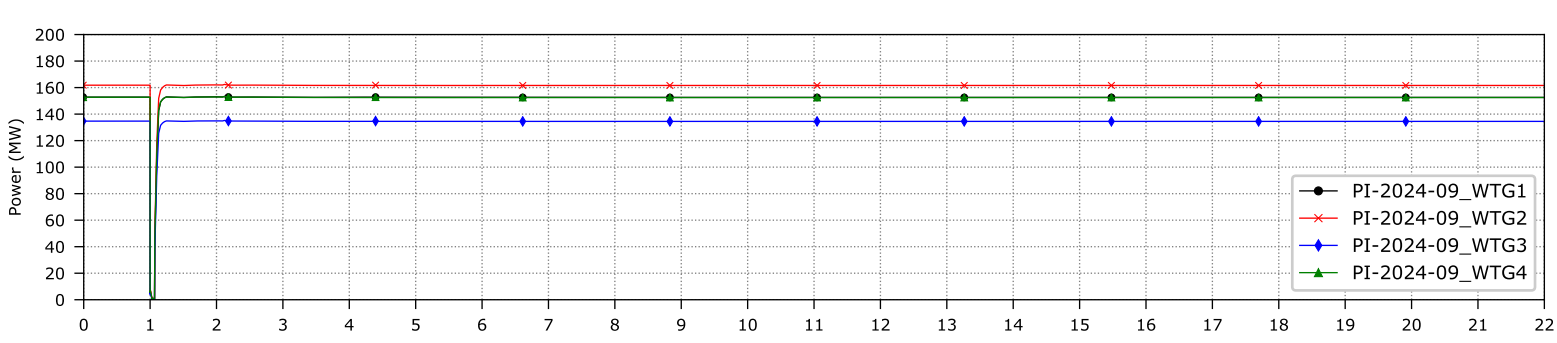


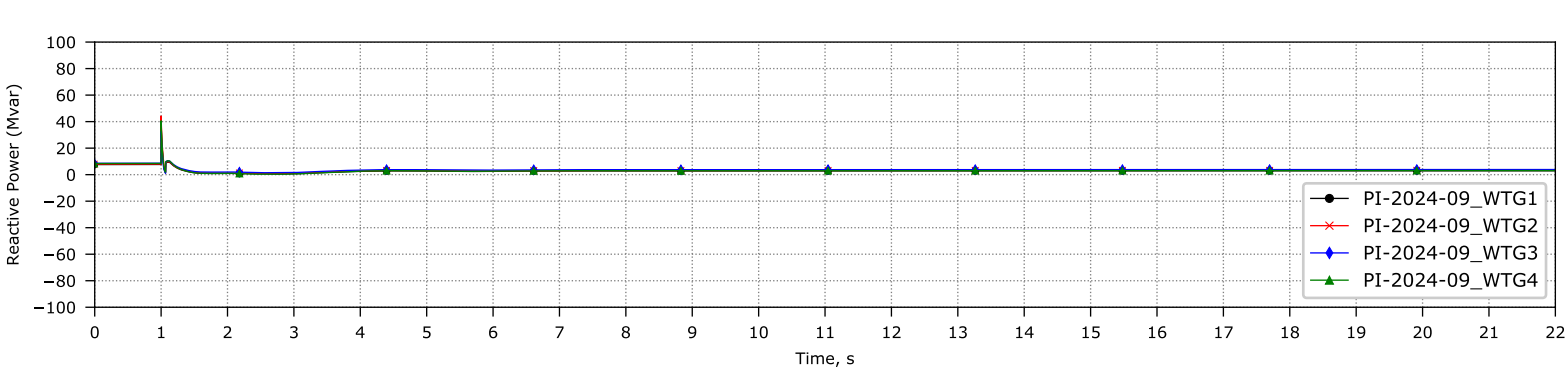
PI-2024-09_Study_East_GooseCrk-CheyRdg_345kV_Vup

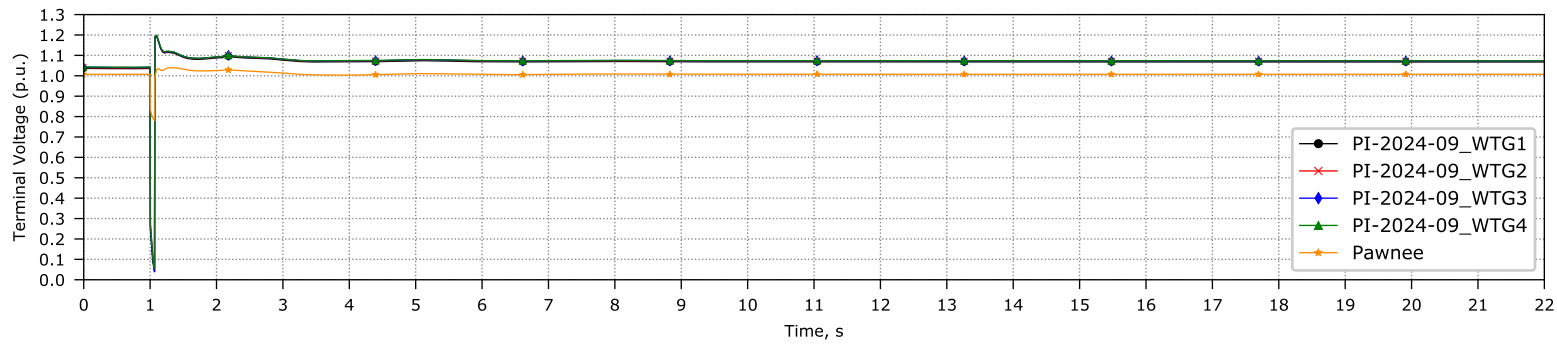


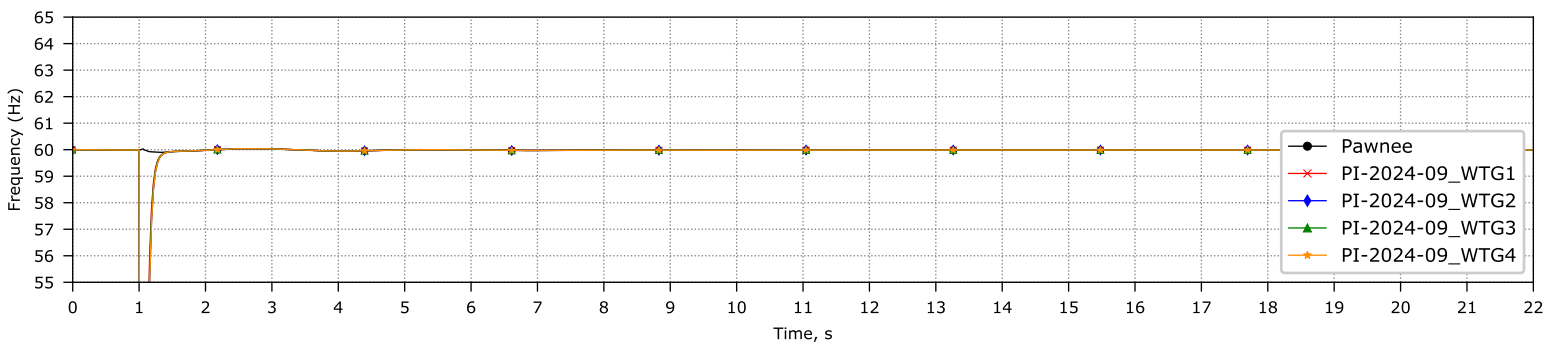


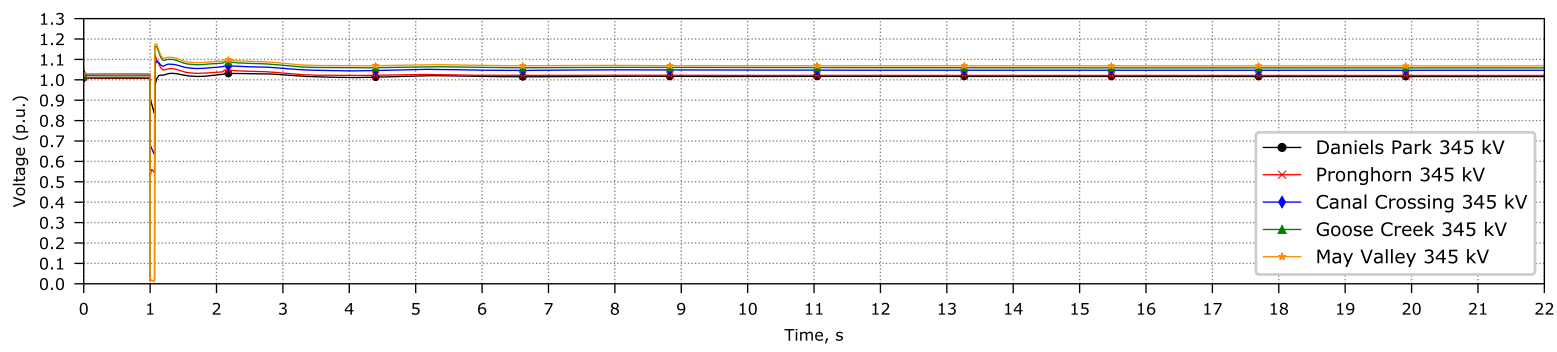












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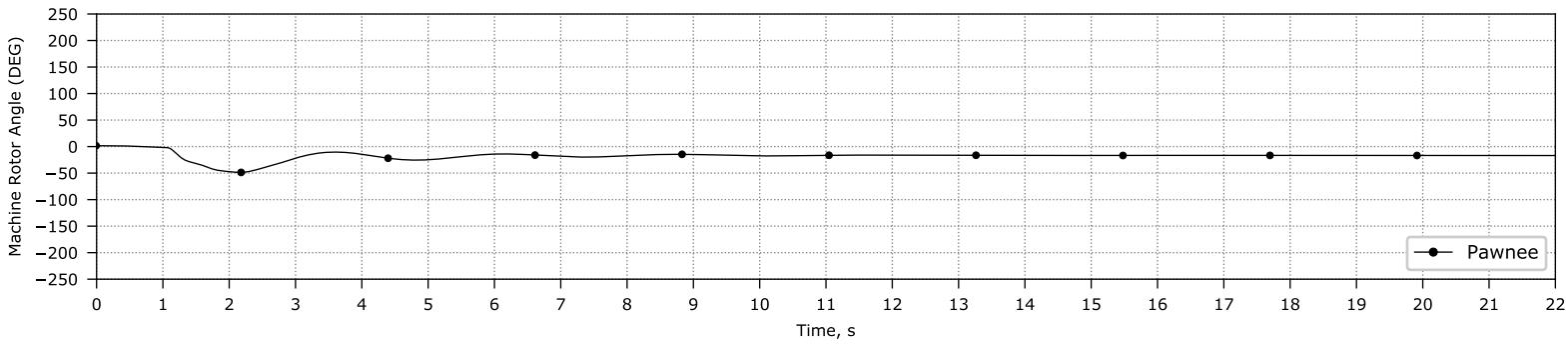

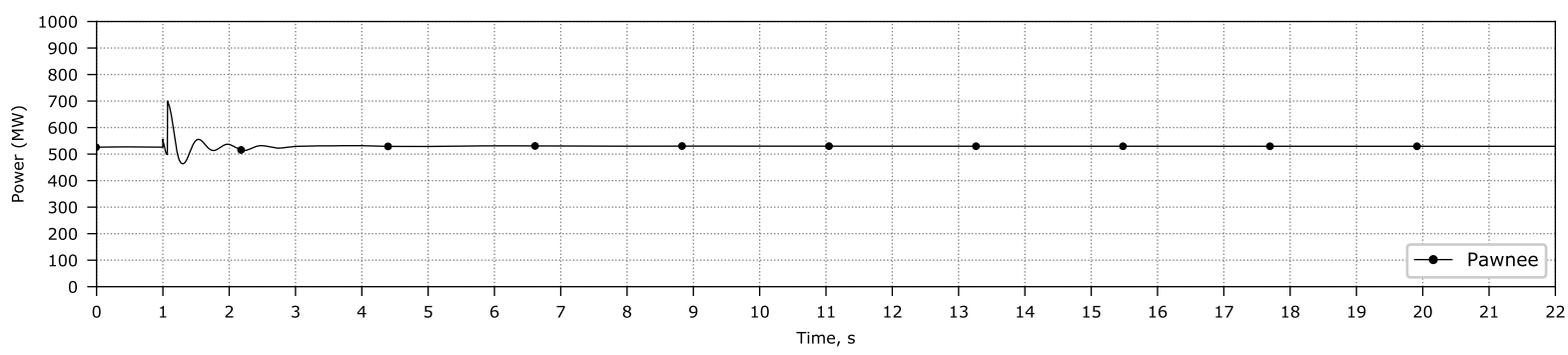

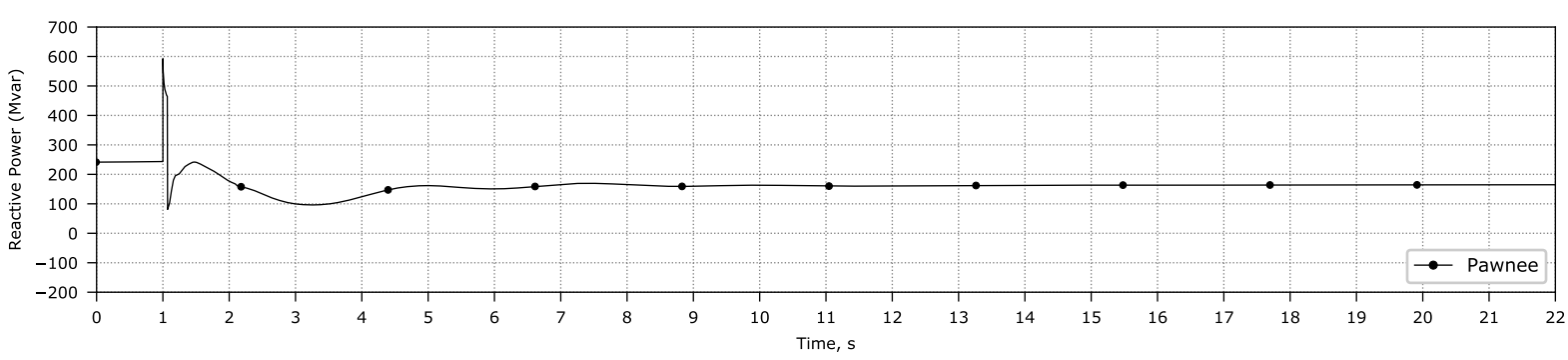

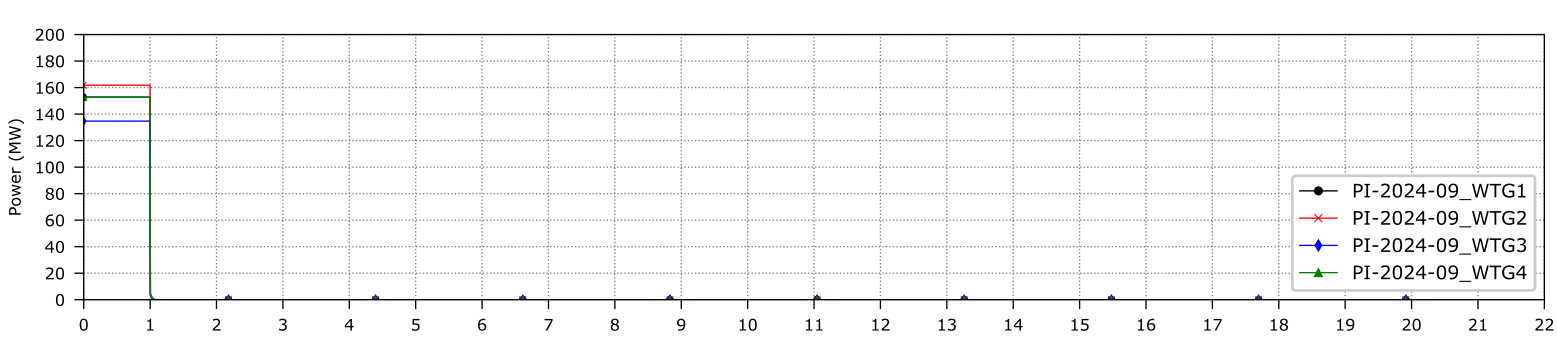

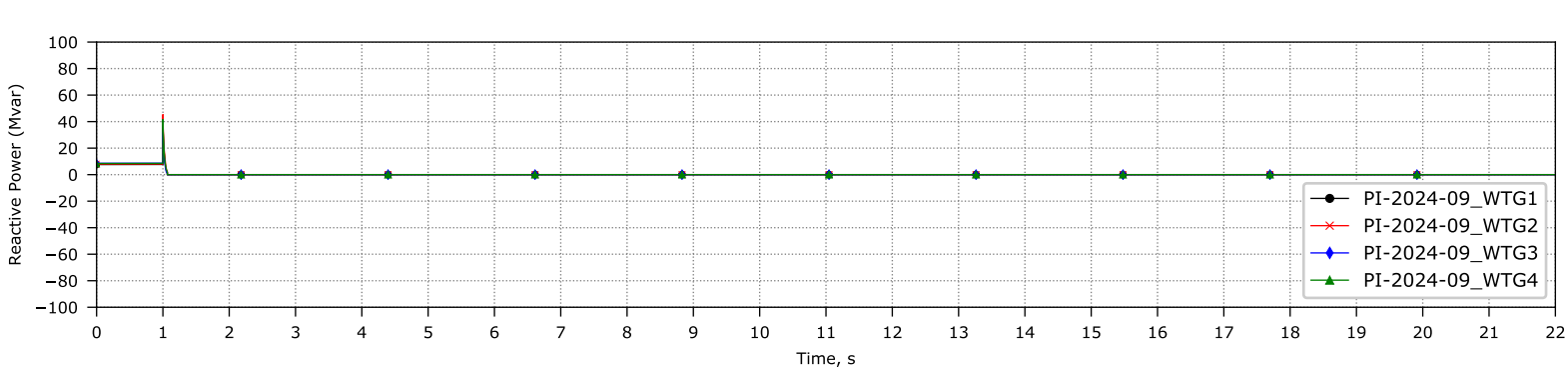

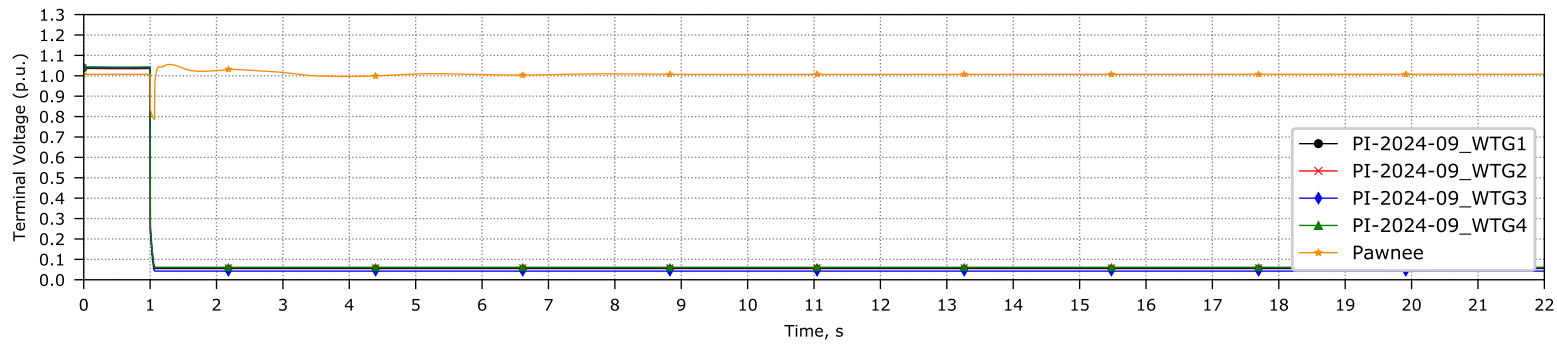

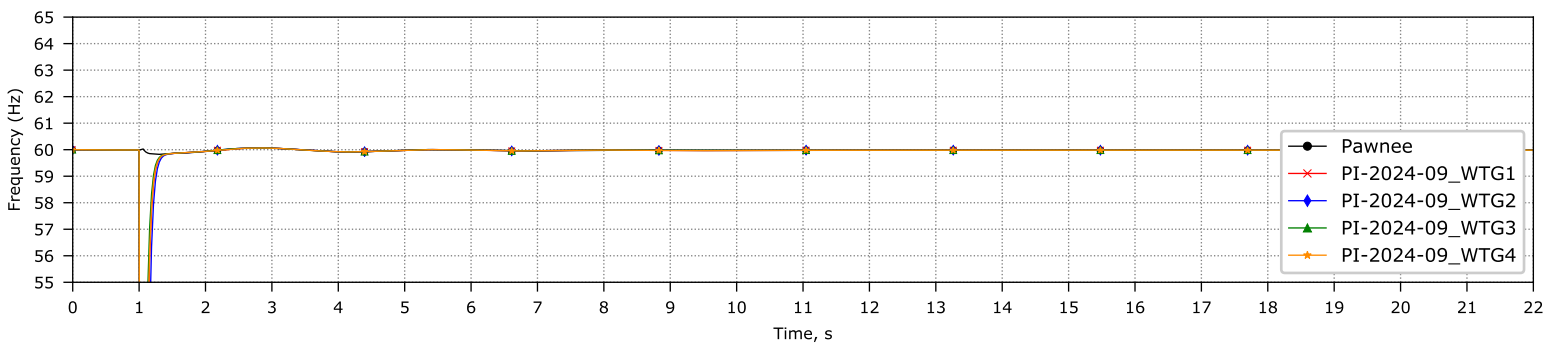

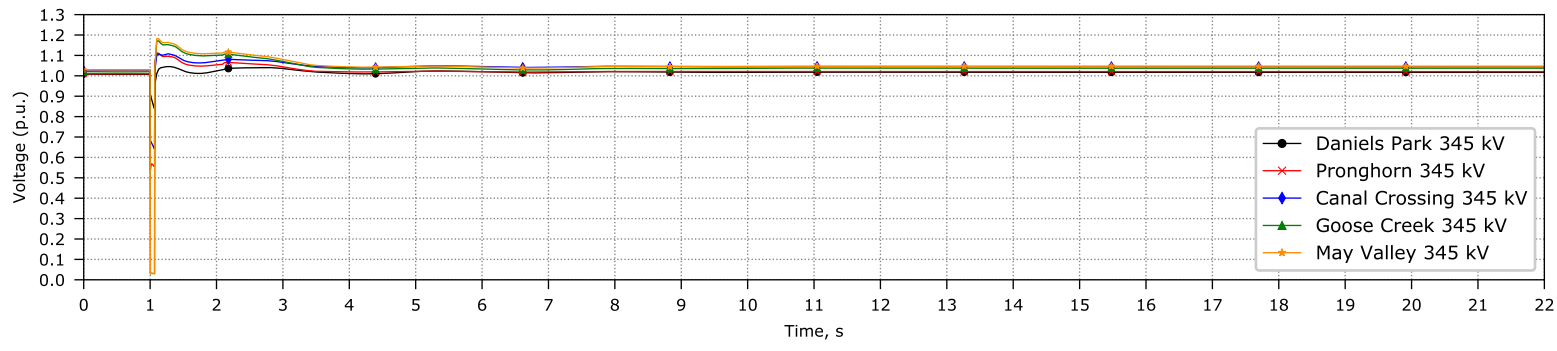

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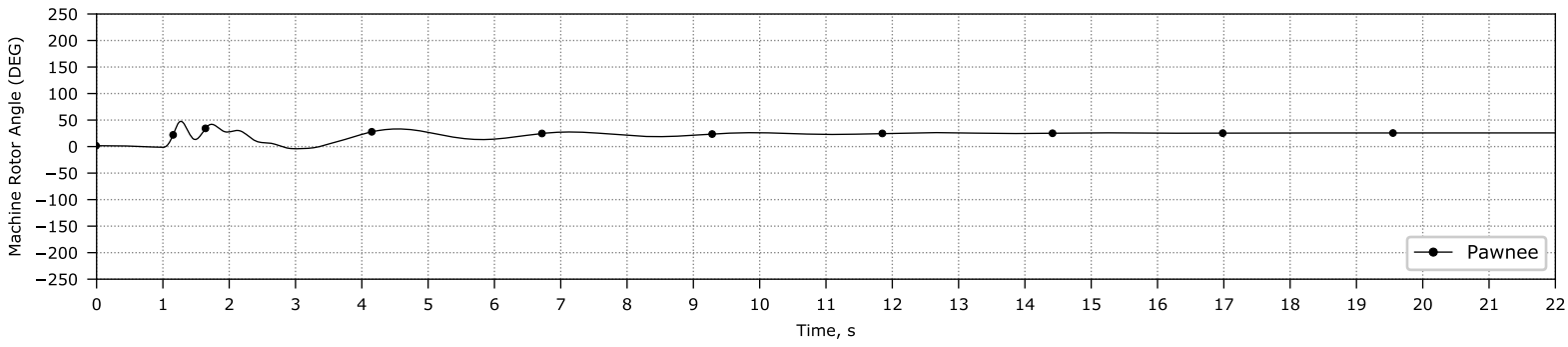

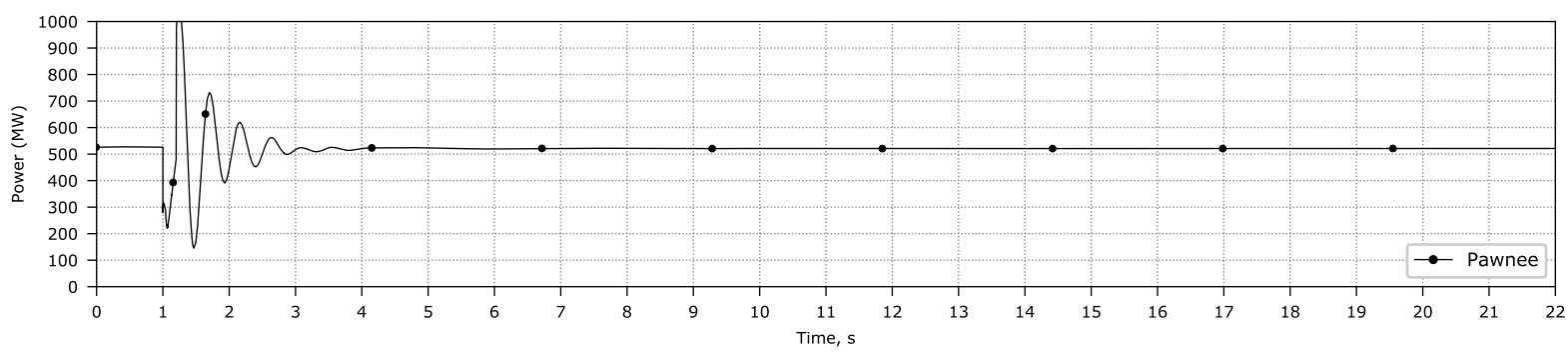

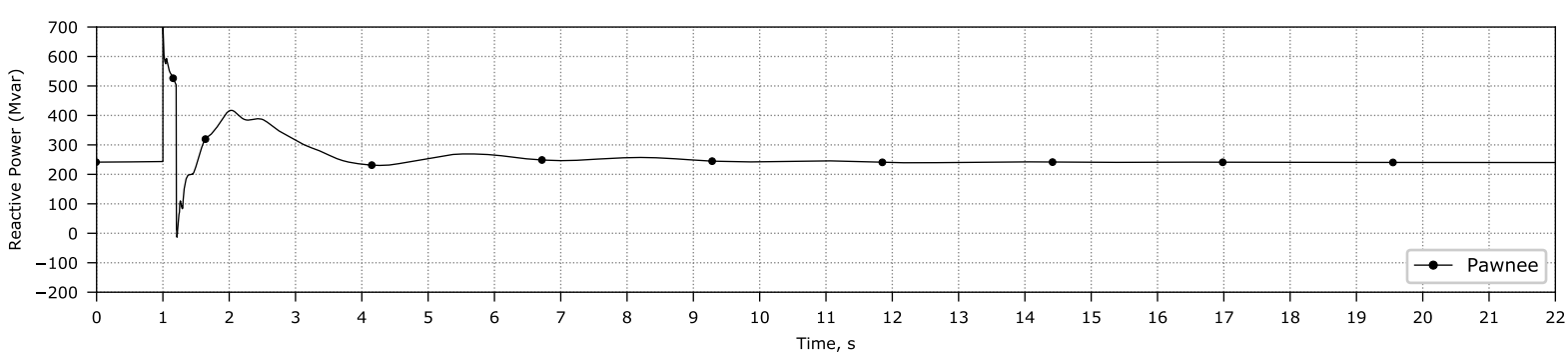

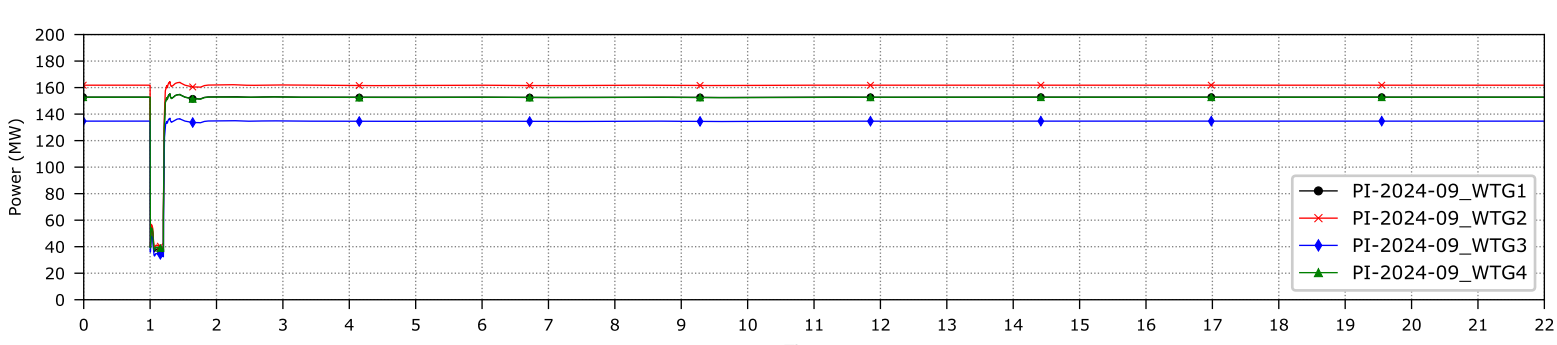

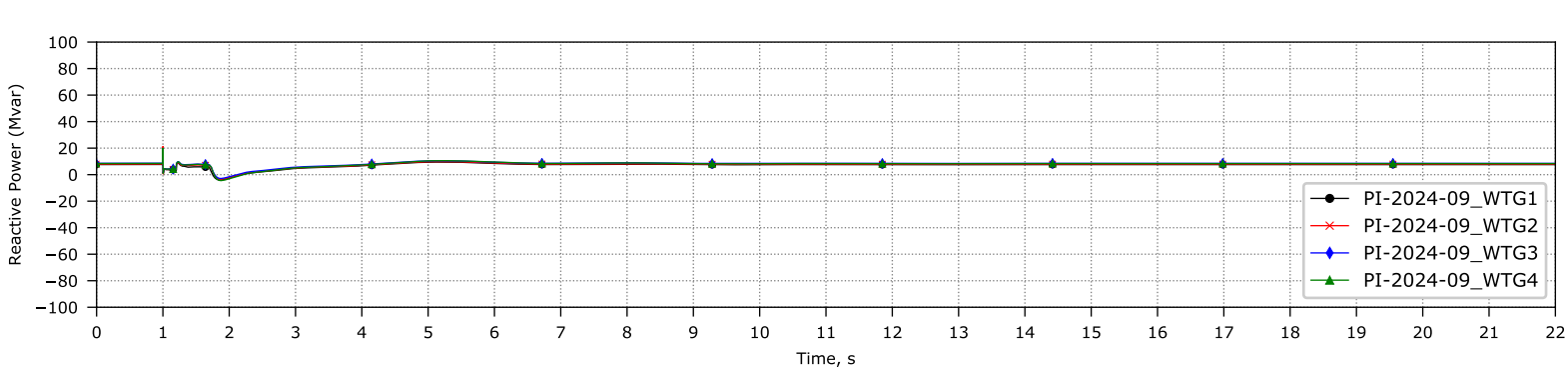

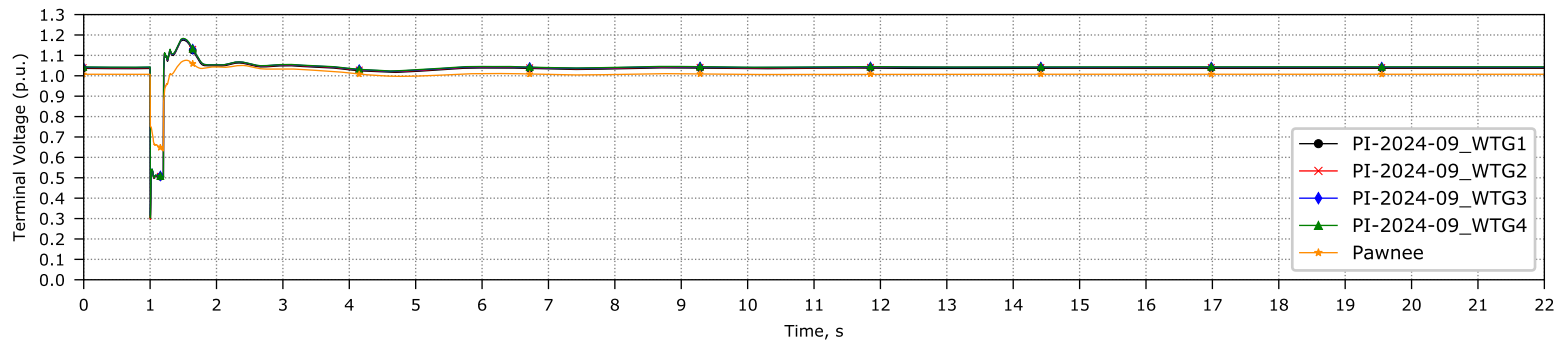

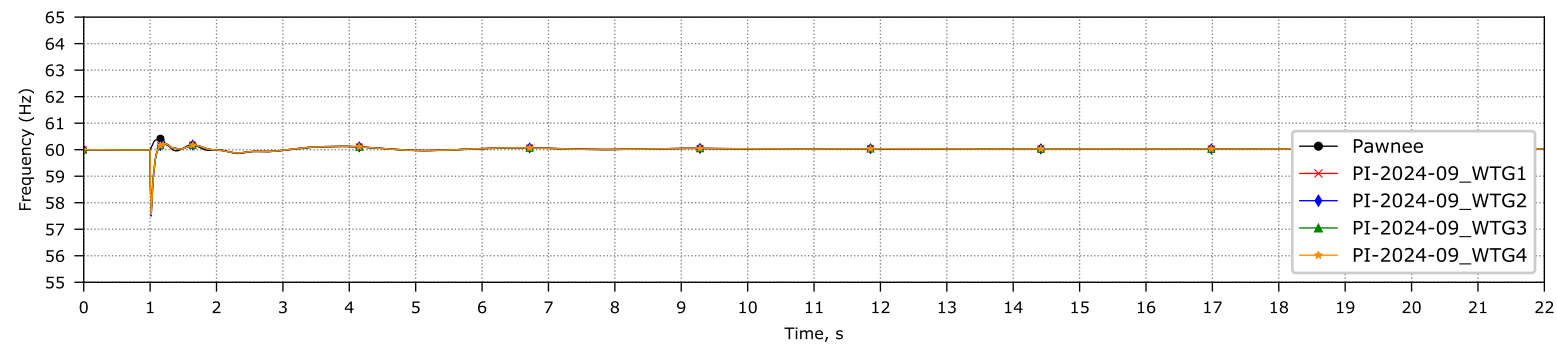

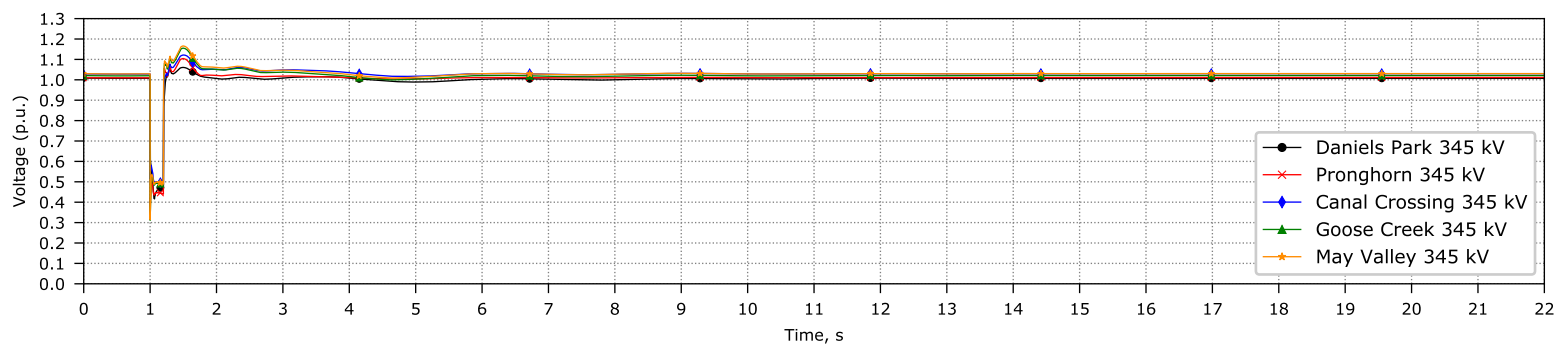

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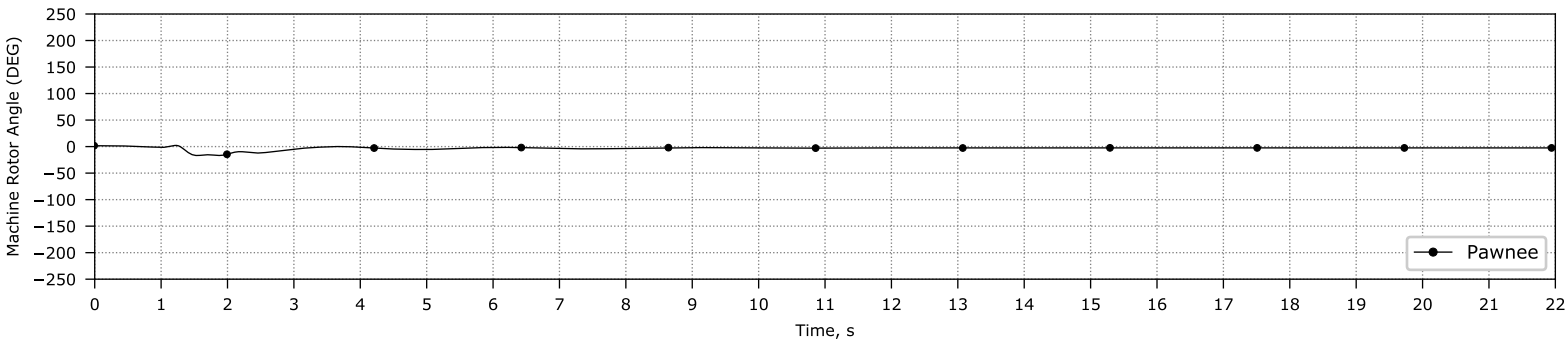

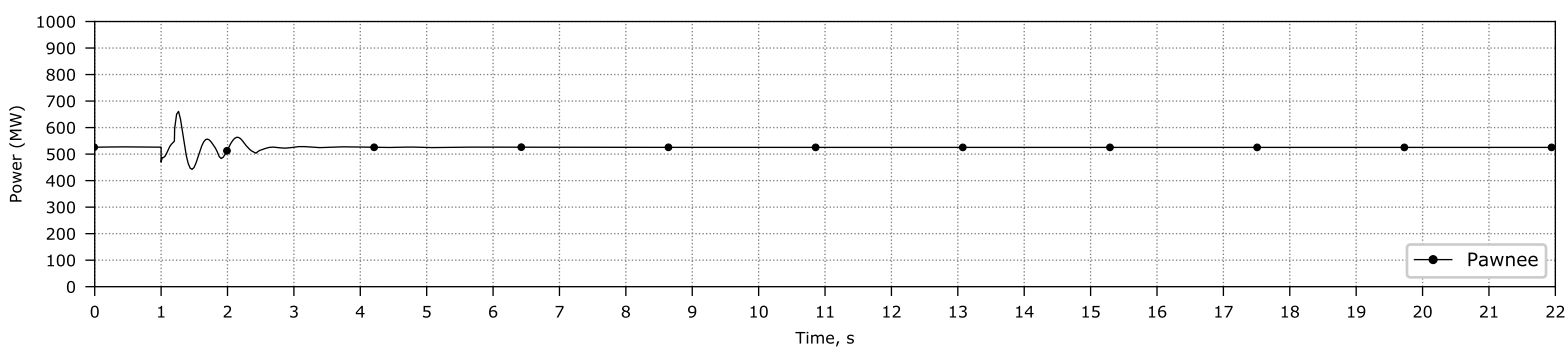

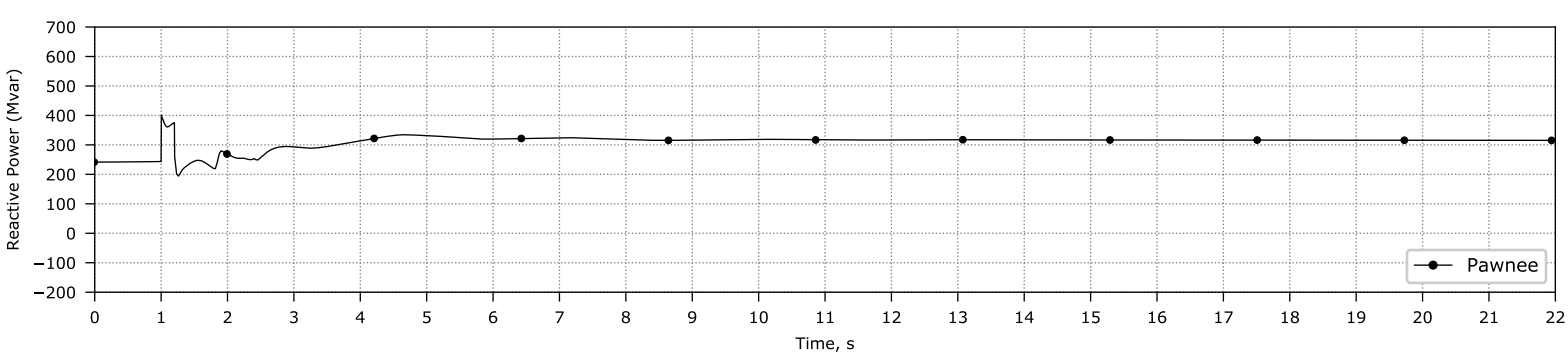

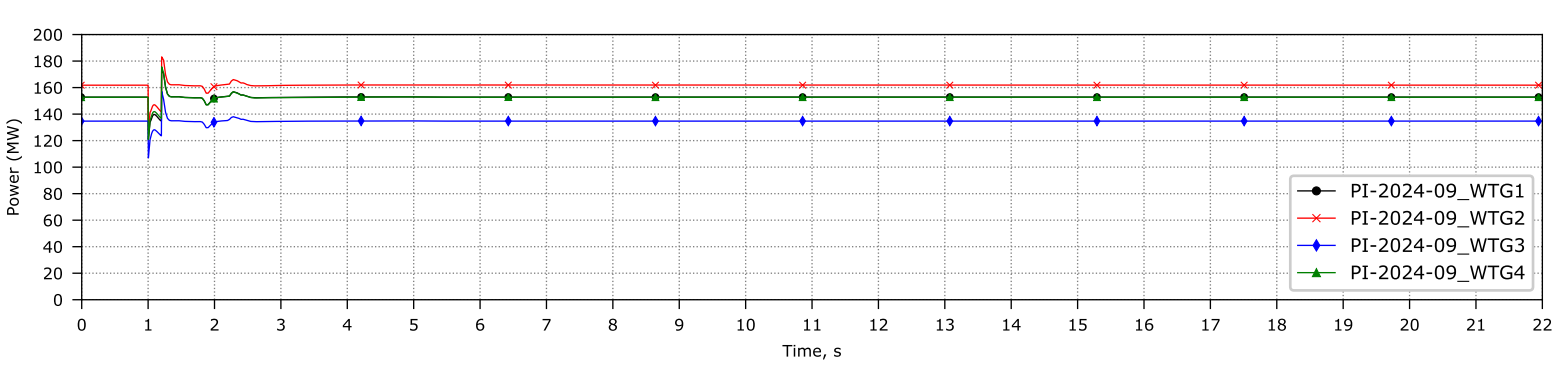

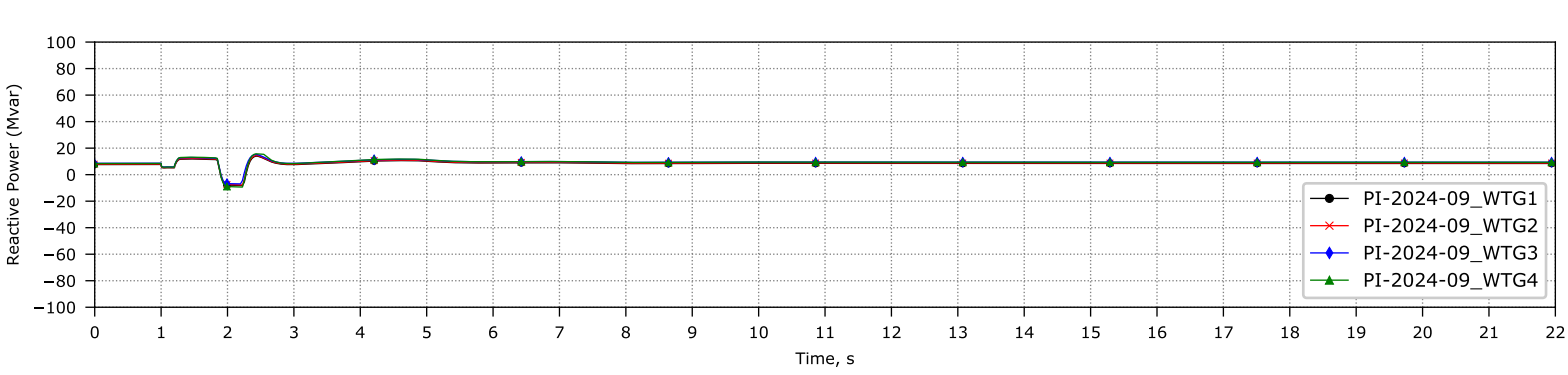

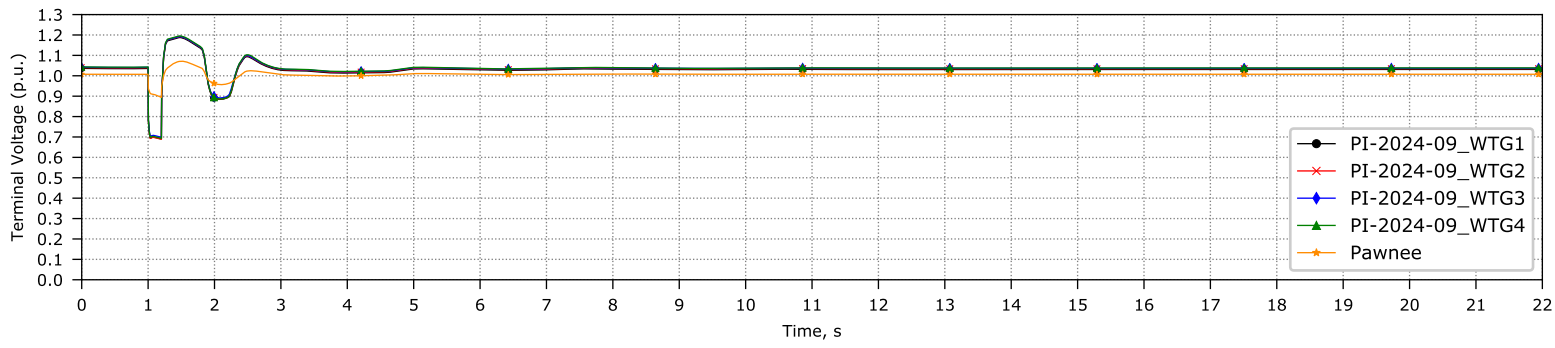

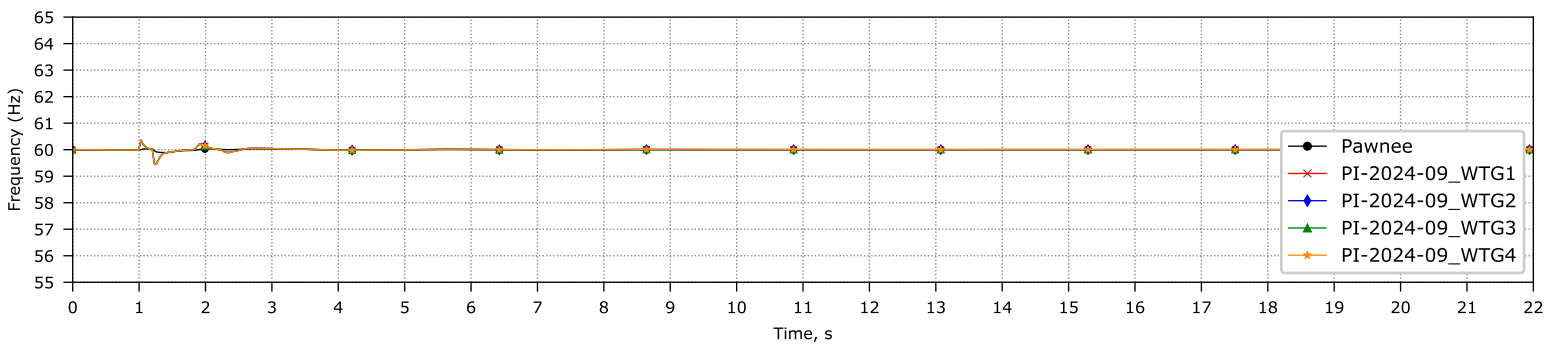

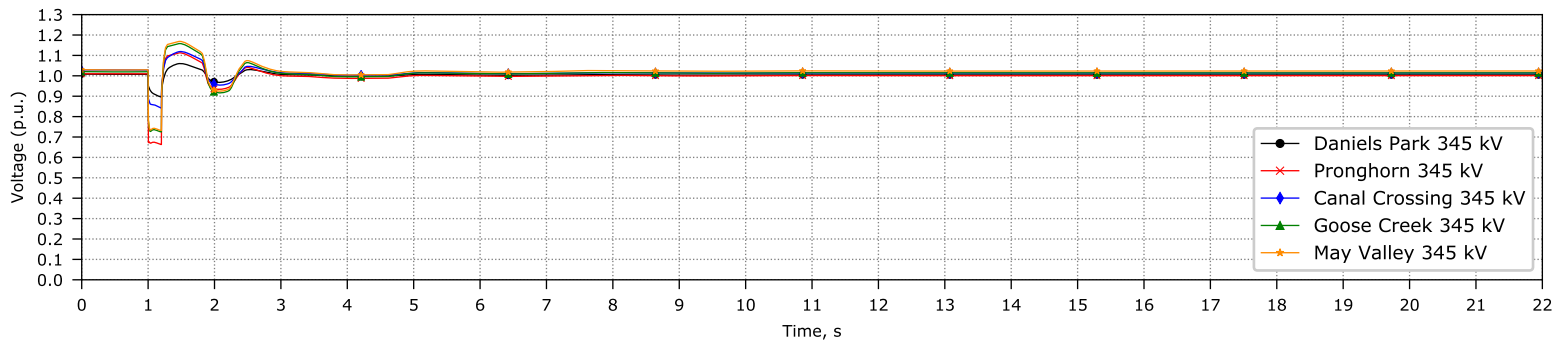

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