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City of Edmonton Transmission Reinforcement

Planning Report

AESO Project Number: P7078

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Executive Summary

The AESO performs system planning studies to assess transmission system reliability. This Planning Report describes the planning studies conducted by the AESO to assess the need for transmission development in the City of Edmonton and the Preferred Transmission Development to continue to serve load reliably in the long-term. The City of Edmonton Transmission Reinforcement (CETR) Study Area consists of the service areas of the existing Kennedale and Namao substations in the Edmonton Planning Area (Area 60). The transmission lines connecting the Kennedale substation are reaching their available capacity and the substation is forecasted to exceed its load serving capability in 2027. In addition, the transmission facility owner (the TFO) in the Study Area has confirmed that certain transmission assets in the area, namely within the Kennedale substation and the transmission lines connecting Kennedale and Namao to Clover Bar substation are reaching end of life, in poor condition and in need of life cycle replacements in the near future. This project proposes an optimized Preferred Transmission Development to address both the need to serve growing load and replace the aged transmission assets in a cost-effective manner.

To evaluate transmission system reliability as load continues to grow in the Study Area, the AESO carried out planning studies based on the load forecast for the Study Area. The planning studies performed in this report were used to establish one of the two need drivers for transmission development, evaluate the merits of Transmission Development Options and to select the Preferred Transmission Development.

Need Assessment

The AESO conducted power flow studies to assess the performance of the existing transmission system (pre-development) in the Study Area. With the forecasted growth in load in the Study Area, Category B[1] thermal criteria violations were observed on the 72 kV transmission lines 72CK12 and 72CK13 feeding the existing Kennedale substation. Without any transmission development, the Study Area does not have the capability of accommodating the growing load without the potential risk of Category B violations occurring.

Therefore, there is a need for transmission development in the Study Area to alleviate near term Category B thermal criteria violations and to continue to serve load reliably in the long-term. As part of developing this project, opportunities to transfer load to nearby substations were investigated and resulted in moving 4.7 MW of load from Kennedale to Namao and deferring the need for development. Despite the load transfer, the load in the Study Area is still forecasted to exceed the load serving capability in 2027. Additionally, aged and deteriorated transmission assets in the Study Area require developing a transmission solution satisfying the goal of minimizing future life cycle replacements in the Study Area.

Transmission Development Options and Comparative Assessment

To alleviate the identified constraints in the Study Area, the AESO investigated various Transmission Development Options, taking into consideration the technical performance, initial capital cost, life cycle cost

[1] Represents the loss of any single element in the system under specified fault conditions with normal clearing (N-1)

offsets and land use and environmental effects. The Transmission Development Options are presented in Table E-1.

Table E-1: Transmission Development Options

Option	Description
1A	Upgrade 72 kV transmission lines 72CK12 and 72CK13 between the Clover Bar and Kennedale substations
1B	Upgrade the 72 kV underground transmission lines (72CK12, 72CK13, 72NK23, 72NW15, 72JW19) between the existing Clover Bar, Kennedale, Namao, Woodcroft, and Jasper substations
2A	Add a 240 kV substation, add two 72 kV circuits and upgrade the transmission lines between the Kennedale and Namao substations
2B	Add a 240 kV substation, add two 72 kV circuits and upgrade the transmission line between the Kennedale and Namao substations
3	Add a 138 kV substation, add two 72 kV circuits and upgrade the transmission line between the Kennedale and Namao substations
4	Add a 240 kV substation, add two 72 kV circuits and discontinue from use the Kennedale substation

Option 1B and 3 were considered in the initial stage of alternative development but were later deemed infeasible. Option 1B was not feasible due to the lack of physical space required for the 240 kV bus modifications at the Clover Bar substation. Option 3 was deemed infeasible due to the TFO's limited 138 kV asset base and spare inventory, and the limited potential expandability to connect to the other existing 240 kV substations in the area. AACE class 4 (+50%/-30%) cost estimates and environmental and land use effects were prepared in accordance with section 7.1.1 of Alberta Utilities Commission (AUC) Rule 007 for the remaining four options. Option 4 as presented in Figure E-1 is the Preferred Transmission Development Option for the following considerations:

- It meets the technical requirements and will serve required load reliably in the long-term.
- It is the lowest cost option when considering both initial capital cost and future life cycle replacements offsets.
- It has one of the lowest impacts and highest net benefit overall.
- It provides the provision to expand to serve additional load in the area.
- It provides an alternative option for the future lifecycle replacement of Victoria to Rossdale underground transmission lines when these circuits reach end of life.

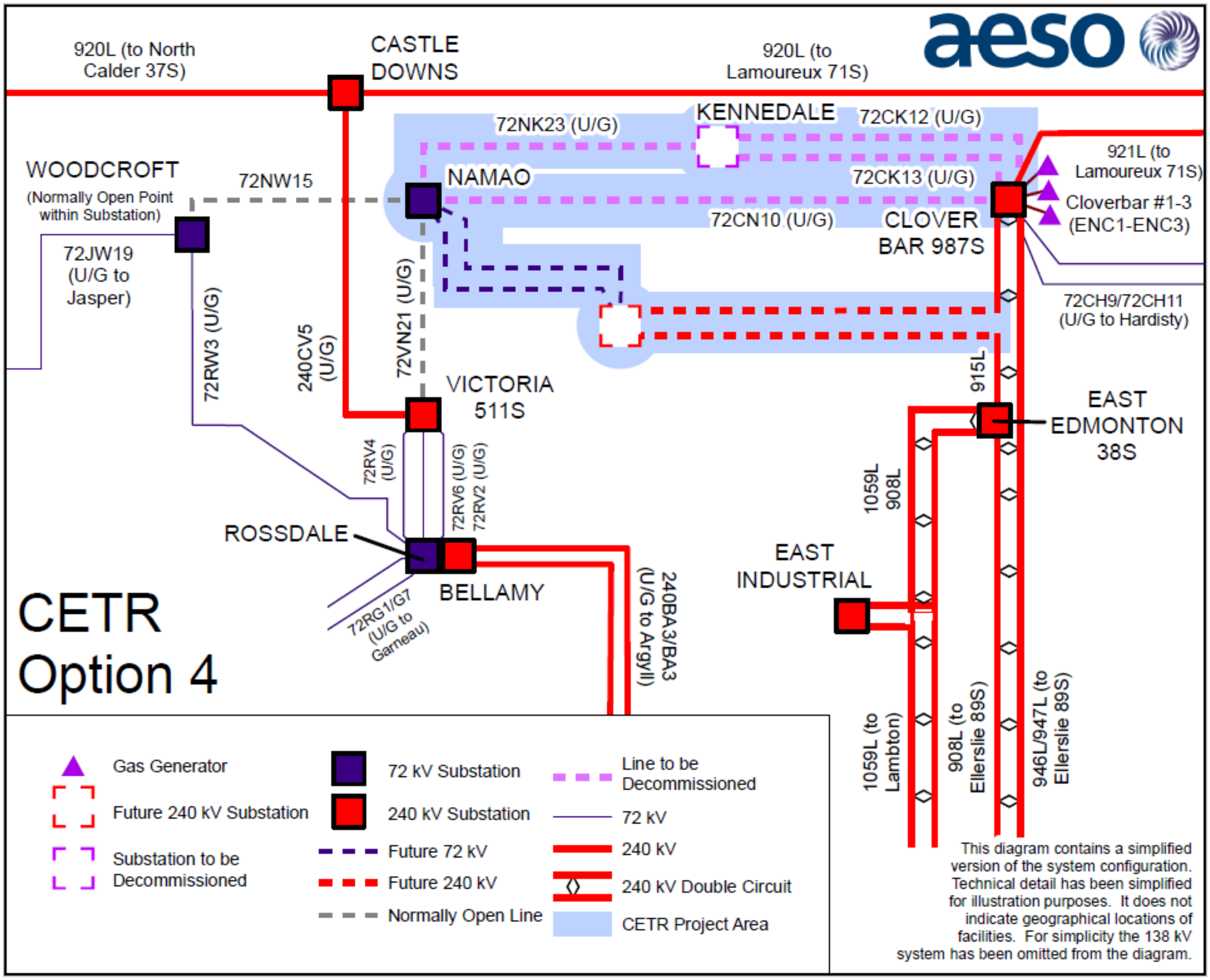

Figure E-1: Preferred Transmission Development

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Abbreviations

AESO	Alberta Electric System Operator
AC	alternating current
AIES	Alberta interconnected electric system
BC	British Columbia
DC	direct current
EATL	Eastern Alberta Transmission Line
ISD	in-service date
km	kilometer
kV	kilovolt
LTO	AESO's Long-term Outlook
LTP	AESO's Long-term Transmission Plan
MVA	megavolt ampere
MVAr	megavolt ampere reactive
MW	megawatt
NID	Needs Identification Document
RAS	Remedial action scheme
TFO	legal owner of a transmission facility
TPL	Transmission Planning Standards (part of the Alberta Reliability Standards)
VAr	volt ampere reactive
WATL	Western Alberta Transmission Line
WECC	Western Electricity Coordinating Council

1. Introduction

The AESO periodically assesses the reliability of the transmission system and compares available capacity to anticipated load and generation growth, in fulfilment of its duty to maintain a long-term transmission plan. This report describes the planning studies conducted by the AESO to assess the need for transmission development in the northeastern portion of the City of Edmonton and the Preferred Transmission Development to continue serving load reliably in the long-term. The need for upgrades in the City of Edmonton was most recently affirmed in the *2022 Long-term Transmission Plan* (2022 LTP), but it was also observed in the 2020 LTP and earlier.

The City of Edmonton is located within the Edmonton planning area (Area 60) and is served by 240 kV and 72 kV transmission systems. 240 kV Point-of-delivery (POD) substations serve load in the suburbs, while the inner city is primarily served by a network of 72 kV overhead and underground transmission lines. The 72 kV network is supplied from multiple 240 kV sources, namely, Clover Bar, Lambton, Dome, Bellamy, Victoria, Poundmaker and Jasper substations. The 72 kV network is operated primarily radial with normally open (NO) points for backup as follows:

- Namao, Kennedale and Hardisty substations are each supplied radially from 240 kV system at Clover Bar substation.
- Strathcona substation is supplied from the 240 kV system at Dome and Lambton substations.
- Rossdale substation is supplied from the 240 kV system at Victoria and Bellamy and is connected to Garneau and Woodcroft substations. Woodcroft substation is also supplied from the 240 kV system at Jasper.
- Meadowlark is supplied from the 240 kV system at Jasper and Poundmaker substations.

Figure 1-1 shows the transmission system serving the City of Edmonton.

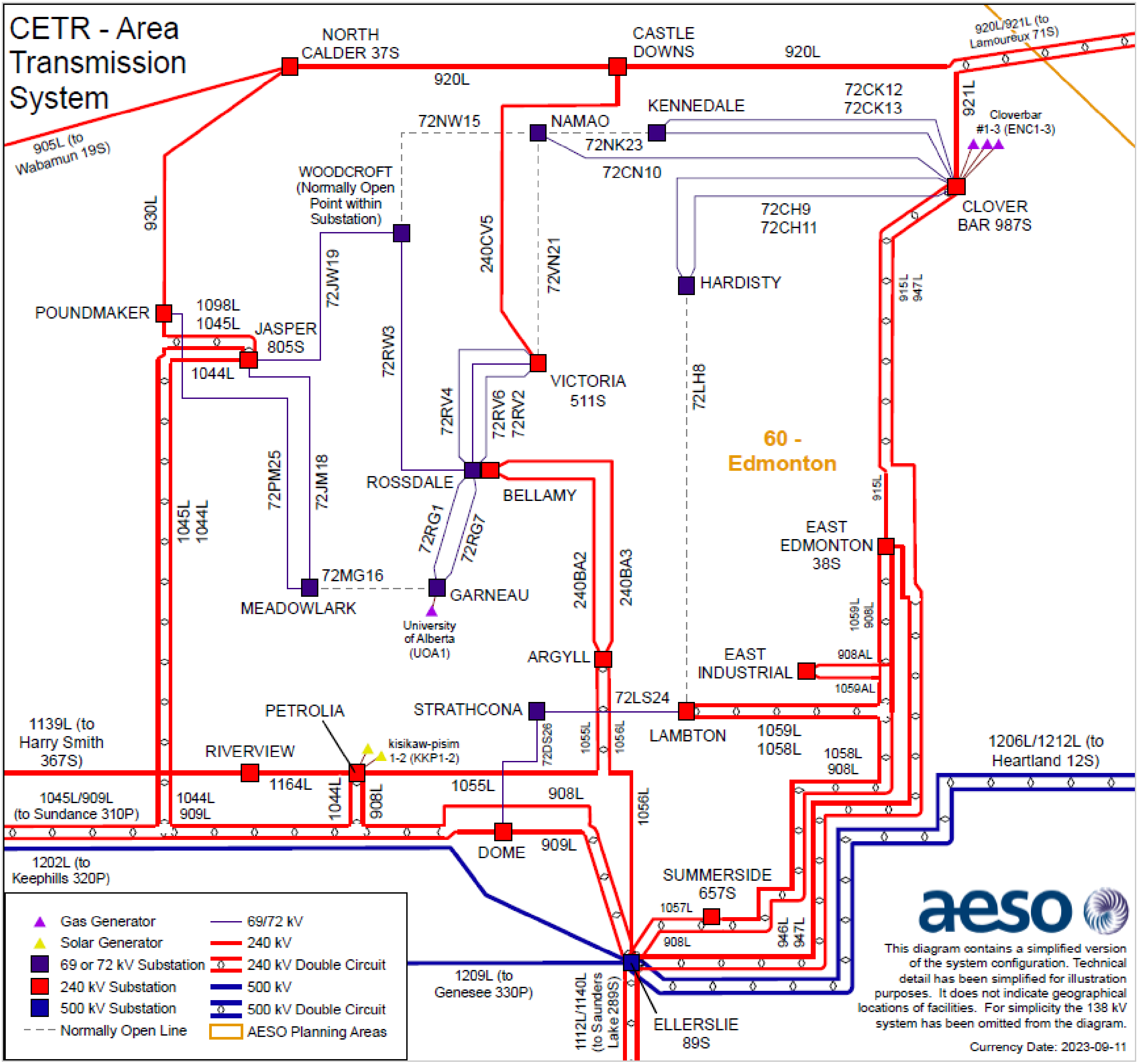


Figure 1-1: City of Edmonton Transmission System

1.1 Study Area Definitions

The Study Area of this planning report consists of the service area of Kennedale and Namao POD substations in the Edmonton planning area (Area 60). While the need identified is restricted to the 72 kV system serving the named substations, the performance of the Preferred Transmission Development was studied through the entire Edmonton planning area (Area 60) during the alternative identification and evaluation phase to ensure the preferred option does not introduce adverse impact on the rest of the planning area.

1.2 Transmission System in the Study Area

The Kennedale substation is connected to the transmission system by three underground 72 kV transmission lines. 72CK12 and 72CK13 to Clover Bar and 72NK23 to Namao. Under normal operating conditions, 72NK23 is operated normally open[2].

Namao is connected to the transmission system by three underground 72 kV transmission lines and one 72 kV overhead transmission line. 72NK23 to Kennedale, 72CN10 to Clover Bar, 72VN21 to Victoria and 72NW15 to Woodcroft substation. Under normal operating conditions, 72NW15, 72VN21 and 72NK23 are operated normally open and Namao is connected radially to the 240 kV system via 72CN10.

Figure 1-2 shows the transmission system in the Study Area. More details on how the 72 kV transmission system is operated is in Section 2.9.

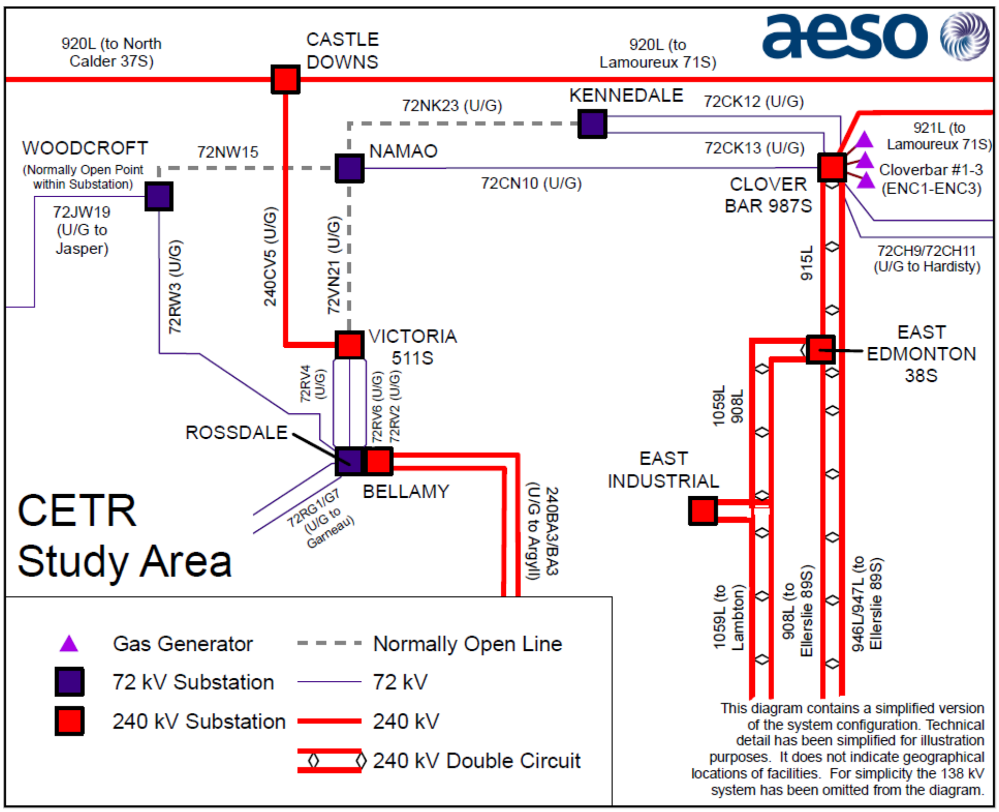


Figure 1-2: Transmission System in Study Area

1.3 Study Objectives

The objectives of the study are the following:

- Assess the need for transmission development in the Study Area.
- Develop options to address the identified transmission constraints.
- Assess options and compare performance of these options.

[2] The transmission line is open under normal system conditions.

- Recommend a preferred option.
- Identify mitigation measures if any, that may be required to ensure reliable transmission system performance.

1.4 Study Scope

The scope of the planning studies consists of three main components:

- **Need Assessment**
  The need assessment used steady state power flow analysis to calculate the load serving capability of the Kennedale and Namao substations. The load serving capability was compared against the most recent load forecast to investigate and confirm the need timing.

- **Options Analysis and Selection of Preferred Option**

  Several options were considered to address the load serving deficiency in the Study Area. The technical performance of each option was evaluated by assessing their effectiveness to reliably serve forecast load in the near-term (5 years) and the long-term (20 years). The options were also evaluated based on their total cost (including future life cycle replacement costs) and the environmental and land use effects before selecting the preferred option.

- **Performance Validation of Preferred Option**
  The performance of the preferred option was further evaluated through voltage stability and transient stability studies to ensure its performance meets reliability criteria. Short circuit analysis was performed both before and after the option is in service.

2. Reliability Standards, Criteria, Study Assumptions and System Model

This section discusses the applicable Reliability Standards, criteria, study assumptions and system model that were applied in the planning studies. The information used to create study cases, load and generation assumptions and system configuration reflects the most current information available to the AESO. While the AESO makes assumptions based on the latest available information, it is acknowledged that assumptions are subject to change over time. The AESO addresses the possible impact of changes in assumptions by monitoring active system and customer connection projects and performing regular system planning studies as part of its long-term planning process.

2.1 Transmission Reliability Standards and Criteria

The TPL Standards, which are part of the Alberta Reliability Standards[3], and *Transmission Planning Criteria – Basis and Assumptions*[4] (collectively, the Reliability Criteria) will be applied to evaluate system performance under Category A system condition (i.e., all elements in-service) and following Category B contingencies (i.e., single element outage), and Category C contingencies (i.e., multiple element outage).

Category A, often referred to as the N-0 condition, represents a normal system condition with all elements in service (N-0). All equipment must be within its applicable rating, voltages must be within their applicable range and the system must be stable with no cascading outages. Under Category A system condition, electric supply to load cannot be interrupted and generating units cannot be removed from service.

Category B events, often referred to as the N-1 conditions, results in the loss of any single element (N-1) under specified fault conditions with normal clearing. The specified elements are a generating unit, a transmission circuit, a transformer or a single pole of a direct current transmission line. The acceptable impact on the system is the same as Category A with the exception that radial customers or some local network customers, including loads or generating units, are allowed to be disconnected from the system if they are connected through the faulted element. The loss of opportunity load or opportunity interchanges is allowed. No cascading can occur.

Category C5 events results in loss of two circuits of a multiple circuit tower. All equipment must operate within its applicable rating, voltages must be within their applicable range, and the system must be stable with no cascading outages. For Category C5, the controlled interruption of electric supply to customers (load shedding), the planned removal from service of certain generators, and/or the curtailment of contracted firm (non-recallable reserved) transmission service electric power transfers may be necessary to maintain the overall reliability of the interconnected transmission systems.

Category C3 events referred to as a Category B contingency, manual system adjustments, followed by another Category B contingency. All equipment must operate within its applicable rating, voltages must be within their applicable range, and the system must be stable with no cascading outages. The controlled interruption of electric supply to customers (load shedding), the removal from service of certain generators,

[3] A complete description of these standards can be found on the AESO website at: https://www.aeso.ca/rules-standards-and-tariff/alberta-reliability-standards/

[4] Attachment I – AESO Transmission and Planning Criteria

and/or the curtailment of contracted firm (non-recallable reserved) transmission service electric power transfers is allowed both as a system adjustment and as a corrective action.

The TPL standards, TPL-001-AB-0, TPL-002-AB1-0, and TPL-003-AB-0, have referenced Applicable Ratings when specifying the required system performance under Category A, Category B, and Category C events. For the purpose of applying the TPL standards to the studies documented in this report, Applicable Ratings are defined as follows:

- Normal thermal rating of the line's loading limits for each season.
- The highest specified loading limits for transformers.
- For Category A conditions: Voltage range under normal operating condition per AESO Information Document #2010-007RS, General Operating Practices – Voltage Control (ID #2010-007RS). For the busses not listed in ID #2010-007RS, Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions applies.*
- For Category B and Category C contingency conditions: The extreme voltage range values per Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions.*

2.2 Study Years

Planning studies were carried out for the years 2026 (near-term) and 2043 (long-term). The year 2026 was selected in consideration of when the need for additional transmission capacity will materialize and the earliest possible in-service year of transmission development. The year 2043 was selected to confirm that the preferred transmission development meets the Reliability Criteria over the 20-year planning horizon.

2.3 Load Forecast

Please refer to the Forecasting Appendix for details on the load forecast.

2.4 Generation Assumptions

Generator dispatch does not impact the need of this project and hence economic dispatch was assumed for all study cases. Please refer to the Forecasting Appendix for further details regarding generation assumptions.

2.5 Transmission Developments

The study cases included all customer and system projects that (a) are relevant to the matters in question and (b) are sufficiently certain to warrant inclusion in the study.

Table 2-1 lists the customer connection projects in the Edmonton Planning Region[5] included in the planning studies.

[5] The Edmonton Planning Region consists of Edmonton (Area 60), Wabamun (Area 40) and Wetaskiwin (Area 31)

Table 2-1: Customer Projects Included in the Planning Studies

AESO Project Number	Project Name	Rate DTS (MW)	Rate STS (MW)	In-service Date (ISD)
1649	P1649 EPCOR Garneau Area Upgrade	0	0	Dec 19, 2023
2383	P2383 CP Genesee Unit 6 Gas	0	411	Dec 15, 2023
2389	P2389 CP Genesee 1 Repower ST	0	-100	Apr 17, 2024
2409	P2409 CP Genesee Unit 7 Gas	3	411	Dec 4, 2023
2410	P2410 CP Genesee 2 Repower ST	0	-100	Jun 16, 2024
2453	P2453 EDTI Edmonton 3 H2 Plant Cogen	50	20	Nov 1, 2024

There are no active system projects in the area that are relevant to the need of this project.

2.6 Interties

The Alberta interconnected electric system (AIES) is presently connected to British Columbia via WECC Path 1, which is the Alberta-British Columbia Intertie (AB-BC intertie); to Saskatchewan via WECC Path 2 (AB-SK); and to Montana via the Montana Alberta Tie-Line (MATL) (WECC Path 83). Intertie flows do not impact the need of this project and hence economic dispatch was assumed for all interties.

2.7 Voltage Profile Assumptions

The voltage profile in the Study Area was established with the primary goal of ensuring pre- and post-contingency voltages at substations in the Study Area were within equipment ratings. ID #2010-007RS was used to establish system normal (i.e., pre-contingency) voltage profiles for key area buses prior to commencing any of the planning studies. For the buses not included in ID #2010-007RS, Table 2-1 of the *Transmission Planning Criteria – Basis and Assumptions* [6] applies. These voltages were used to set the voltage profile for the study base cases prior to the planning studies.

2.8 Transmission Facility Ratings

Transmission facility ratings in the Study Area were provided by the respective TFOs, which was the most recent information available when the planning studies commenced. The ratings of major transmission lines in the Study Area which impact the need of this project are summarized in Table 2-2.

Table 2-2: Transmission Line Ratings

Name	From	To	Voltage	Summer	Winter
240CV5	Castle Downs (557S)	Victoria (511S)	240	475	503
72CK12	Clover Bar (987S)	Kennedale	72	48	53
72CK13	Clover Bar (987S)	Kennedale	72	48	53
72CN10	Clover Bar (987S)	Namao	72	55	63

[6] Attachment I – AESO Transmission Planning Criteria

72RG1	Rossdale	Garneau	72	61	64
72RG7	Rossdale	Garneau	72	94	99
72RW3	Rossdale	Woodcroft	72	66	79
920L-2	Castle Downs (557S)	Lamoureux (71S)	240	419	499
72VN21	Victoria	Namao	72	64	76
72NW15	Namao	Woodcroft	72	64	89
72NK23	Namao	Kennedale	72	58	64

2.9 System Operating Assumptions

Some transmission lines, listed in Table 2-3, were assumed to be normally open meaning they are open under normal system conditions. This aligns with current real time operating procedures. The EDTI transmission system is unique in the AIES as it operates with normally open points to ensure the system can remain reliable. Additional overloads can occur if the system is operated in a meshed manner as cross flows can exceed line ratings under both Category A and Category B conditions. These assumptions were tested and validated in a sensitivity study in Section 4.2.3. In addition, fault levels can further increase under these conditions.

Table 2-3: Normally open lines

Line name	From	To
72NK23	Kennedale	Namao
72VN21	Victoria	Namao
72NW15	Namao	Woodcroft
72LH8	Lambton	Hardisty
72MG16	Meadowlark	Garneau

The following operational practices are followed in contingency events of transmission lines feeding Kennedale and Namao substations:

- 72CK12 outage: Transfer to 72CK13 and close the normally open lines 72NK23 and 72VN21. Separate the 72 kV bus at Kennedale to avoid backfeeding Victoria. 72CK12 can be loaded up to emergency ratings[7] to facilitate switching time as 72NK23 cannot be closed remotely.

- 72CK13 outage: Transfer to 72CK12 and drop any load beyond the continuous rating[8] of 72CK12. 72NK23 cannot be utilized to feed Kennedale as it will result in backfeed to Victoria substation. This is the most limiting condition for the purpose of identifying load serving capability as Kennedale substation is served by one remaining 72 kV line.

- 72CN10 outage: Close the normally open line 72VN21.

[7] 72CK13 has summer emergency ratings of 64/115 MVA for 4hrs/10 min when 72CK12 is out of service.

[8] 72CK12 has summer continuous rating of 60 MVA when 72CK13 is out of service.

2.10 Dynamic Data and Assumptions

In the planning studies, validated dynamic data was used for existing equipment in the AIES such as generators, wind farm turbines, motor loads and static VAR compensators (SVCs) when available. If validated data was not available, generic dynamic models were adopted for existing equipment and for facilities planned to be in service within the timeline of the planning studies.

2.11 Protection Fault Clearing Times

The transient stability studies were performed using the protection fault clearing times provided by the TFOs. If the TFO did not specify the fault clearing times (e.g., for new transmission lines) for a selected contingency, then the studies for that contingency were performed using the standard fault clearing times that are specified in Table 2-3 of the AESO's *Transmission Planning Criteria – Basis and Assumptions*.

Fault clearing times for selected contingencies are provided in Attachment E.

2.12 Controllable System Elements

EATL and WATL are HVDC transmission lines. Both were initially dispatched to minimize system losses in the base cases. If there were any relevant transmission line constraints observed and these constraints could be alleviated by re-dispatching WATL and EATL, the power order for WATL and EATL was changed accordingly. The HVDC terminals (WATL and EATL) were assumed to be operated in a way that minimizes VAR exchange, as is standard procedure.

The Keephills phase-shifting transformer had a neutral tap setting.

2.13 Existing RAS in Study Area

The existing transmission system in the Study Area is being operated with the help of RAS and automatic protection scheme (APS) that result in generation curtailment, reconfiguration of transmission lines, and HVDC re-dispatch to avoid thermal criteria violations and/or voltage violations during contingency conditions. Table 2-4 lists the existing RAS and APS in the Study Area that designed to operate automatically in real-time to protect the system from Reliability Criteria violations.

Table 2-4: Existing RAS and APS in Study Area

RAS and APS No.	Scheme Name
172	Garneau – Meadowlark Reconfiguration Scheme
1614	Clover Bar 987s anti-islanding scheme

3. Planning Methodology

The methodology used to conduct the planning studies included the following:

- Develop credible study cases using various load conditions and generation dispatches for the planning studies.
- Conduct need assessment studies in the near-term by evaluating the current load serving capability in the Study Area prior to transmission development and identify potential system constraints in the Study Area in the near-term.
- Develop Transmission Development Options to address the identified system constraints.
- Evaluate the performance of the proposed Transmission Development Options and select the Preferred Transmission Development.
- Evaluate the transmission system performance of the Preferred Transmission Development in the long-term.
- Verify the performance of the Preferred Transmission Development through voltage stability and dynamic stability studies.
- Perform short-circuit analysis for the substations within and surrounding the Study Area, both before and after implementation of the Preferred Transmission Development.

3.1 Study Scenarios

Study cases represent credible stressed operating conditions in the Study Area. All study cases used coincidental peak load conditions and economic dispatches for generation in the Study Area. Two sensitivity cases were developed to test different penetration levels of EV load at Kennedale and Namao substations. Refer to Forecasting Appendix for further details regarding load and generation assumptions. The study cases are listed in Table 3-1.

Table 3-1: Need assessment study cases

Case name	Year	Load condition	System load	Edmonton load	Edmonton generation
P7078_2023RC_2026SP	2026	Summer Peak	11259	1829	239
P7078_2023RC_2026WP	2026	Winter Peak	12294	1781	236
P7078_2023RC_2043SP	2043	Summer Peak	13103	2388	76
P7078_2023RC_2043SP_High EV*	2043	Summer Peak	13091	2376	76
P7078_2023RC_2043SP_Managed*	2043	Summer Peak	13064	2349	76
P7078_2023RC_2043WP	2043	Winter Peak	15330	2792	376
P7078_2023RC_2043WP_High EV*	2043	Winter Peak	15196	2659	376
P7078_2023RC_2043WP_Managed*	2043	Winter Peak	15158	2621	376

* Sensitivity cases for different EV penetration levels at Kennedale and Namao substations.

3.2 Power Flow Analysis

Category A and B power flow analysis was conducted for the 2026 study year to identify thermal and voltage criteria violations on the 72 kV transmission system in the Study Area. This analysis was performed for the need assessment prior to any new transmission development in the area to identify reliability standards violations and limiting elements. Category A and B power flow analysis was conducted again for each of the proposed Transmission Development Options for the 2026 year. Category A and B power flow analysis was completed with the Preferred Transmission Development in-service for the 2043 study year. The observed thermal loading percentage shown in the result tables are as measured by current.

3.3 Voltage Stability Analysis

The objective of the voltage stability analysis was to determine the ability of the system to maintain voltage stability margin under Category A, Category B and select Category C5 system conditions. The power voltage (PV) curve is a representation of voltage change as a result of increased power transfer between two sub-systems. As the transfer between two sub-system increases, the voltage in the source system decreases and eventually voltage collapses at certain level of power transfer. The PV margin is defined as the minimum of the percentage increase in transfer to the point of voltage collapse for all the studied contingencies. Voltage stability studies were carried out both before and after the Preferred Transmission Development systems is in service for 2026 study years. Interface flow and voltages of the all the buses in the Study Area were monitored and the voltage stability analysis was carried out for selected Category B and Category C5 contingencies in the Study Area.

As both the existing system and Preferred Transmission Development in the Study Area consist of a pocket of load fed by the 240 kV at or around the Clover Bar substation. Load at Kennedale and Namao substations were simulated as a sink system while generators outside the Study Area in the Wabamun (Area 40), Northeast Region and South Region were simulated as source system. The flow towards the load at Kennedale and Namao was monitored. The load at Kennedale and Namao substations was increased while generation in the source system was increased until voltage collapse. The voltage stability criteria defined in Table 2-2 of the *Transmission Planning Criteria – Basis and Assumptions* was used to test if voltage stability margin can be met up to the forecast load of 2043 to assess that the Preferred Transmission Development can meet the forecast long-term load.

3.4 Transient Stability Analysis

The objective of the transient stability analysis is to determine the ability of the system to maintain rotor angle stability under Category B and select Category C5 system conditions. In the transient stability analysis, three-phase-to-ground faults for Category B contingencies and single-phase-to-ground faults for Category C5 contingencies were applied to critical 69 kV and higher voltage class transmission elements in the Study Area to assess transmission system stability both before and after the Preferred Transmission Development is in service for both 2026 and 2043 study years. The faults were cleared by opening the near-end and far-end breakers according to the fault clearing times shown in Attachment E. The Reliability Criteria was applied as outlined in Section 2 and a system dynamic response was considered acceptable if the following conditions were met after a disturbance:

- All the generators remained stable and connected to the AIES.
- The post-contingency voltage did not differ from the pre-fault voltage by more than 10%.
- All oscillations in the system were damped successfully.
- No uncontrolled separation of the interties is allowed.

3.5 Short-circuit Analysis

The objective of short-circuit analysis was to assess whether the maximum fault currents exceed the capability for the circuit breakers to clear faults and to ensure equipment in the area is capable of carrying the anticipated short-circuit flow. Short-circuit levels were analyzed under three-phase-to-ground faults and single-line-to-ground faults with all the generators in and around the Study Area dispatched. The short-circuit analysis was carried out both before and after Preferred Transmission Development system is in service for both 2026 and 2043 study years.

4. Need Assessment

4.1 Need Assessment Methodology

Under normal conditions described in Section 2.9, Kennedale substation is connected to the transmission system radially via the parallel transmission lines 72CK12 and 72CK13 as shown in Figure 4-1.

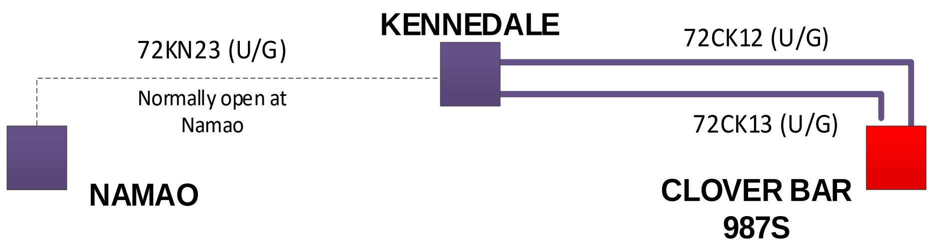


Figure 4-1: Kennedale under Normal Conditions

The load at Kennedale substation was scaled up to determine the capability to serve load reliably without special operational measures. Specifically, the load serving capability was determined for Category B system condition of either 72CK12 or 72CK13 respecting the continuous ratings in Table 2-2.

A similar study was done for Namao which is connected radially via 72CN10 as shown in Figure 4-2.

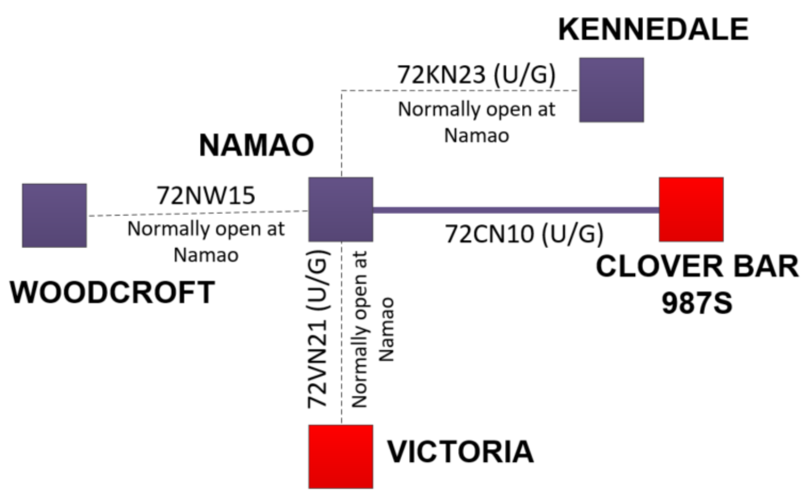


Figure 4-2: Namao under Normal Conditions

Load serving capability was compared to the load forecast to estimate the year when the system will be unable to serve load in a reliable manner.

A sensitivity study was also completed to determine the load serving capability for a different configuration of normally opened and closed lines. This was to confirm whether the current system configuration results in highest load serving capability.

4.2 Need Assessment Results

4.2.1 Load Serving Capability of Existing System - Kennedale

The load serving capability of the existing system was determined to be 55.1 MW. The most limiting contingency is 72CK13 and the limit is the continuous rating of 72CK12 when 72CK13 is out of service. The year when the existing system will no longer be able to serve the load based on the load forecast at Kennedale substation is 2027. There are no operational measures available to increase the capability of the existing system.

Due to the configuration of Kennedale substation shown in Figure 4-3, the contingency of 72CK12 does not result in the same impact. This is because post contingency of 72CK12, the substation bus can be split via a bus breaker keeping 72CK13 feeding load of one transformer and then 72NK23 from Namao substation can be closed to feed the second transformer. The theoretical capability limit of the existing system post operational measure is the thermal rating of both 72CK13 and 72NK23 notwithstanding violating the thermal limits of other elements upstream or downstream from the 72 kV cables and other limits (e.g., voltage limits). This operational measure is not available for the contingency of 72CK13 because both 72CK12 and 72NK23 are physically on the same side of the bus and closing 72NK23 would result in backfeeding Victoria. When 72NK23 is closed, 72VN21 must also be closed. This results in violations on all lines on the path from Clover Bar to Victoria as the stations are no longer connected radially and Clover Bar generation is being pushed to it through stressed lines 72CK12, 72CK13, 72CN10, 72NK23, and 72VN21.

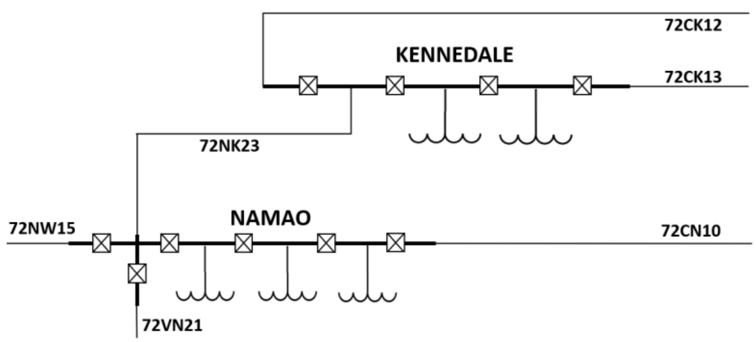


Figure 4-3: Kennedale and Namao Substation Configuration

4.2.2 Load Serving Capability of Existing System - Namao

The load serving capability of existing system at Namao was determined to be 49.9 MW which the peak load on the existing system exceeds. To address potential Category A overload on 72CN10 under peak load, the system is reconfigured to bring 72VN21 into service in order to split Namao load between 72CN10 and 72VN21. This mitigates potential Category A overloads during peak load but this reconfiguration is not a viable long term solution as 72CN10 is in deteriorated condition and will require lifecycle replacement in the next 10 years (see Section 4.6).

4.2.3 Sensitivity of Load Serving Capability under Normally Closed System

A sensitivity study was completed to confirm that the existing system in its present configuration (i.e., operated as a normally open system) is maximizing the use of existing load serving capability. The normally open lines around Namao and Kennedale, 72NK23, 72VN21, and 72NW15 were closed in different combinations. The impact of these combinations was assessed under both high and low Clover Bar dispatch. The results of the study are present in Table 4-1 and Table 4-2.

Table 4-1: Number of flow violations under each contingency under high Clover Bar dispatch

	N-0	72CK12	72CK13	Kennedale TX	72CN10	72RW3	Victoria-T5 / 240CV5	908L-2	920L-2	240BA2 / 1056L	Bellamy TX
72VN21 Open 72NW15 Open 72NK23 Open (**ExistingSystem**)	1	1	1								
72VN21 Closed 72NW15 Open 72NK23 Open	2	1	1								
72VN21 Open **72NW15 Closed** 72NK23 Open	1	1	1		1						
72VN21 Open 72NW15 Open **72NK23 Closed**	0	1	1		3						
72VN21 Closed **72NW15 Closed** 72NK23 Open	2	1	1								
72VN21 Closed 72NW15 Open **72NK23 Closed**	5										
72VN21 Open **72NW15 Closed** **72NK23 Closed**	2			1	1		2			2	2
72VN21 Closed **72NW15 Closed** **72NK23 Closed**	5										

Table 4-2: Number of flow violations under each contingency under low Clover Bar dispatch

	N-0	72CK12	72CK13	Kennedale TX	72CN10	72RW3	Victoria-T5 / 240CV5	908L-2	920L-2	240BA2 / 1056L	Bellamy TX
72VN21 Open 72NW15 Open 72NK23 Open (**ExistingSystem**)	1	1	1								
72VN21 Closed 72NW15 Open 72NK23 Open	1	1	1								
72VN21 Open **72NW15 Closed** 72NK23 Open	1	1	1		1						
72VN21 Open 72NW15 Open **72NK23 Closed**	0	1	1		3						
72VN21 Closed **72NW15 Closed** 72NK23 Open	1	1	1								
72VN21 Closed 72NW15 Open **72NK23 Closed**	0	1	1		2		3		1	2	2
72VN21 Open **72NW15 Closed** **72NK23 Closed**	0	1	1		3	1	2			1	1
72VN21 Closed **72NW15 Closed** **72NK23 Closed**	0	1	1		2		3	1	2	2	2

Closing normally open lines worsened the number and severity of violations on monitored lines under both scenarios as compared to the existing system. Thus, reconfiguring the existing system was unsuccessful in improving the load serving capability of the area.

4.3 Power Flow Analysis of Existing System

Contingency list

The following contingencies were simulated:

- All transmission lines rated 69 kV and above with one or more terminal in the AESO's Edmonton and Wabamun planning areas
- All TFO-owned POD transformers
- All other transformers in the Edmonton and Wabamun planning areas with at least one terminal rated 69 kV or higher, including generator transformers

Thermal overloads

Thermal overloads relevant to the City of Edmonton are reported in Table 4-3 and Table 4-4 for the near-term study cases.

Table 4-3: Category A thermal overloads (2026)

Overloaded line	Rating (MVA)	Study Case	Highest Flow (MVA)	Highest loading (%)
72CN10	63	P7078_2023RC_2026WP	65.7	104.3
72CN10	55	P7078_2023RC_2026SP	59.7	108.6

Table 4-4: Category B thermal overloads (2026)

Contingency	Overloaded Element	Rating (MVA)	Study Case	Highest Flow (MVA)	Highest loading (%)
72CK12	72CK13	53	P7078_2023RC_2026WP	56.0	105.7
72CK13	72CK12	53	P7078_2023RC_2026WP	56.0	105.7
72CK12	72CK13	48	P7078_2023RC_2026SP	60.2	125.5
72CK13	72CK12	48	P7078_2023RC_2026SP	60.2	125.5

Category A overload is observed for 72CN10 in the near-term. As discussed in Section 4.2.2, the TFO plans to split Namao's station load between 72CN10 and 72VN21 under peak load conditions in order to address these overloads as a temporary operational measure due to the deteriorated condition of 72CN10.

Under 72CK12 contingency, 72CK13 overload can be dealt with by following the current operational of switching 72NK23 into service to feed one transformer with 72CK13 taking care of the other one. However, there is no procedure to mitigate 72CK13 contingency.

Additionally, under 72CK12 or 72CK13 contingency, the current operational procedure is to operate its parallel line beyond its continuous rating, at 60 MVA in the summer and 67 MVA in the winter instead. Even with this increased rating, 72CK12 shows summer peak loading of 99.1% under 72CK13 contingency and is expected to exceed the 60 MVA rating in 2027 based on the load forecast.

4.4 Historical Observations

The load in the Study Area is steadily increasing and surpassing Kennedale's load serving capability. The summer peak load at Kennedale over 2020 and 2021 was 53.3 MW and 63.3 MW, respectively. As described in the Forecast Appendix, 2021 was the highest historical peak recorded at Kennedale substation and was attributed to the heat wave that occurred that year. The TFO managed the system by transferring load between substations to maintain load reliability during the recorded 37°C heat. The AESO anticipated Kennedale to surpass its load serving capability and worked with the TFO on an interim solution in the distribution system to shift load from Kennedale to Namao in 2021. The load shift resulted in a peak of 51.3 MW at Kennedale in 2022. Despite that, the load forecast anticipates the load at Kennedale to exceed its load serving capability by 2027 resulting in Category B thermal violations on 72CK12 under 72CK13 contingency (see Section 4.2.1). Similarly, the summer peak load at Namao over 2020, 2021 and 2022 was 53.6 MW, 54.5 MW and 55.8 MW, respectively. Based on the current rating of the transmission line supplying Namao, the load at Namao exceeds its load-serving capability.

4.5 Underground Transmission Line Rating Practices

The thermal rating of 72kV underground cables in the Study Area are determined by the TFO following their rating practices. The TFO indicated that underground transmission line ratings are determined based on technical studies, asset health condition and a risk profile which considers environmental risks, impact of unplanned outages and routing. Depending on the mentioned, underground transmission line ratings may change over time. More information about the TFO's rating practices is included in Attachment G.

4.6 Asset Condition

The TFO in the Study Area has indicated that some transmission assets are in deteriorated condition and in need of life cycle replacement. Below are some excerpts from the TFO's reports. The detailed 2023 asset condition reports are filed under a separate cover in Appendix F.

- **Underground Transmission Lines 72CK12 and 72CK13:** 50-year-old oil-filled cables in deteriorating condition. In the conclusion of the condition assessment report, the TFO stated:

  > *"…replacement of circuits 72CK12 and 72CK13 should be prioritized in the interest of system reliability and environmental risk. Considering that lead time of a new transmission line is in the range of 3-5 years, immediate initiation of circuit replacement is required."*

- **Underground Transmission Line 72CN10:** 53-year-old oil filled cable in deteriorating condition. In the conclusion of the condition assessment report, the TFO stated:

  > *"…, but given the deteriorating condition and indicators for this cable, as well as giving consideration to all the other factors and drivers with respect to OFPT technology (see General OFPT Cables – LCR Assessment) and the SEAS Report (Appendix A), EDTI Asset Management is recommending the initiation of the replacement of 72CN10 within the next*

> *5-7 years in order to have the replacement accomplished within the next 10 year timeframe."*

- **Kennedale Substation:** Built in 1973, the substation has a number of major equipment in deteriorated condition and will require life cycle replacements in the near future. The TFO report states the following about the major equipment at this substation:

  > *"Based on the above assessments of the existing transformers, reactors, switchgear and HV breakers within the Kennedale substation, there are condition based drivers to replace these assets in the near future. The transformers currently have issues with obsolescence of the tapchangers, a past failure identified, secondary cable termination issues and minor leaks. The switchgear circuit breakers are needing replacement and the PILC termination issues are all factors for replacement. The 72kV breakers are in an acceptable condition, however, will be approaching a typical end of life age for a breaker replacement".*

The above indicates the need for life cycle replacements in the Study Area in addition to the need to serve the growing load. These life cycle replacements were considered to optimize the preferred transmission development as detailed in Section 6.

4.7 Risk Presented by Aging Underground Transmission Line

As mentioned in previous section, the cables supplying Kennedale and Namao are aging, in deteriorated condition and present reliability risks. A failure of one of these cables would result in a lengthy outage due to the difficulty to locate the fault and the length of time required to repair the fault. Oil Filled Pipe Type (OFPT) cable technology is obsolete and being replaced by new cable technology such as cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR). OFPT technology is not well supported, with only one supplier left in North America and limited technical resources for maintenance and upgrades. This makes sourcing material and contractor expertise a lengthy and difficult process.

These cables compromise the reliability to supply load in the City of Edmonton. In May 2023, the TFO informed the AESO that the underground transmission line connecting Rossdale and Garneau substations 72RG7 failed. This cable is of similar vintage and technology as the cables being replaced in this project. It took the TFO five weeks to locate the fault on this cable and from fault occurrence to restoration, the entire process is anticipated to take a total of 27 weeks for a total estimated cost of $5M. the TFO took steps to manage reliability risks during the extended outage by working with customers that have generation connected to the distribution system and developing a response plan in case of contingencies. Despite this, the supply to Garneau substation remains in a compromised state for the entire length of this outage as certain contingency conditions will result in shedding up to 20 MW of load post contingency and rotating load shed of up to 4 MW after the recovering from the initial load loss. A similar risk exists for the load at Kennedale substation as an extended unplanned outage of either 72CK12 or 72CK13 will increase the risk of the loss of load under the next contingency. This reliability risk along with other risks presented by these aged underground transmission lines are mitigated by the Preferred Transmission Development and any delay to the ISD of the Preferred Transmission Development will result in longer exposure to the mentioned risks.

The above is a recent example of the significant consequence this aging and obsolete technology can have on the reliability of transmission supply to major urban load such as the City of Edmonton.

4.8 Conclusions (Need Assessment Summary)

Based on the current load forecast in the Study Area, Kennedale substation is expected to exceed its load serving capability in 2027. It is not possible to serve the growing load without enhancing the transmission system in the Study Area. Additionally, many transmission assets in the Study Area are in need of life cycle replacement in the near future due to their deteriorating condition. Thus, there is a need to develop an optimal solution to serve the growing load reliably while considering upcoming life cycle replacement requirements in the Study Area.

5. Project Options

5.1 Distribution Load Transfers

Options to transfer load to other substations were investigated with EDTI which is both the TFO and the distribution facility owner (DFO) in the Study Area. The investigation resulted in EDTI adding a 265-meter distribution feeder and transferring 4.7 MW of load from Kennedale to Namao in 2021, at a cost of less than $1M.

In exploring other options to transfer load to other substations, EDTI confirmed that the cost of transferring additional load from Kennedale would be $6 Million (+50%/-30%). EDTI also confirmed that transferring load from Kennedale and Namao substations to Castle Downs substation after the approved Castle Downs Substation Modification project is in service is not possible. The existing Castle Downs distribution infrastructure at the boundary of the Kennedale and Namao service areas does not have capacity to transfer load without major distribution infrastructure upgrades (including 4 to 6 km of distribution feeders). Such upgrades would introduce significant cost, operational complexity and compromise reliability. Shifting load to Castle Downs would also use up the capacity required to serve loads near Castle Downs, and will accelerate the need for further investment at Castle Downs.

As per the above, there are no reasonable opportunities to transfer additional load and defer the need for development temporarily or permanently. It is also noted that transferring load away from Kennedale and Namao does not eliminate the need for transmission development as a permanent solution is required to address the deteriorated transmission infrastructure.

5.2 System Reconfiguration

As discussed in Section 4.2.3, the load serving capability of the existing system does not improve when modifying the existing system from its current configuration (i.e., operated as a normally open system). In addition, any system reconfiguration in aid of serving load growth will not eliminate the need to address aging transmission infrastructure in the Study Area. Hence, there is no system reconfiguration option suitable to address the complete need of this project.

5.3 Non-Wire Solutions

Energy storage was considered as a potential non-wires option to mitigate load growth, but was dismissed due to the need address aging transmission infrastructure in the near future. A solution comprising energy storage may mitigate peak loads, but the transmission system supply to Kennedale and Namao will remain dependent on aging transmission infrastructure which the TFO has identified for replacement in the near future.

5.4 Transmission Development Options

This section presents the Transmission Development Options considered to address the need identified in Section 4. The Transmission Development Options were formulated taking into account the type of violations, the geographical locations of the transmission system constraints, and the long-term forecast. Based on the Need Assessment, the load serving capability in northeast Edmonton needs to be enhanced to continue to serve growing load reliably.

This section outlines six Transmission Development Options to enhance the load serving capability in the Study Area. All options presented are 72 kV or a combination of 72 kV and 138/240 kV developments. The six options consist of three main options with variations:

- **Options 1A/1B:** these options represent like-for-like replacement with 1A only covering the scope of replacing what is required to keep the existing system operation as is (radial with normally-open backup lines) and 1B adds what is required to convert the current system to closed loop system.
- **Options 2A/2B:** these options connect Kennedale and Namao from a new 240 kV substation from two different 240 kV sources. 2A is to connect the new substation to the existing 240 kV transmission line 915L (Clover Bar 987S and East Edmonton 38S) and 2B is to connect the new substation in-and-out to the existing 240 kV transmission line 240CV5 (Victoria 511S and Castle Downs 557S).
- **Option 3:** this option connects Kennedale and Namao from a new 138 kV substation.
- **Option 4:** a variation of 2A that involves decommissioning the existing Kennedale substation and moving its load to the new 240 kV substation.

5.4.1 Option 1A – Replace 72 kV transmission lines 72CK12 and 72CK13

Option 1A consists of the following components:

- Replace the existing 72 kV underground lines 72CK12 and 72CK13 with two 72 kV circuits with a minimum capacity of 95 MVA each; and
- Add or modify associated equipment as required for the above transmission developments.

Figure 5-1 shows the simplified diagram for Option 1A.

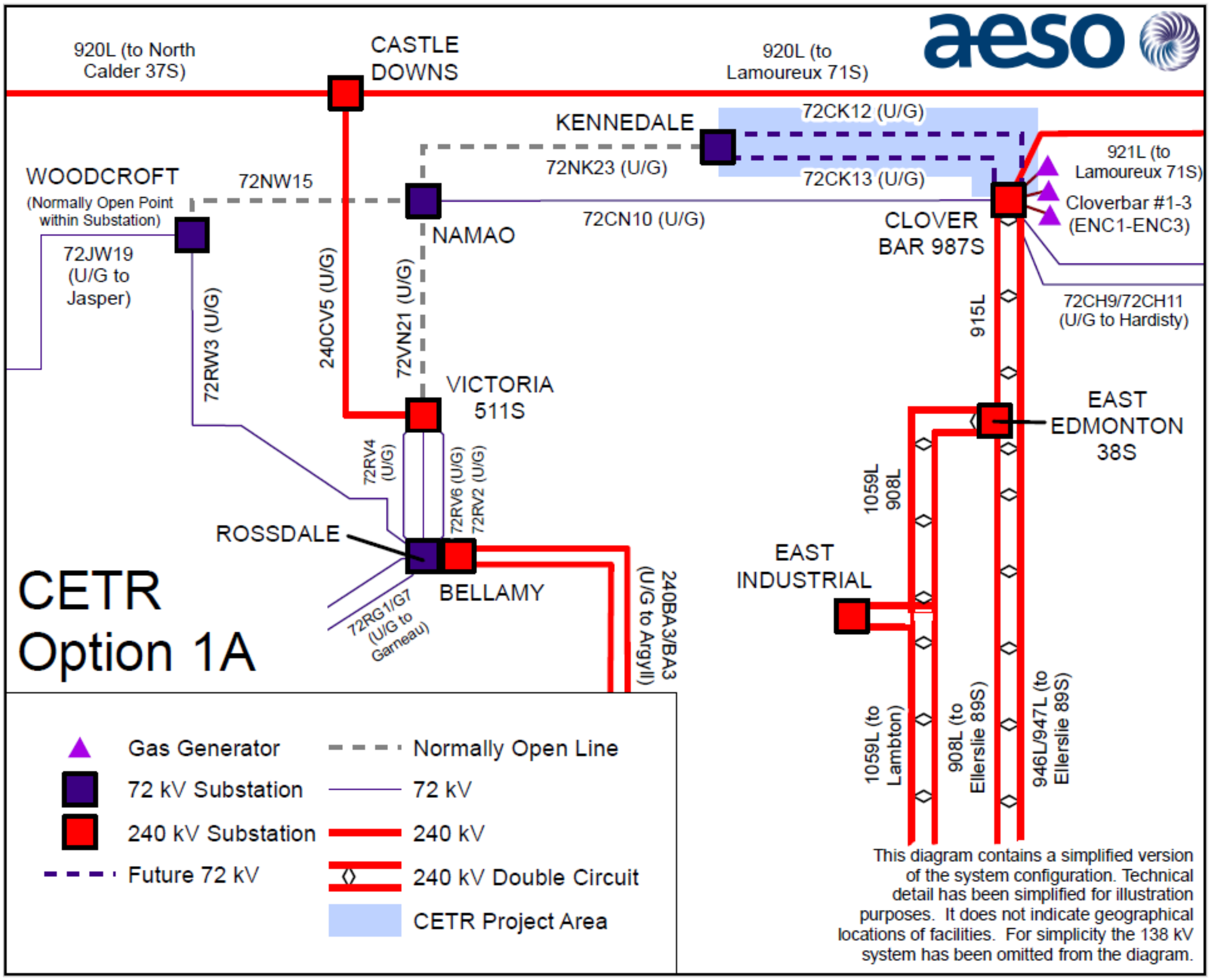


Figure 5-1: Option 1A

5.4.2 Option 1B – Replace the 72 kV underground transmission lines 72CK12, 72CK13, 72NK23, 72NW15 and 72JW19

Option 1B consists of the following components:

- Replace the existing 72 kV underground lines 72CK12 and 72CK13 with two 72 kV circuits with a minimum capacity of 150 MVA each;
- Replace the existing 72 kV underground line 72NK23 with a 72 kV circuit with a minimum capacity of 140 MVA;
- Replace the existing 72 kV overhead line 72NW15 with a 72 kV circuit with a minimum capacity of 90 MVA;
- Replace the existing 72 kV overhead line 72JW19 with a 72 kV circuit with a minimum capacity of 130 MVA;
- Add a new 240/72 kV transformer of 200 MVA and seven circuit breakers at Clover Bar substation and move the connection point of the three existing generators at Clover Bar from 72 kV to 240 kV yard; and
- Add or modify associated equipment as required for the above transmission developments.

Additionally, the following operational procedure adjustments need to be made:

- Operate 72NK23 and 72NW15 as normally closed; and
- Operate 72CN10 and 72RW3 as normally open.

Figure 5-2 shows the simplified diagram for Option 1B.

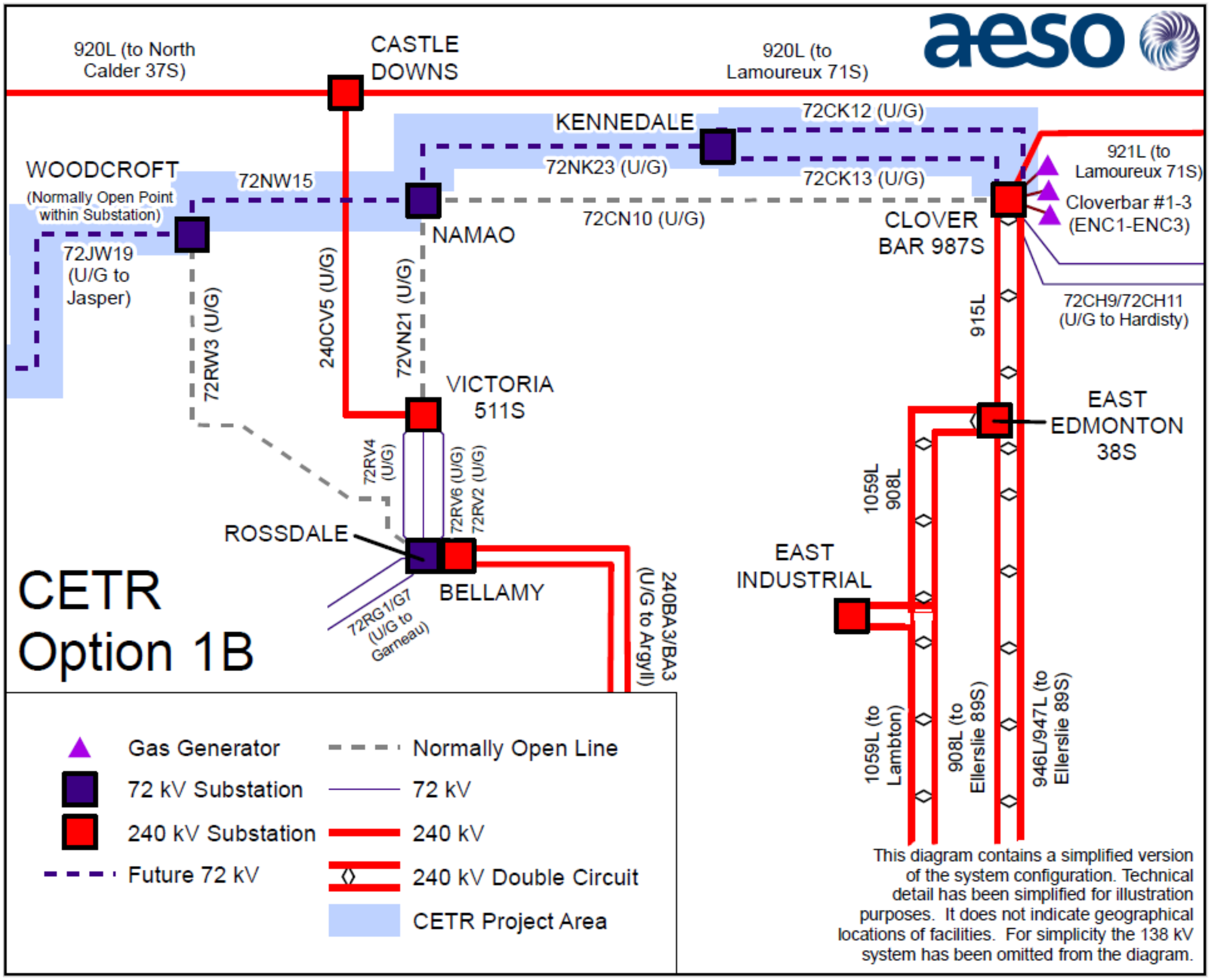


Figure 5-2: Option 1B

Based on a recent update from the TFO, this option is no longer feasible as Clover Bar does not have the physical space for 240 kV bus modifications required to reconnect the generators at Clover Bar substation from 72 kV to 240 kV. The available space was taken by the approved connection project P2453 – Transmission Enhancements in the Northeast Edmonton Area[9]

[9] Approved on July 19, 2023 in AUC Decision 27676-D01-2023. P2453 is connecting to the 240 kV bus at Clover Bar

5.4.3 Option 2A – Add a 240 kV substation connected to the 240 kV transmission line 915L and reconfigure the 72 kV network

Option 2A consists of the following components:

- Add a 240 kV substation with two 240/72 kV transformers (each with a minimum capacity of 200 MVA), five 240 kV circuit breakers and four 72 kV circuit breakers;
- Connect the proposed substation to the existing 240 kV transmission line 915L in an in-and-out configuration;
- Add one 72 kV circuit with a minimum capacity of 165 MVA to connect the substation to the Kennedale substation;
- Add one 72 kV circuit with a minimum capacity of 170 MVA to connect the substation to the Namao substation;
- Replace the 72 kV transmission line 72NK23 with a 72 kV circuit with a minimum capacity of 95 MVA;
- Discontinue from use for transmission purposes three existing 72 kV transmission lines (72CK12, 72CK13, and 72CN10);
- Modify the Namao substation, including adding one 72 kV circuit breaker; and
- Add or modify associated equipment as required for the above transmission developments.

Figure 5-3 shows the simplified diagram for Option 2A.

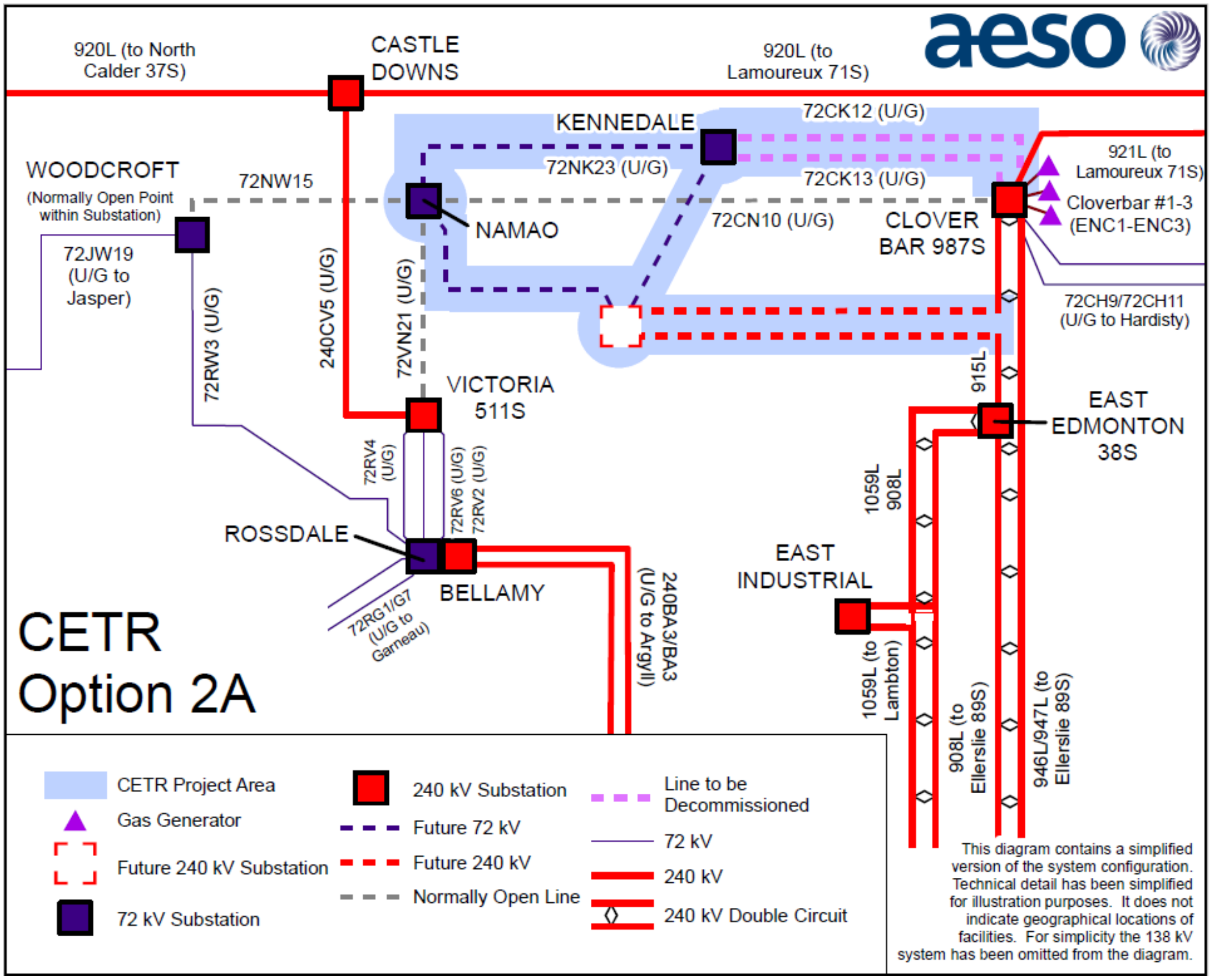


Figure 5-3: Option 2A

5.4.4 *Option 2B – Add a 240 kV substation connected to the 240 kV transmission line 240CV5 and reconfigure the 72 kV network*

Option 2B consists of the following components:

- Add a 240 kV substation with one 240/72 kV transformer with a minimum capacity of 200 MVA, three 240 kV circuit breakers and one 72 kV circuit breaker;
- Connect the proposed substation to the 240 kV underground transmission line 240CV5 in an in-and-out configuration;
- Add one 72 kV circuit with a minimum capacity of 175 MVA to connect the new substation and the Namao substation;
- Add one 72 kV circuit with a minimum capacity of 165 MVA to connect the Castle Downs substation and the Kennedale substation;
- Modify the Castle Downs substation, including adding a 240/72 kV transformer with a minimum capacity of 200 MVA, one 240 kV circuit breaker and one 72 kV circuit breaker;
- Replace the 72 kV transmission line 72NK23 with a 72 kV circuit with a minimum capacity of 95 MVA;
- Modify the Namao substation, including adding one 72 kV circuit breaker;
- Discontinue from use for transmission purposes the three existing 72 kV transmission lines 72CK12, 72CK13, and 72CN10; and
- Add or modify associated equipment as required for the above transmission developments.

Figure 5-4 shows the simplified diagram for Option 2B.

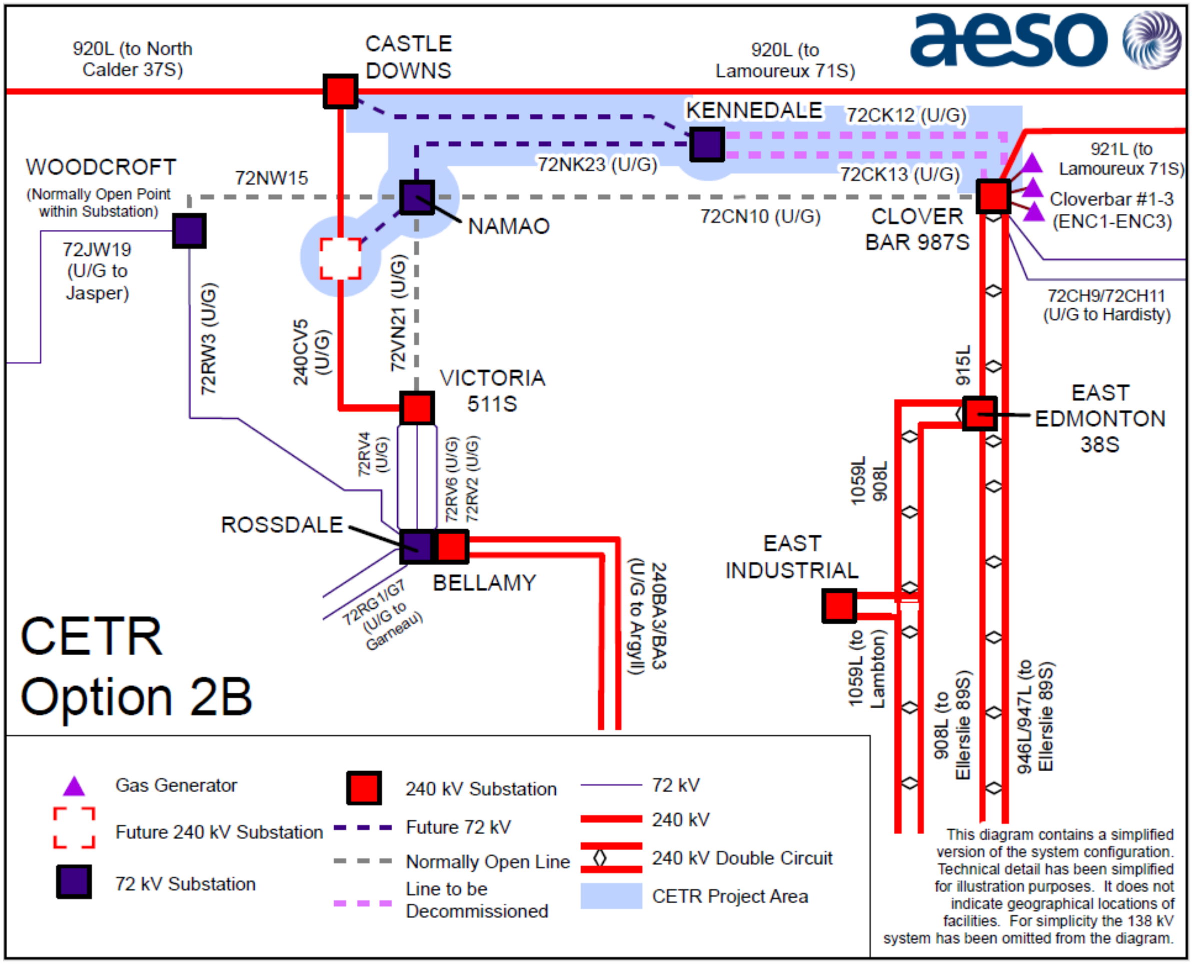


Figure 5-4: Option 2B

5.4.5 Option 3 – Add a 138 kV substation and reconfigure the 72 kV network

Option 3 consists of the following components:

- Add a 138 kV substation with two 138/72 kV transformers with a minimum capacity of 200 MVA, four 240 kV circuit breakers and four 72 kV circuit breakers;
- Connect the proposed substation to the 138 kV transmission lines 726L and 761L using a T-tap configuration with two 138 kV transmission lines (ones to 726L and one to 761L) having a minimum capacity of 169 MVA and 175 MVA respectively;
- Add one 72 kV circuit with a minimum capacity of 175 MVA to connect the proposed substation and the existing Namao substation;
- Add one 72 kV circuit with a minimum capacity of 165 MVA to connect the proposed substation and the existing Kennedale substation;
- Replace the existing 72 kV underground line 72NK23 with a 72 kV circuit with a minimum capacity of 100 MVA;
- Discontinue from use for transmission purposes two 72 kV transmission lines 72CK12 and 72CK13; and
- Add or modify associated equipment as required for the above transmission developments.

Additionally, the following operational procedure adjustment needs to be made:

- Operate 72CN10 as normally open.

Figure 5-5 shows the simplified diagram for Option 3.

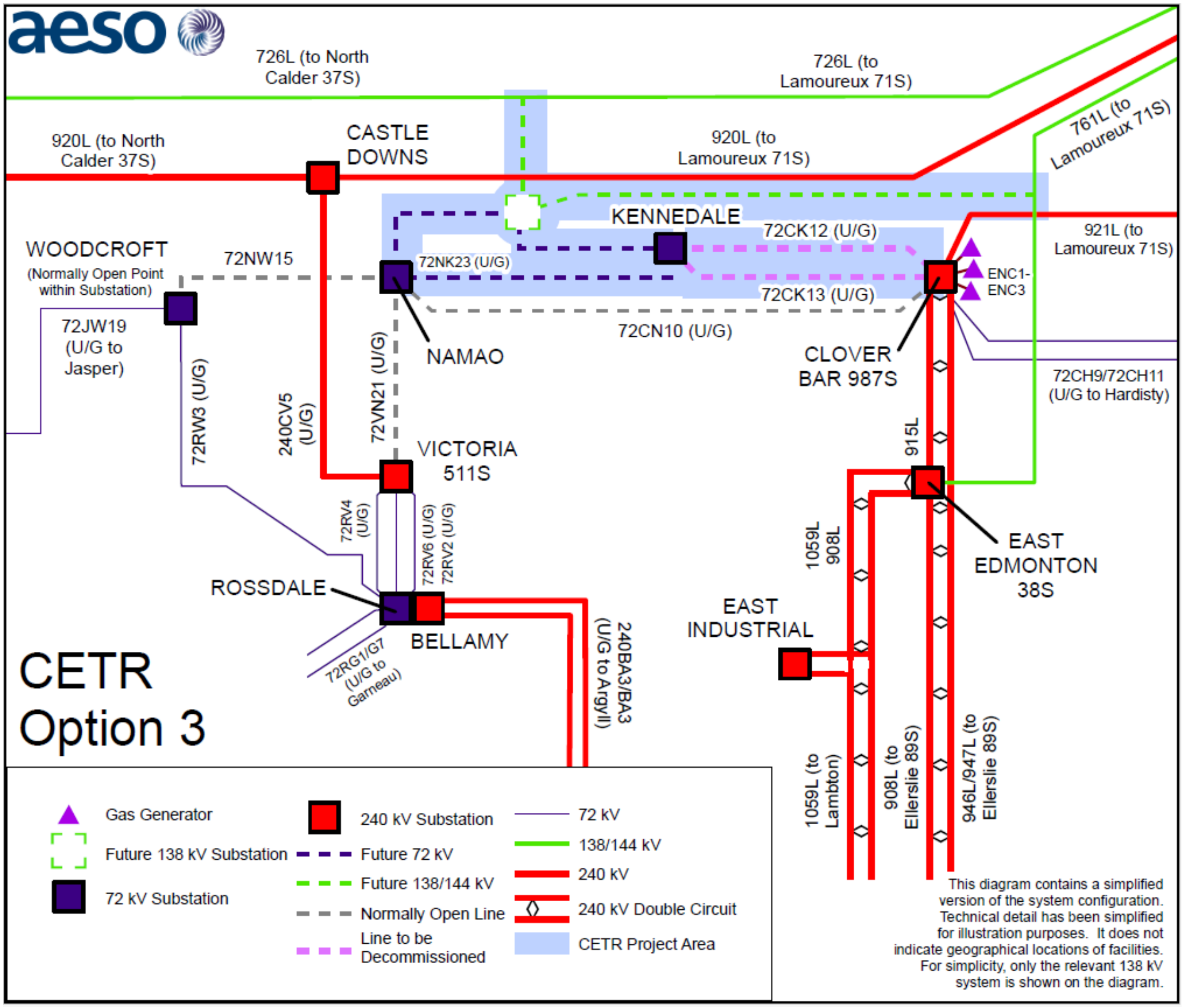


Figure 5-5: Option 3

This option was deemed infeasible and was excluded from further analysis based on the following reasons:

- The TFO in the project area has limited 138 kV asset base, spare parts inventory and tools to manage additional 138 kV fleet.
- 138 kV development requires upgrading existing substations to be compatible with 138 kV which is technically challenging due to limited space available for site expansion at many of the TFO’s existing substations and long duration outage associated with such work.

5.4.6 Option 4 – Add a 240 kV substation connected to the 240 kV transmission line 915L, reconfigure the 72 kV network, and decommission the Kennedale Substation

Option 4 consists of the following components:

- Add a 240 kV substation with two 240/72 kV transformers (each with a minimum capacity of 167 MVA), two 240/15 kV transformers (each with a minimum capacity of 75 MVA), six 240 kV circuit breakers and four 72 kV circuit breakers;
- Connect the substation to the existing 240 kV transmission line 915L using an in-and-out configuration;
- Add two 72 kV circuits, each with a minimum capacity of 85 MVA, to connect the new substation and the Namao substation;
- Modify the Namao substation, including adding one 72 kV circuit breaker;
- Discontinue from use for transmission purposes the Kennedale substation and the four 72 kV transmission lines 72CK12, 72CK13, 72NK23 and 72CN10; and
- Add or modify associated equipment as required for the above transmission developments.

Figure 5-6 shows the simplified diagram for Option 4.

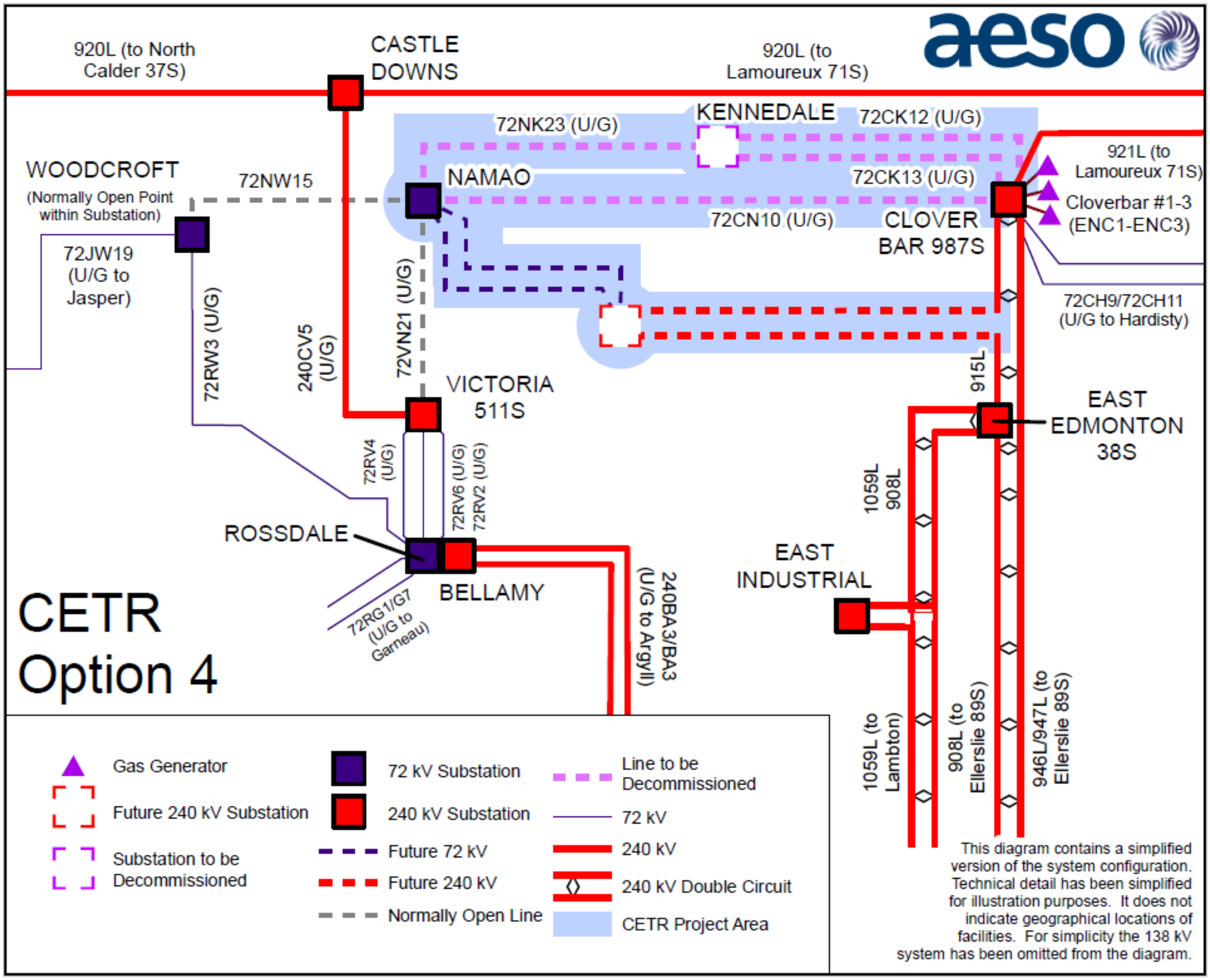


Figure 5-6: Option 4

6. Selection of the Preferred Transmission Development

This section presents the evaluation and comparison of all Transmission Development Options described in Section 5, including the planning studies carried out to evaluate the transmission system performance of the Transmission Development Options. The Transmission Development Options were evaluated based on their technical merits, economic value and environmental and land use effects.

6.1 Technical Assessment of the Transmission Development Options

Power flow studies were performed on all Transmission Development Options using the 2026 Summer Peak cases. The results are as follows.

6.1.1 Option 1A

Category A (N-0) Conditions

As indicated in Table 6-1, overloads on 72CN10 were observed under Category A which are currently being addressed operationally by bringing 72VN21 into service and splitting Namao load between 72CN10 and 72VN21.

Table 6-1: 1A Category A (N-0) Overloads

Overloaded Element	Rating (MVA)	Study Case	Flow (MVA)	Overload (%)
72CN10	63	P7078_2023RC_2026WP_Option1A	65.7	104.3
72CN10	55	P7078_2023RC_2026SP_Option1A	59.8	108.8

The 2026 analysis depicts overloads under Category A conditions that would be unacceptable. 72CN10's rating was reduced in 2022 due to the underground transmission line condition and the increased risk of failure. Therefore, the minimum capacity of 72CN10 would need to be increased to address this overload. This additional scope would result in greater costs for Option 1A. Please refer to Section 6.2 for more details on the cost comparison of all options.

Category B (N-1) Conditions

No additional flow violations were observed under Category B.

6.1.2 Option 2A

No flow violations were observed under Category A and B system conditions.

6.1.3 Option 2B

No flow violations were observed under Category A and B system conditions. However, this option has disadvantages that may impact reliability in the area both during and after construction:

- Extended construction outage required on 240CV5 will result in the system in the area operating under N-1 for an extended period and restricting outages to the following transmission elements:
    - 72RV2, 72RV4, 72RV6
    - Bellamy 240/72kV Tx1 and Tx2

  - 230BA2 and 240BA3
  - 1055L (Argyll transfer – Petrolia) and 1056L (Argyll Transfer – Ellerslie) (The aerial portion of the 240BA cables)

- An outage on any of the elements above during the extended N-1 condition to 240CV5, will result in compromised reliability to Victoria, Rossdale and Garneau substations that may result in loss of load.
- Connecting the new substation to 240CV5 brings 240 kV supply in the area from an existing 240 kV source (i.e., 240CV5 cable from Castle Downs substation). This configuration relies heavily on a single 240 kV source and provides less operational flexibility compared to Option 2A and 4 where a second 240 kV source from 915L can help supply the area under a contingency.

6.1.4 Option 4

No flow violations were observed under Category A and B system conditions.

6.1.5 Technical Assessment Summary

All options resolved the overloads on 72CK12 and 72CK13. Due to the derate on 72CN10 and higher load growth at Namao, Option 1A would require additional transmission development to permanently address Category A thermal criteria violations on 72CN10. Option 2B contains additional reliability risks, particularly during construction, and provides limited operational flexibility as compared to Options 2A and 4.

6.2 Transmission Development Option Costs

The AESO directed the TFO to prepare AACE class 4 cost estimates (+50%/-30%) for Options 1A, 2A, 2B, and 4 according to the requirements of section 7.1.1 NID 4 of Alberta Utilities Commission (AUC) Rule 007. Detailed estimated cost for each option is provided in the AESO Cost Estimates Appendix[10].

Options 1A, 2A, 2B and 4 are compared in terms of their initial capital cost and their impact to future life cycle replacement costs anticipated on remaining transmission infrastructure in the near and long-term.

Table 6-2 provides a summary of the capital costs of options along with life cycle cost offsets resulting from each option. The TFO estimates the life cycle replacement cost required for Kennedale substation to be $47M[11] which will be required for all options except Option 4 over the next twenty years[12]. Option 4 includes the decommissioning of the existing Kennedale substation and serving Kennedale load out of a new 240 kV substation hence avoiding the life cycle replacement cost of Kennedale.

The lowest cost option from an initial capital cost is Option 1A, however, as indicated in Section 6.1, this option does not include mitigating the overload 72CN10 and including 72CN10 replacement in the scope of this option will make this option higher cost[13]. Considering anticipated life cycle replacement costs required for the Kennedale substation, the lowest overall cost option is Option 4.

Table 6-2: Capital Cost Estimates of Options and Life cycle Cost Offset

Option	Capital Cost	Life cycle Cost Offset (Kennedale)	Capital Cost + Life cycle Cost Offset	Rank based on known cost information (1st is least cost)
1A	$260M	$47M	$307M	2
2A	$271M	$47M	$318M	4
2B	$270M	$47M	$317M	3
4	$276M	N/A	$276M	1

10 Filed under separate cover as Appendix C

11 Attachment H – Kennedale Lifecycle Replacement Cost

12 The TFO forecasts the power transformers to be due for replacement in the 2027 to 2028 time frame, medium voltage switchgear in the 2033-2036 time frame and high voltage breakers sometime after 2040

13 72CN10 will require lifecycle replacement due to its condition even if not addressed as part of this project

6.3 Environmental and Land Use Effects

The AESO directed the TFO to prepare a report comparing the four Transmission Development Options according to the environmental and land use effects information contemplated under section 7.1.1 NID 2 of Alberta Utilities Commission (AUC) Rule 007.

As indicated in the Environmental and Land Use Effects (ELUE) Appendix[14]:

- All overhead options are viable except for overhead 72 kV transmission lines to Clover Bar substation due to existing 138 kV and 240 kV overhead lines and space constraints in Clover Bar substation (Option 1A).
- Option 2B poses higher potential residential impact than Option 2A
- Options 2A and 4 have lowest ELUEA effects and approximately similar potential residential impacts.
- Options that facilitate the eventual decommissioning of existing oil-filled pipe cables present a net benefit due to reduced potential environmental risk. Options 2A and 4 facilitate the immediate decommissioning four existing aged oil-filled cables (72CK12, 72CK13, 72NK23 and 72CN10) and the eventual decommissioning of three oil-filled cables (72RV2, 72RV4 and 72RV6) once they reach their end of life.
- Option 4 has the shortest circuit length and poses the lowest overall levels of impacts and highest net benefit.

6.4 Selection of the Preferred Transmission Development Option

Table 6-3 provides a summary of the performance comparison between the Transmission Development Options.

Option 4 is the Preferred Transmission Development Option for the following reasons:

- It meets the technical requirement and will serve required load reliably in the long-term.
- It is the lowest cost option when considering both initial capital cost and future life cycle replacements offsets.
- It has one of the lowest impacts and highest net benefit overall.
- It provides the provision to expand to serve additional load in the area.
- It provides an alternative option for the future lifecycle replacement of Victoria to Rossdale underground transmission lines when these circuits reach end of life.

[14] Filed under separate cover as Appendix E

Table 6-3: Summary of Performance Comparison for Transmission Development Options

Option	Description	Technical Assessment	Cost Estimates	Environmental and Land use Effects Rank
1A	Upgrade 72 kV transmission lines 72CK12 and 72CK13 between the Clover Bar and Kennedale substations	Additional transmission development required to resolve Category A thermal violations on 72CN10	Capital Cost: $260M Overall Cost: $307M	High
2A	Add a 240 kV substation, add two 72 kV circuits and upgrade the transmission lines between the Kennedale and Namao substations	No planning criteria violations	Capital Cost: $271M Overall Cost: $318M	Low
2B	Add a 240 kV substation, add two 72 kV circuits and upgrade the transmission line between the Kennedale and Namao substations	No planning criteria violations but has reliability disadvantages	Capital Cost: $270M Overall Cost: $317M	High
4	Add a 240 kV substation, add two 72 kV circuits and discontinue from use the Kennedale substation	No planning criteria violations	Capital Cost: $276M Overall Cost: $276M	Low

7. Additional Assessments for the Preferred Transmission Development

7.1 Power Flow Analysis

Power flow studies were performed on 2043 Summer and Winter peak cases to assess the performance of the Preferred Transmission Development in meeting forecast load in the Study Area.

7.1.1 Main Scenario (2043)

Category A (N-0) Conditions

No flow violations were observed under Category A in 2043.

Category B (N-1) Conditions

As indicated in Table 7-1, overloads on the lines between the proposed substation and the existing Namao substation appear in 2043.

Table 7-1: Preferred Option Category B (N-1) Overloads

Contingency	Overloaded Element	Rating (MVA)	Study Case	Highest Flow (MVA)	Highest loading (%)
72FN27	72FN28	88.7	P7078_2023RC_2043SP	97.3	109.7
72FN28	72FN27	88.7	P7078_2023RC_2043SP	97.3	109.7
72FN27	72FN28	88.7	P7078_2023RC_2043WP	119.7	134.9
72FN28	72FN27	88.7	P7078_2023RC_2043WP	119.7	134.9

Based on input from the TFO, Namao has undergone recent condition-based (life-cycle) equipment replacements that have maintained its 80MVA transformation capacity; the new 72kV circuit ratings are also sized to enable the current capability of Namao. The current DFO load forecast does not project any loads that would exceed the 80 MVA capacity at Namao over the next 25 years. Furthermore, it would be challenging to serve future loads from Namao due to the configuration of the equipment and the physical size of the substation without a significant reconfiguration of the station. The new Fort Road substation can be expanded to serve more load and provide additional 72 kV connections.

7.1.2 Managed EV Load (2043)

Category A (N-0) Conditions

No flow violations were observed under Category A in 2043.

Category B (N-1) Conditions

As indicated in Table 7-2, the same Category B thermal violations are observed as in the Main Scenario but the overload magnitude is lower due to the lower load forecast in this sensitivity scenario.

Table 7-2: Preferred Option Category B (N-1) Overloads under Managed EV Load

Contingency	Overloaded Element	Rating (MVA)	Study Case	Highest Flow (MVA)	Highest loading (%)
72FN27	72FN28	88.7	P7078_2023RC_2043SP_Managed	93.6	105.5
72FN28	72FN27	88.7	P7078_2023RC_2043SP_Managed	93.6	105.5
72FN27	72FN28	88.7	P7078_2023RC_2043WP_Managed	109.8	123.8
72FN28	72FN27	88.7	P7078_2023RC_2043WP_Managed	109.8	123.8

The conclusion is similar to the Main Scenario with regards to overloads observed on 72FN27 and 72FN28.

7.1.3 High EV Penetration (2043)

Category A (N-0) Conditions

No flow violations were observed under Category A in 2043.

Category B (N-1) Conditions

As indicated in Table 7-3, the same Category B thermal violations are observed as in the Main Scenario but the overload magnitude is higher due to the higher load forecast in this sensitivity scenario.

Table 7-3: Preferred Option Category B (N-1) Overloads under High EV Penetration

Contingency	Overloaded Element	Rating (MVA)	Study Case	Highest Flow (MVA)	Highest loading (%)
72FN27	72FN28	88.7	P7078_2023RC_2043SP_High EV	117.0	131.9
72FN28	72FN27	88.7	P7078_2023RC_2043SP_High EV	117.0	131.9
72FN27	72FN28	88.7	P7078_2023RC_2043WP_High EV	144.1	162.5
72FN28	72FN27	88.7	P7078_2023RC_2043WP_High EV	144.1	162.5

The conclusion is similar to the Main Scenario with regards to overloads observed on 72FN27 and 72FN28.

7.2 Voltage Stability Analysis

Voltage stability analysis were carried out both before and after the Preferred Transmission Development is in service using the 2026 summer peak power cases.

Detailed results of PV analysis are presented in Attachment D. Results indicate that the voltage stability criteria of 5% margin for Category B contingencies and 2.5% margin for select Category C5 contingencies can be met with 2043 forecast load for Kennedale and Namao.

7.3 Short-Circuit Analysis

Short-circuit analysis was performed using the 2026 and 2043 study cases to determine the maximum short-circuit current levels in the Study Area. Detailed short-circuit study results are presented in Attachment F. The short-circuit fault levels for post Preferred Transmission Development were not significantly higher than the levels of pre Preferred Transmission Development and short-circuit levels were found to be within the designed capabilities of the nearby facilities. Additionally, the Preferred Transmission Development provides provision to build a 240 kV transmission line from the proposed Fort Road substation to Victoria substation as described in Section 9. Doing so would greatly reduce these short circuit levels if the need arises.

7.4 Transient Stability Analysis

Transient stability studies were performed both before and after the Preferred Transmission Development is in service using the 2026 and 2043 power flow cases. The results confirm that the transmission system remains stable under select Category B and select Category C5 contingencies in the Study Area under normal clearing conditions. Detailed transient stability study results are provided in Attachment E.

8. Alignment with AESO's Long-Term Transmission Plan

The AESO's long-term transmission system plans are high-level assessments of transmission capability and required transmission system development in Alberta focusing on broad technical aspects. More detailed studies are performed in preparation of a needs identification document application to ensure that the AESO's Preferred Transmission Development will address the identified reliability violations in the most efficient manner. The need for upgrades in the City of Edmonton was most recently affirmed in the 2022 LTP, but it was observed in the 2020 LTP and earlier. The Preferred Transmission Development proposed by the AESO in this Application is aligned with the 2022 LTP in that transmission development in the City of Edmonton is recommended.

9. Future Transmission Plans for the City of Edmonton

The Preferred Transmission Development facilitate an alternative option for the future life cycle replacement of 72RV2/4/6 between Victoria and Rossdale substations. These three underground cables can be replaced with a single 240 kV circuit between the new 240 kV substation proposed by the Preferred Transmission Development and the existing Victoria substation. The selection of the preferred replacement option (like-for-like or new 240 kV as described) will be assessed when the lifecycle replacement need arises.

Figure 9-1 showed a simplified diagram of the replacement of 72RV2/4/6 with a single 240 kV circuit.

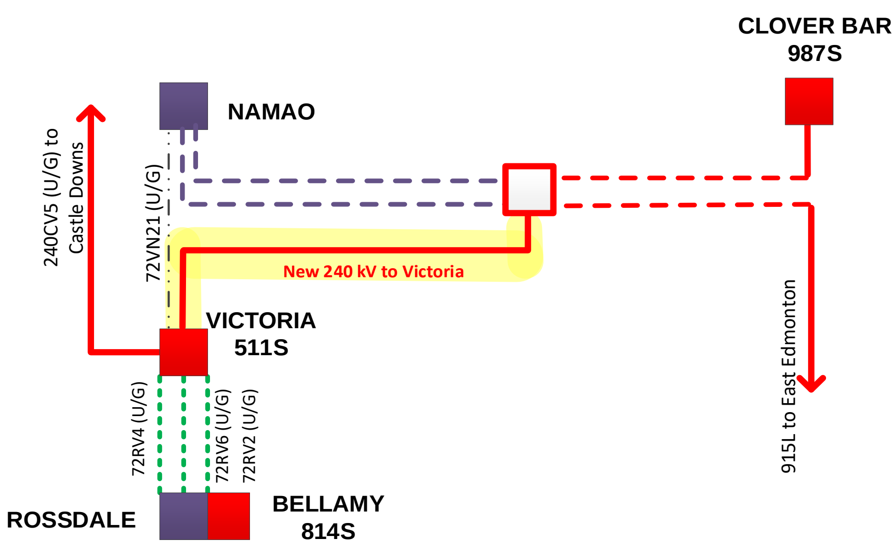


Figure 9-1: Future Replacement of 72RV2/4/6

10. Project Interdependencies

The Preferred Transmission Development is not dependent on other transmission developments that are currently planned within the AIES in this timeframe.

Public

11. Summary and Conclusions

The AESO conducted planning studies to assess the need of transmission development in the Study Area consisting of the service area of Kennedale and Namao POD substations in the Edmonton planning area (Area 60). Planning study results demonstrate that the existing system will be unable to support load growth in the area by 2027 without Category B thermal violations. Additionally, assets in the area are aging and in need of life cycle replacement. Thus, there is a need for transmission development in the area to continue to reliability serve load in the Study Area.

The AESO investigated six transmission development options to address the need as shown in Table 11-1.

Table 11-1: Transmission Development Options

Option	Description
1A	Upgrade 72 kV transmission lines 72CK12 and 72CK13 between the Clover Bar and Kennedale substations
1B	Upgrade the 72 kV underground transmission lines (72CK12, 72CK13, 72NK23, 72NW15, 72JW19) between the existing Clover Bar, Kennedale, Namao, Woodcroft, and Jasper substations
2A	Add a 240 kV substation, add two 72 kV circuits and upgrade the transmission lines between the Kennedale and Namao substations
2B	Add a 240 kV substation, add two 72 kV circuits and upgrade the transmission line between the Kennedale and Namao substations
3	Add a 138 kV substation, add two 72 kV circuits and upgrade the transmission line between the Kennedale and Namao substations
4	Add a 240 kV substation, add two 72 kV circuits and discontinue from use the Kennedale substation

Option 1B and 3 were considered in the initial stage of alternative development, but were later deemed infeasible. Option 1B was not feasible due to the lack of physical space required for the 240 kV bus modifications at the Clover Bar substation. Option 3 was deemed infeasible due to the TFO's limited 138 kV asset base and spare inventory, and the limited potential expandability to connect to the other existing 240 kV substations in the area.

The four remaining transmission development options were assessed, taking into consideration the cost, future capability, and land use and environmental effects. Options 1A, 2A, 2B, and 4 were all technically feasible, but Option 1A requires further development to mitigate Category A thermal violations on 72CN10 (Clover Bar – Namao). Cost estimates were compared to assist in the selection of the Preferred Transmission Development. With assets in the area being at the end of life and needing replacement in the near future, life cycle cost replacement was also taken into consideration. Options 2A and 4 have lowest ELUEA effects and approximately similar potential residential impacts. Table 11-2 provides a summary of the performance comparison between the transmission development options.

Table 11-2: Summary of Performance Comparison for Transmission Development Options

Option	Technical Assessment	Cost Estimates	Environmental and Land use Effects Rank
1A	Additional transmission development required to resolve Category A thermal violations on 72CN10	Capital Cost: $260M Overall Cost: $307M	High
2A	No planning criteria violations	Capital Cost: $271M Overall Cost: $318M	Low
2B	No planning criteria violations but has reliability disadvantages	Capital Cost: $270M Overall Cost: $317M	High
4	No planning criteria violations	Capital Cost: $276M Overall Cost: $276M	Low

Option 4 is the Preferred Transmission Development for the following reasons:

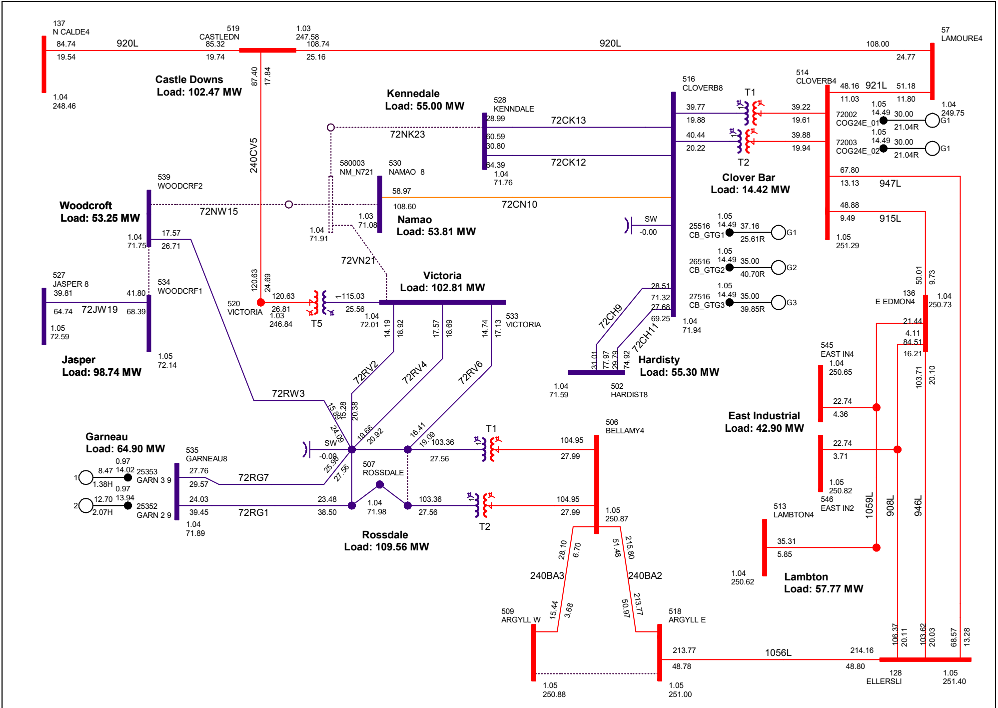
- It meets the technical requirement and will serve required load reliably in the long-term.
- It is the lowest cost option when considering both initial capital cost and future life cycle replacements offsets.
- It has one of the lowest impacts and highest net benefit overall.
- It provides the provision to expand to serve additional load in the area.
- It provides an alternative option for the future lifecycle replacement of Victoria to Rossdale underground transmission lines when these circuits reach end of life.

The Preferred Transmission Development involves adding a 240 kV substation connected to the existing 915L out of the Clover Bar 987S substation. This new substation will connect to Namao through two 72 kV circuits. The existing Kennedale substation will be decommissioned with its load transferred to the new 240 kV substation. The higher line ratings will address the current need to serve electricity reliably and continue to be able to supply forecasted load in the area for the long-term.

Attachment A: Power Flow SLDs – Pre-Transmission Development 2026

Attachment A Summary

No.	Study Year	Season	Option	Contingency	Figure Number
1	2026	SP	Existing	None	Fig. A-1
2	2026	SP	Existing	72CK12	Fig. A-2
3	2026	SP	Existing	72CK13	Fig. A-3
4	2026	WP	Existing	None	Fig. A-4
5	2026	WP	Existing	72CK12	Fig. A-5
6	2026	WP	Existing	72CK13	Fig. A-6



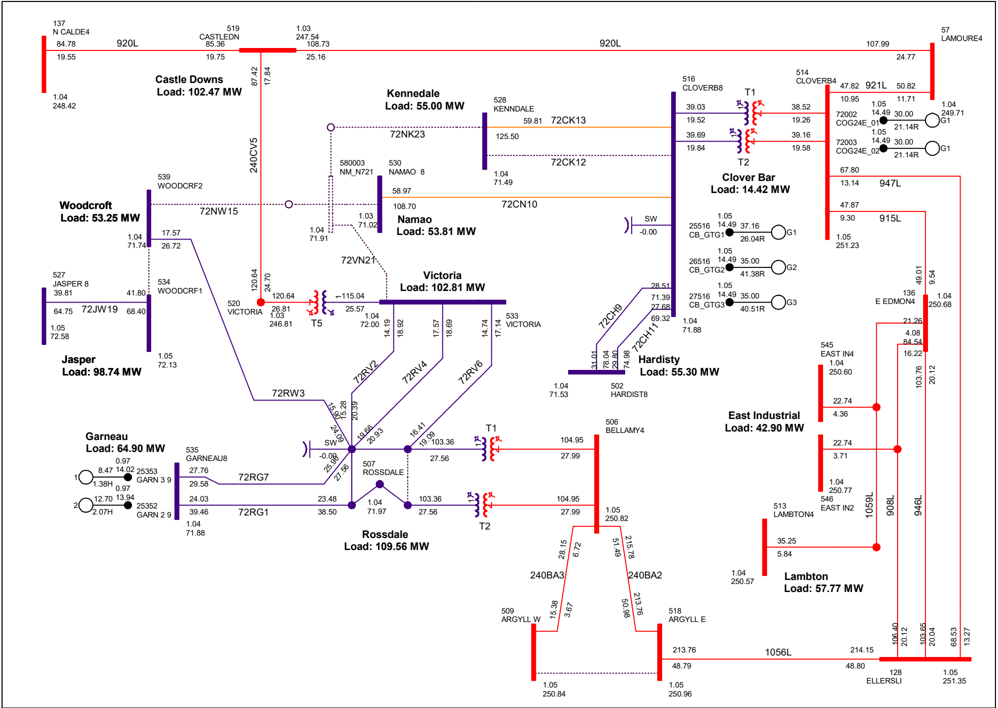
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2026 Summer Peak - Existing System

Figure A-1



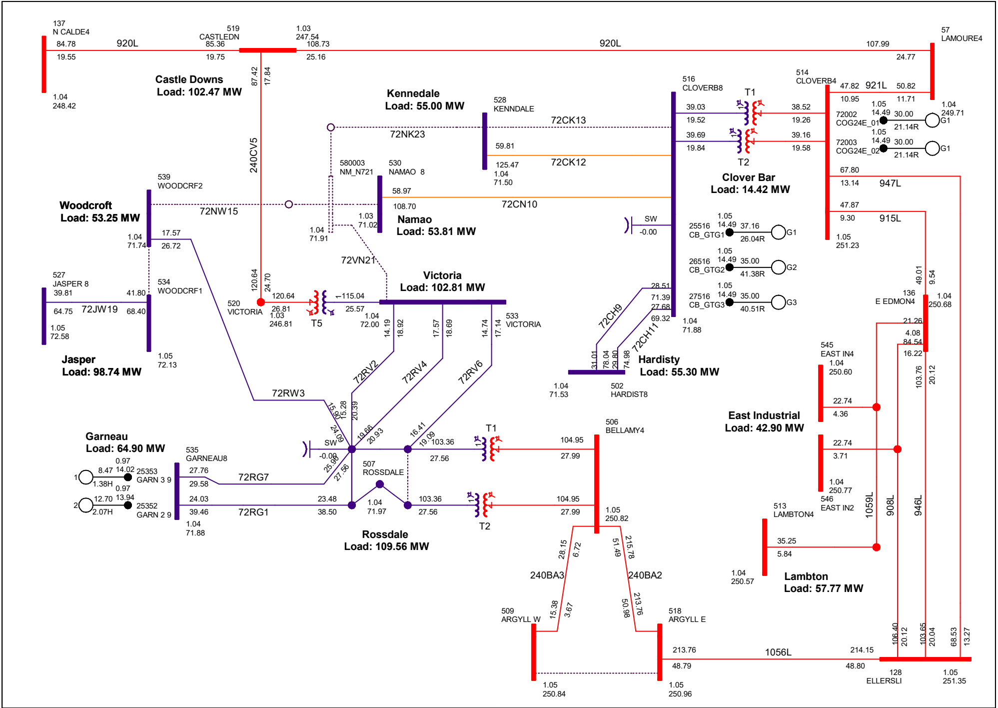
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

2026 Summer Peak - Existing System

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

Figure A-2



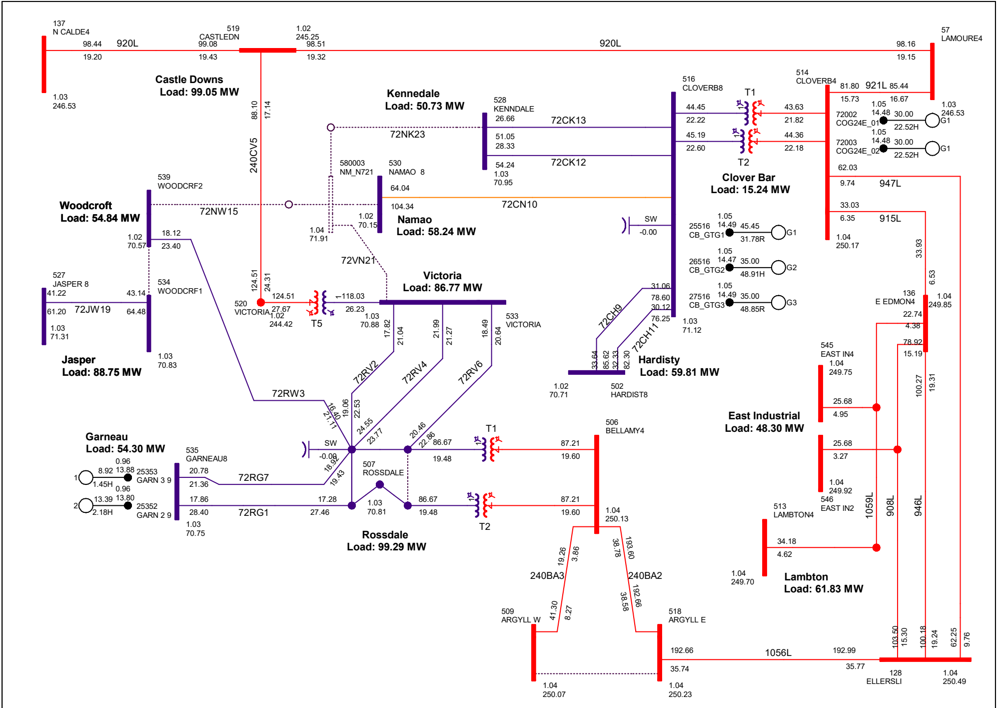
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2026 Summer Peak - Existing System

Figure A-3



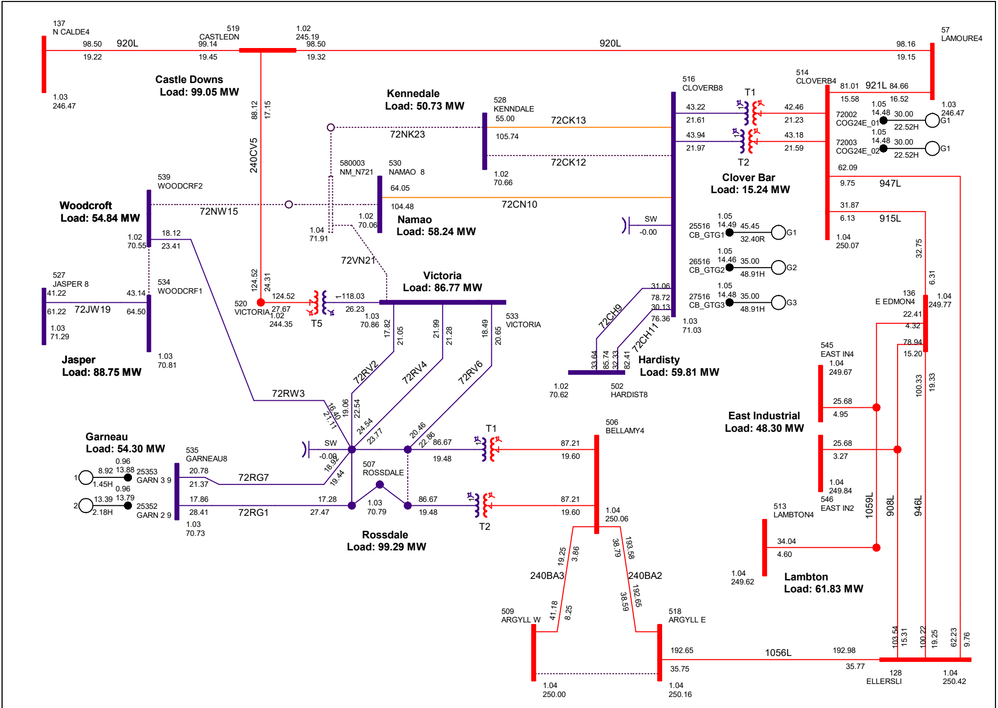
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2026 Winter Peak - Existing System

Figure A-4



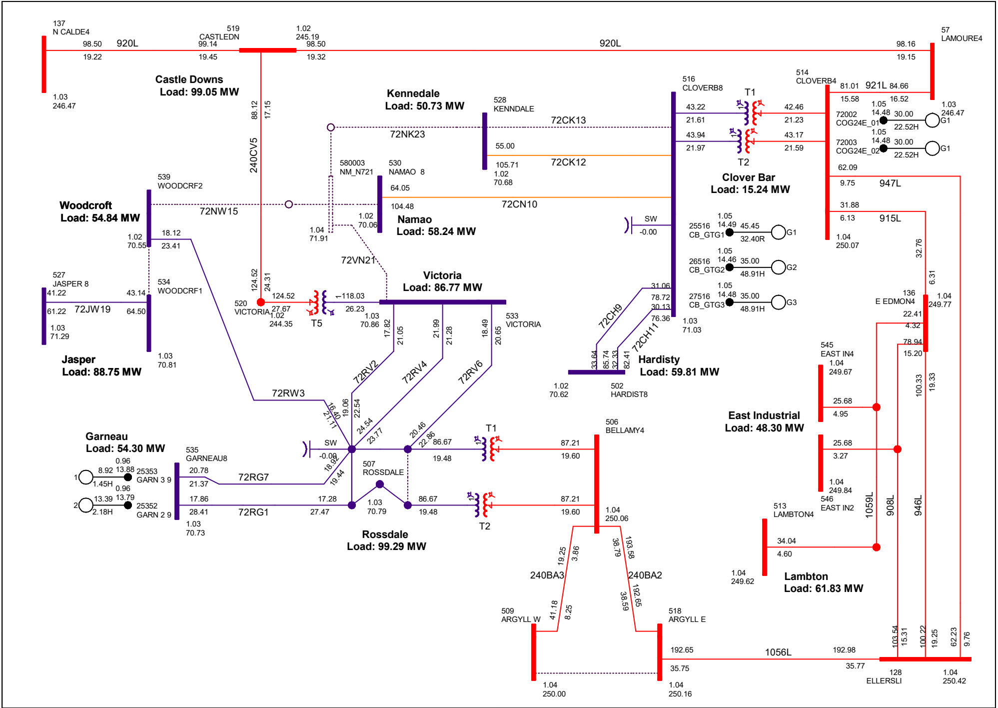
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2026 Winter Peak - Existing System

Figure A-5



P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

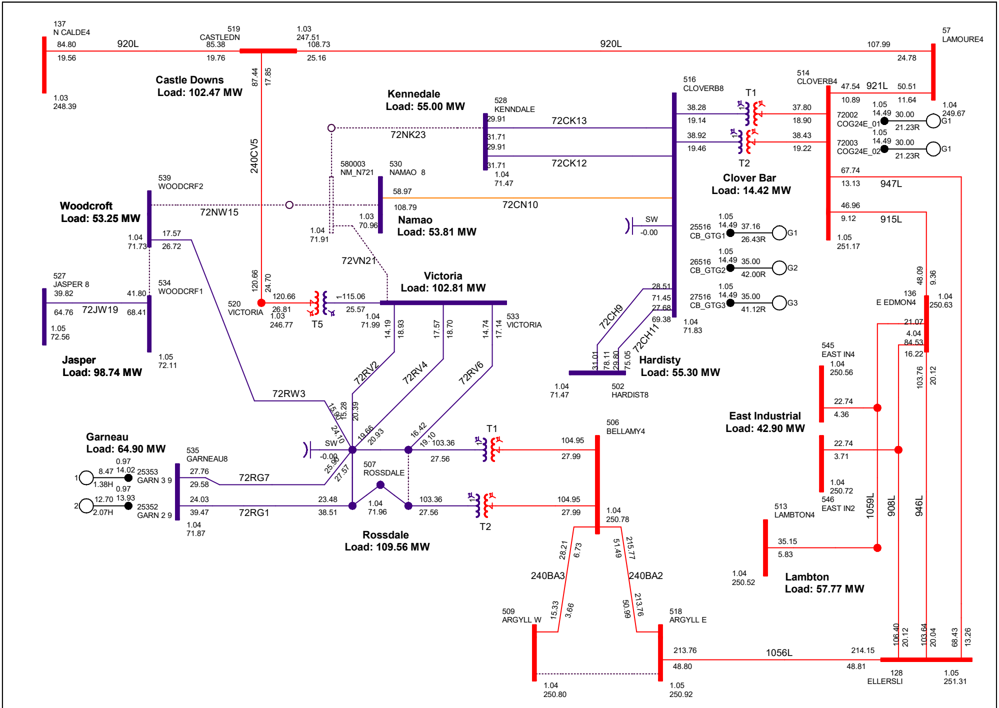
2026 Winter Peak - Existing System

Figure A-6

Attachment B: Power Flow SLDs – Assessment of Transmission Development Options

Attachment B Summary

No.	Study Year	Season	Option	Contingency	Figure Number
1	2026	SP	Option1A	None	Fig. B-1
2	2026	WP	Option1A	None	Fig. B-2
3	2026	SP	Option4	None	Fig. B-3
4	2026	WP	Option4	None	Fig. B-4



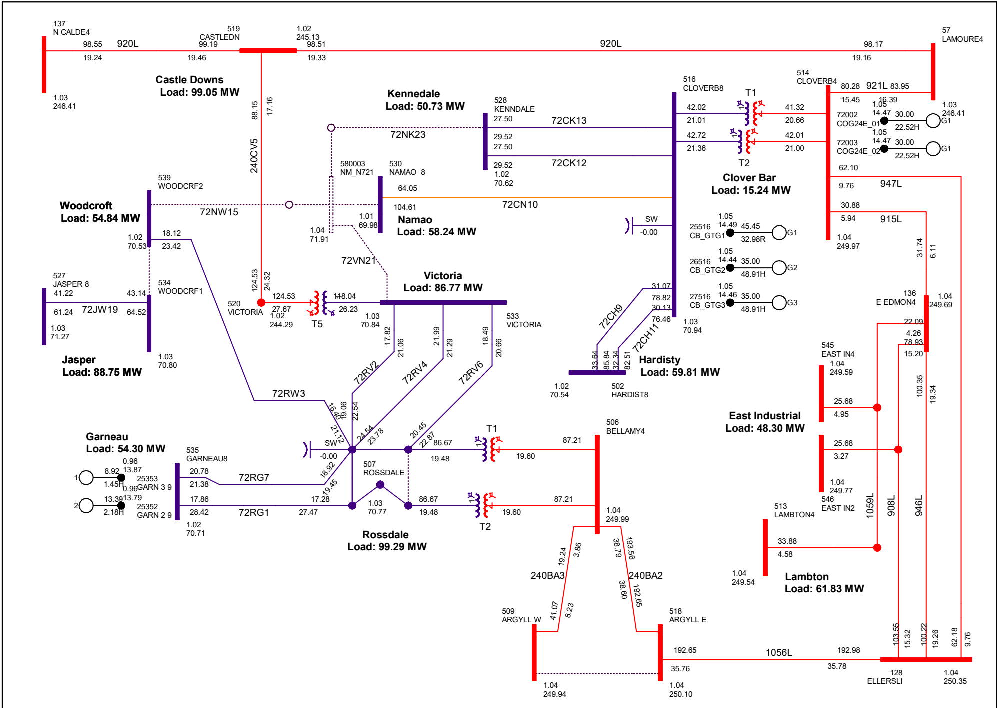
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2026 Summer Peak - Option 1A

Figure B-1



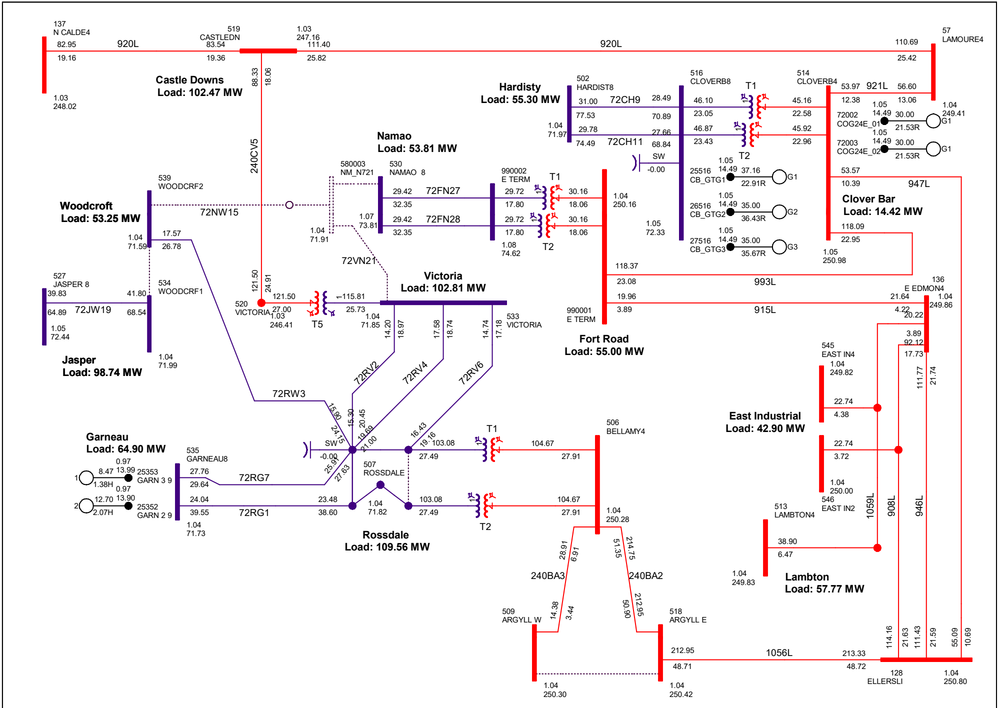
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2026 Winter Peak - Option 1A

Figure B-2

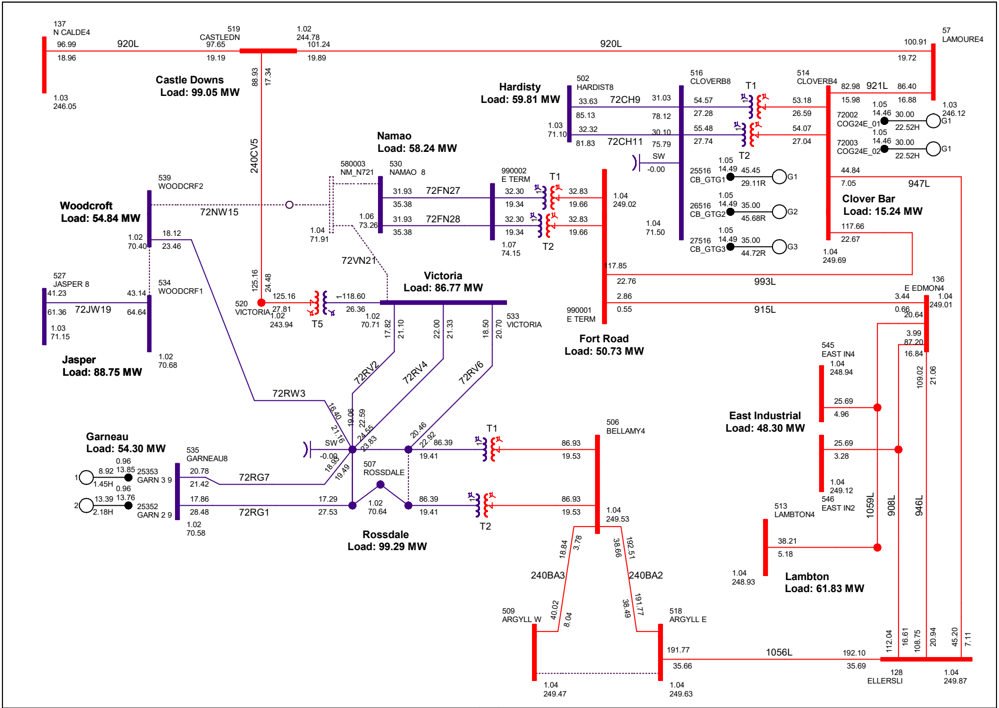


P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1
kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2026 Summer Peak - Option 4

Figure B-3



P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

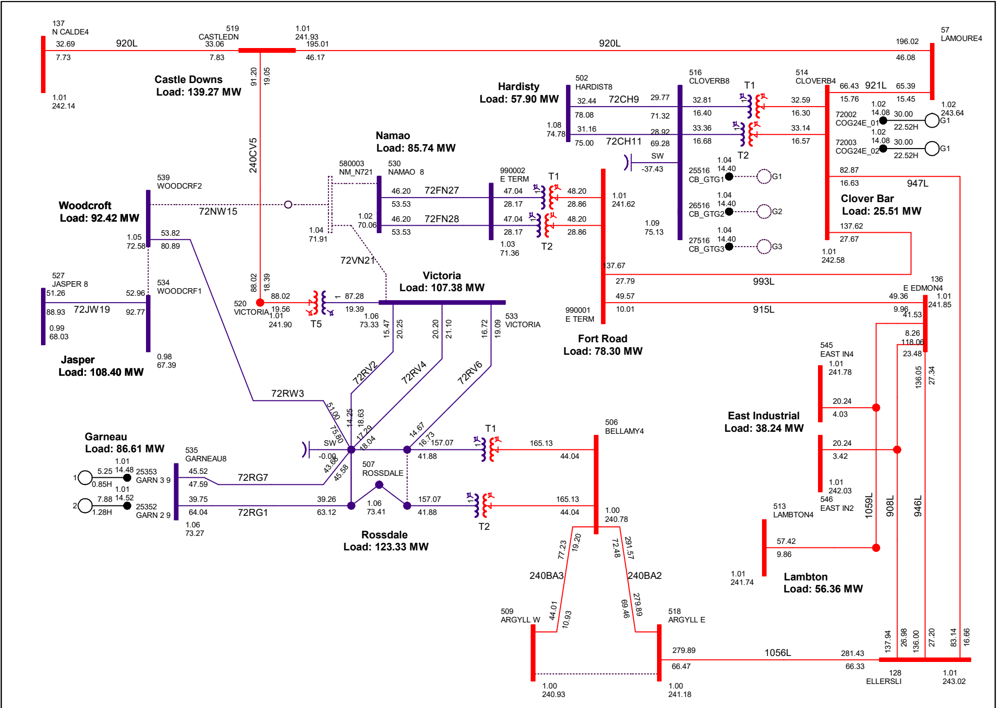
2026 Winter Peak - Option 4

Figure B-4

Attachment C: Preferred Transmission Development 2043

Attachment C Summary

No.	Study Year	Season	Option	Contingency	Figure Number
1	2043	SP	Option4	None	C-1
2	2043	SP	Option4	72FN27	C-2
3	2043	SP	Option4	72FN28	C-3
4	2043	WP	Option4	None	C-4
5	2043	WP	Option4	72FN27	C-5
6	2043	WP	Option4	72FN28	C-6
7	2043	SP_managed	Option4	None	C-7
8	2043	SP_managed	Option4	72FN27	C-8
9	2043	SP_managed	Option4	72FN28	C-9
10	2043	WP_managed	Option4	None	C-10
11	2043	WP_managed	Option4	72FN27	C-11
12	2043	WP_managed	Option4	72FN28	C-12
13	2043	SP_highEV	Option4	None	C-13
14	2043	SP_highEV	Option4	72FN27	C-14
15	2043	SP_highEV	Option4	72FN28	C-15
16	2043	WP_highEV	Option4	None	C-16
17	2043	WP_highEV	Option4	72FN27	C-17
18	2043	WP_highEV	Option4	72FN28	C-18



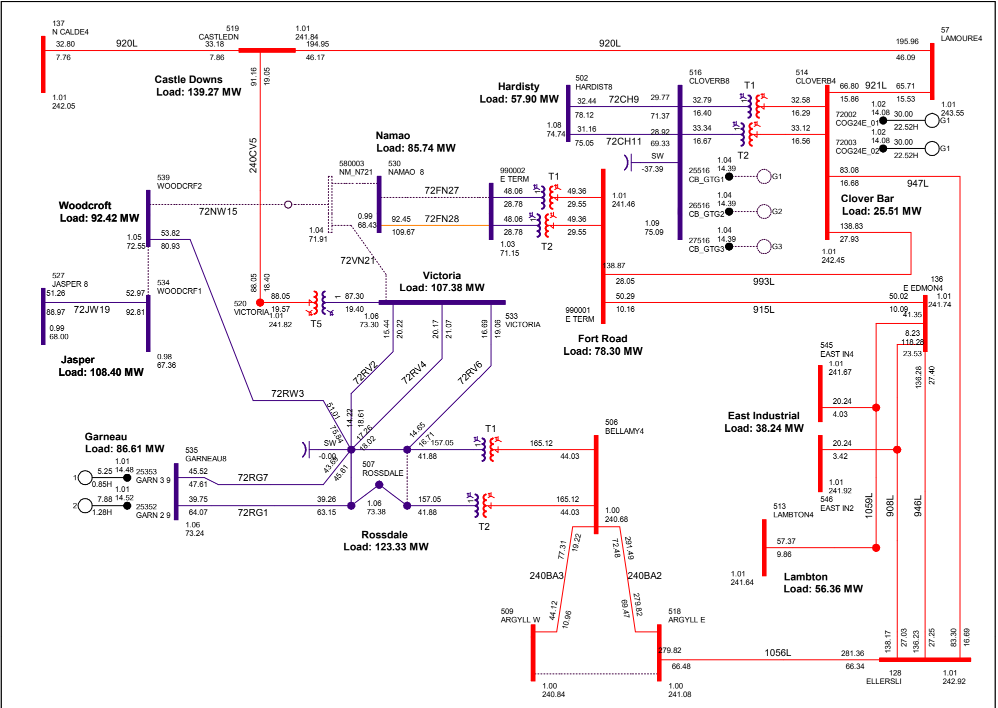
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-1



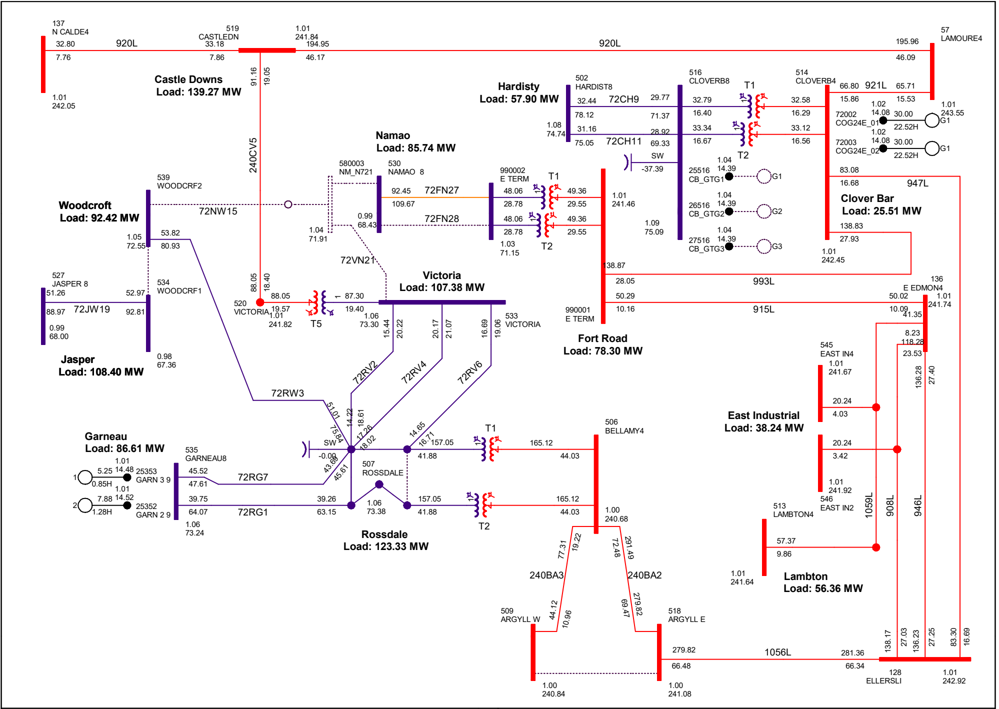
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-2



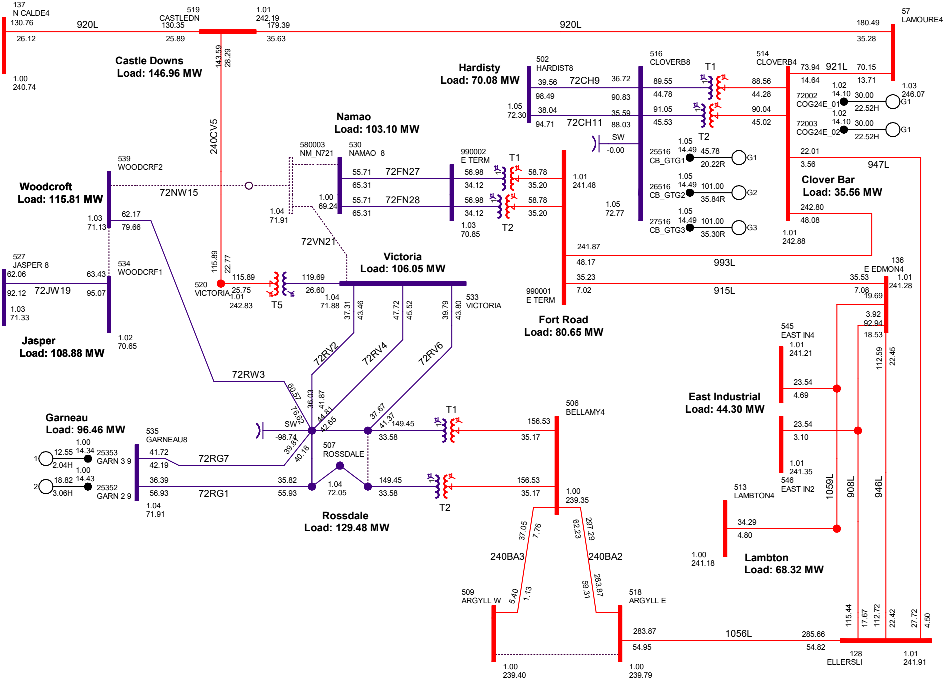
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-3



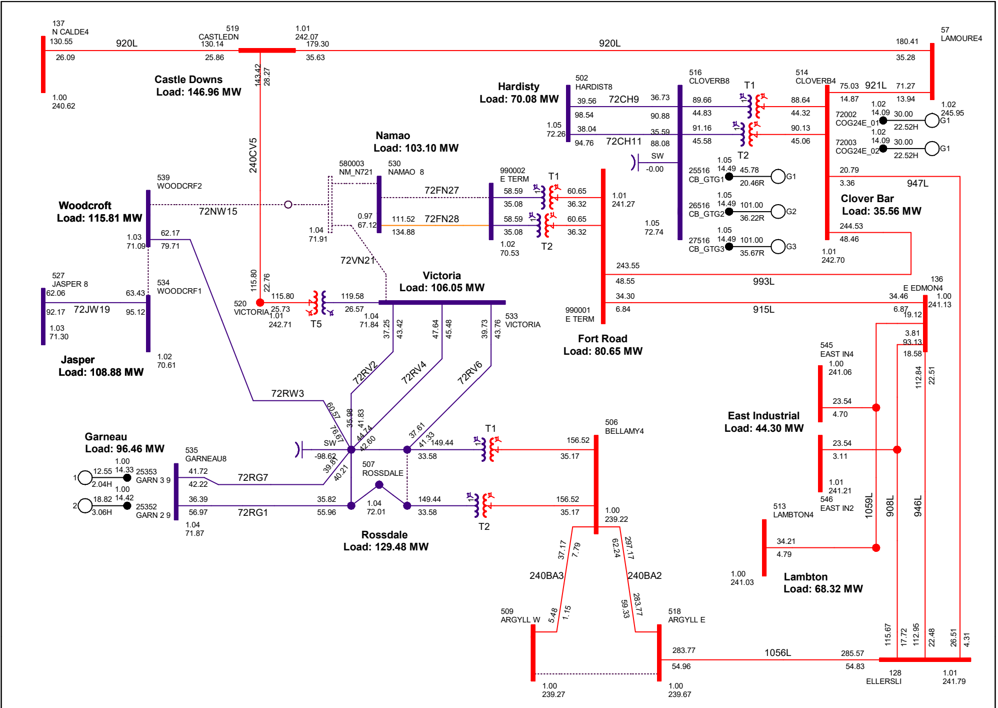
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Winter Peak - Option 4

Figure C-4



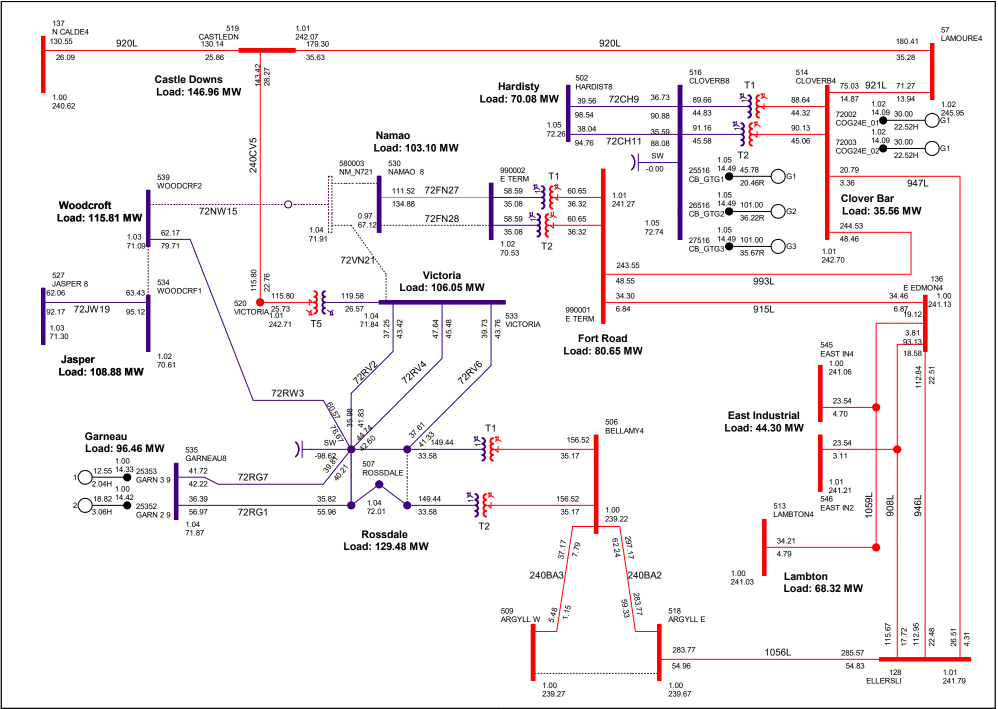
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Winter Peak - Option 4

Figure C-5



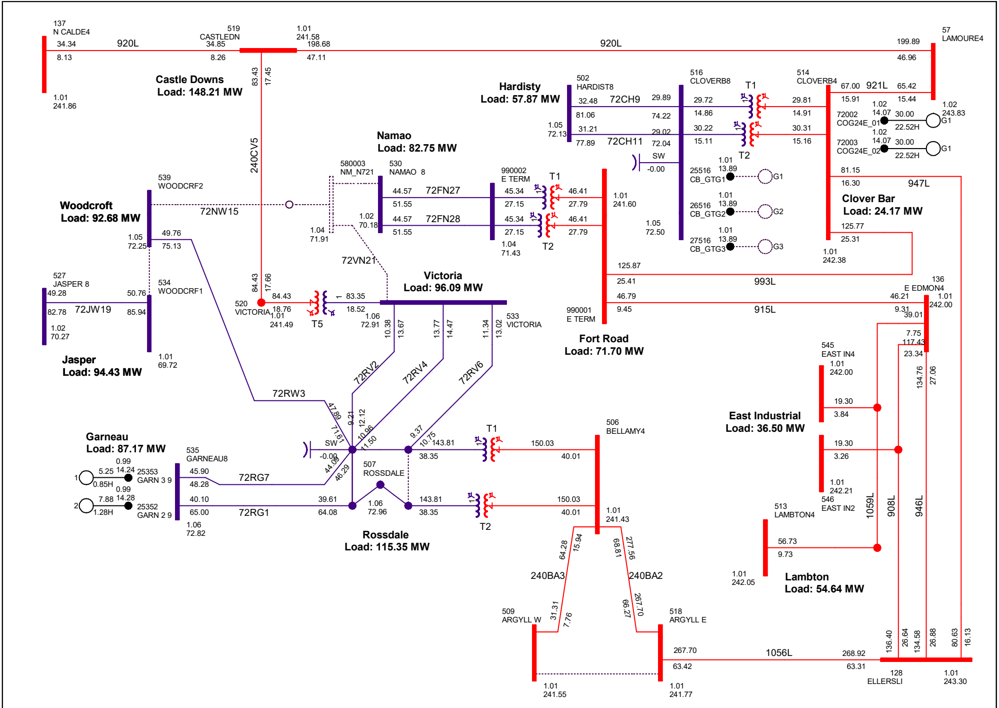
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Winter Peak - Option 4

Figure C-6

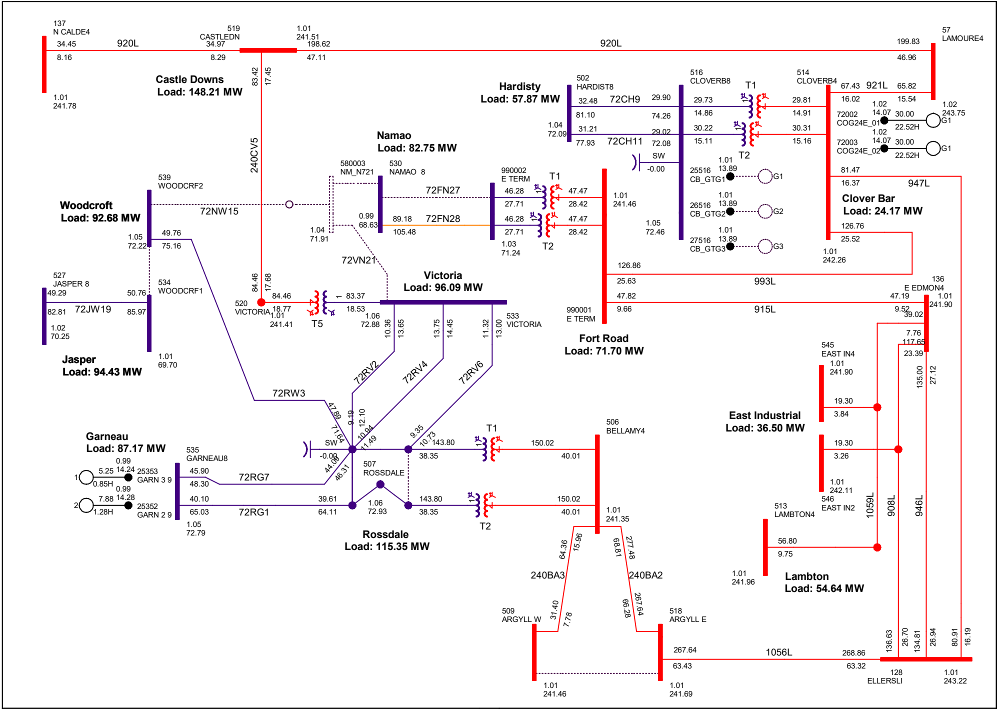


P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1
kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-7



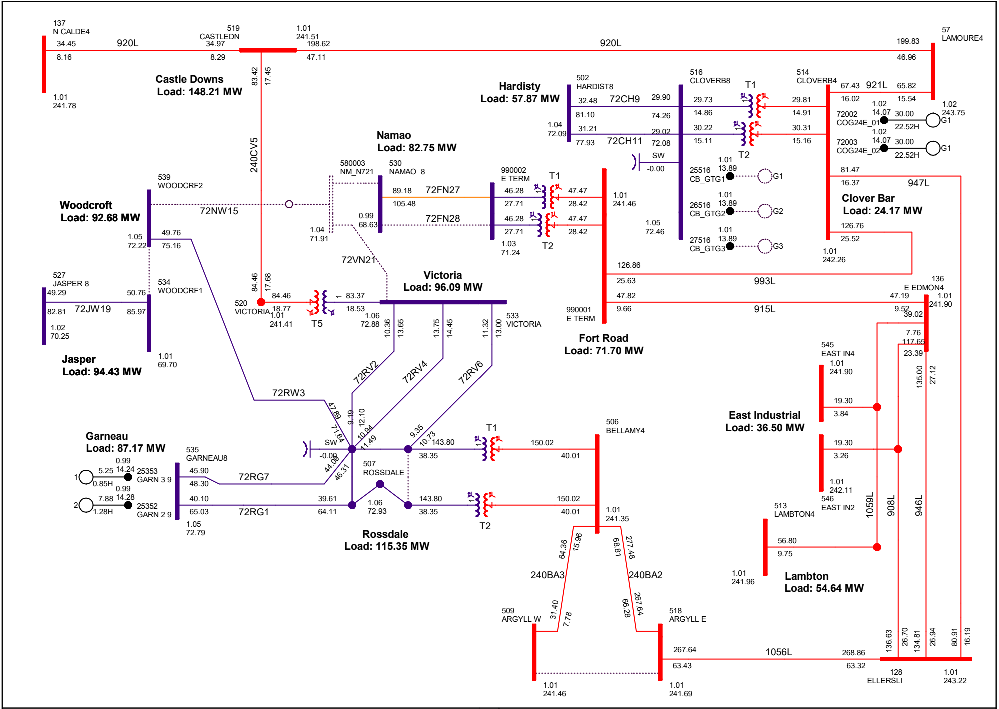
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-8



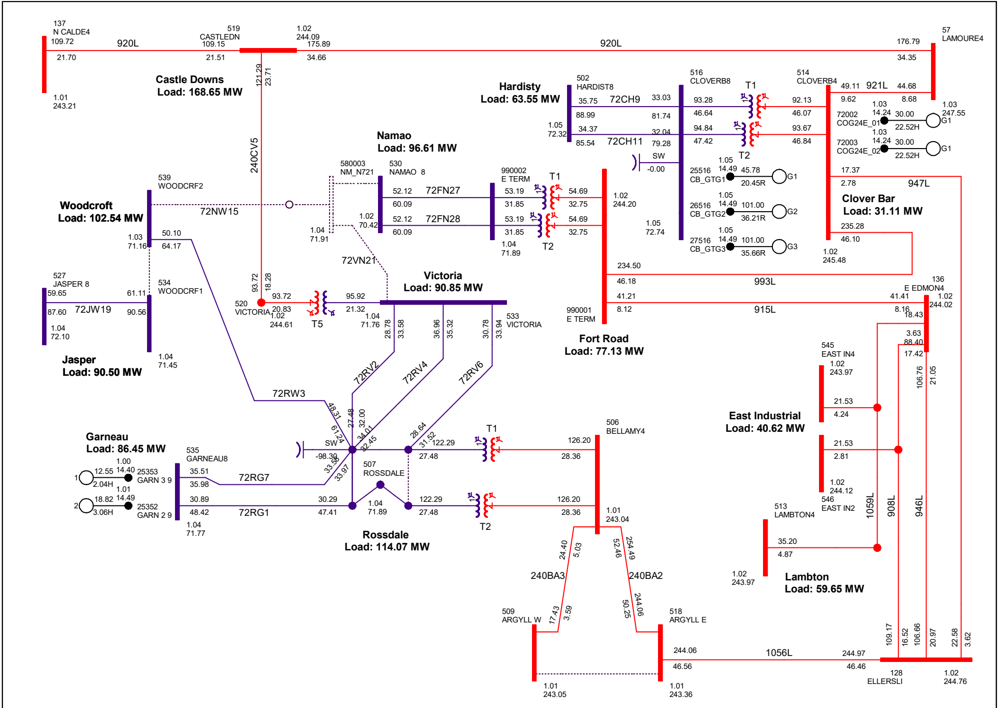
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-9



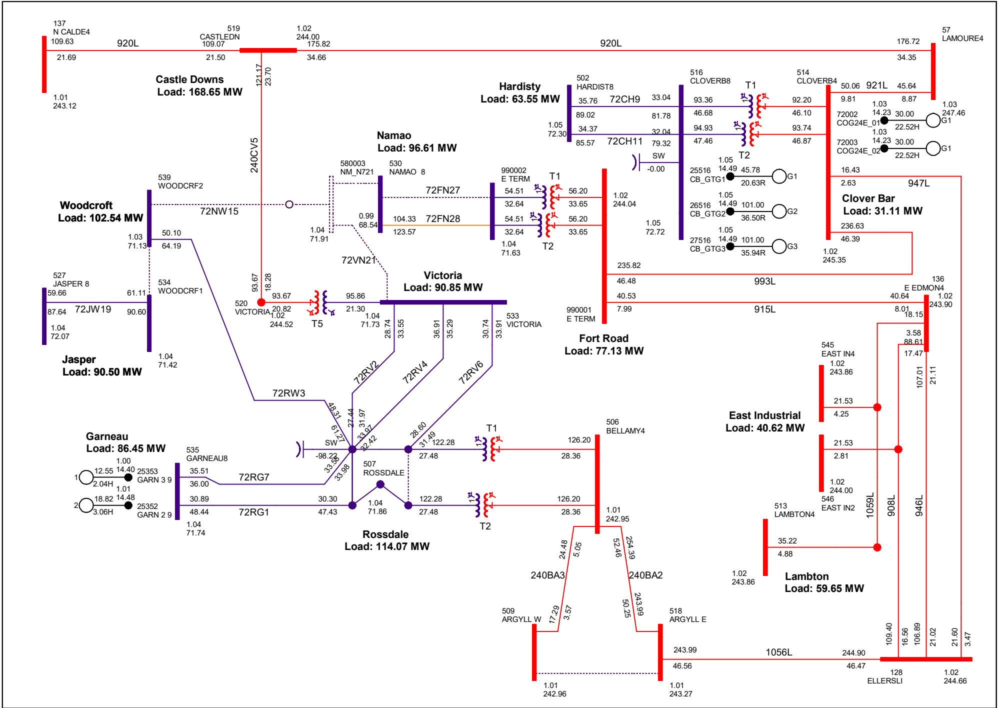
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Winter Peak - Option 4

Figure C-10



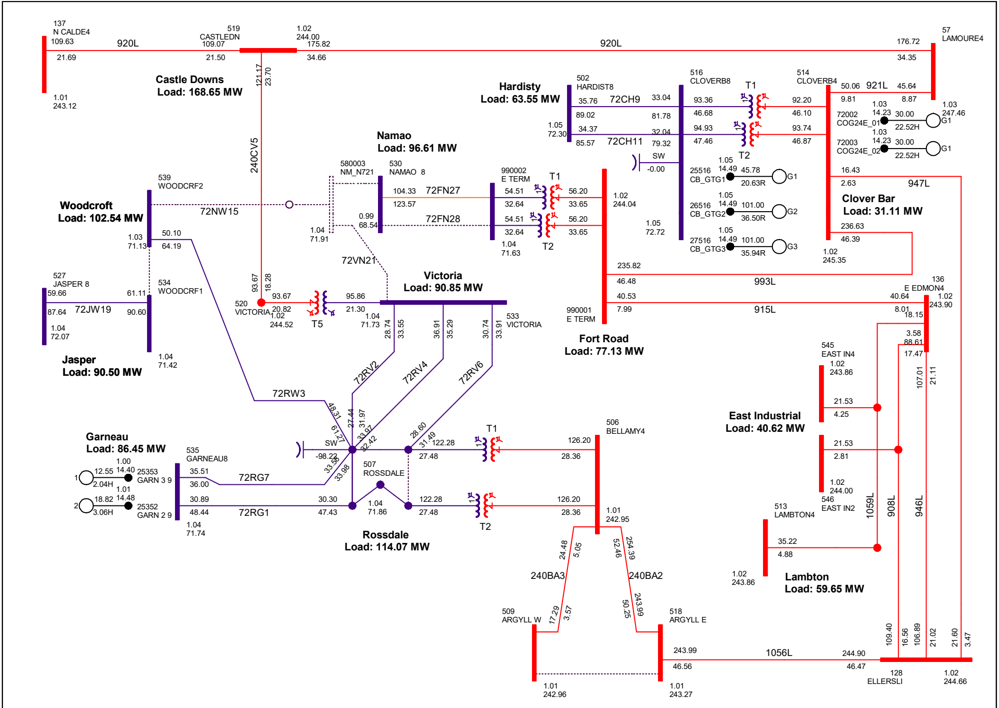
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

2043 Winter Peak - Option 4

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

Figure C-11



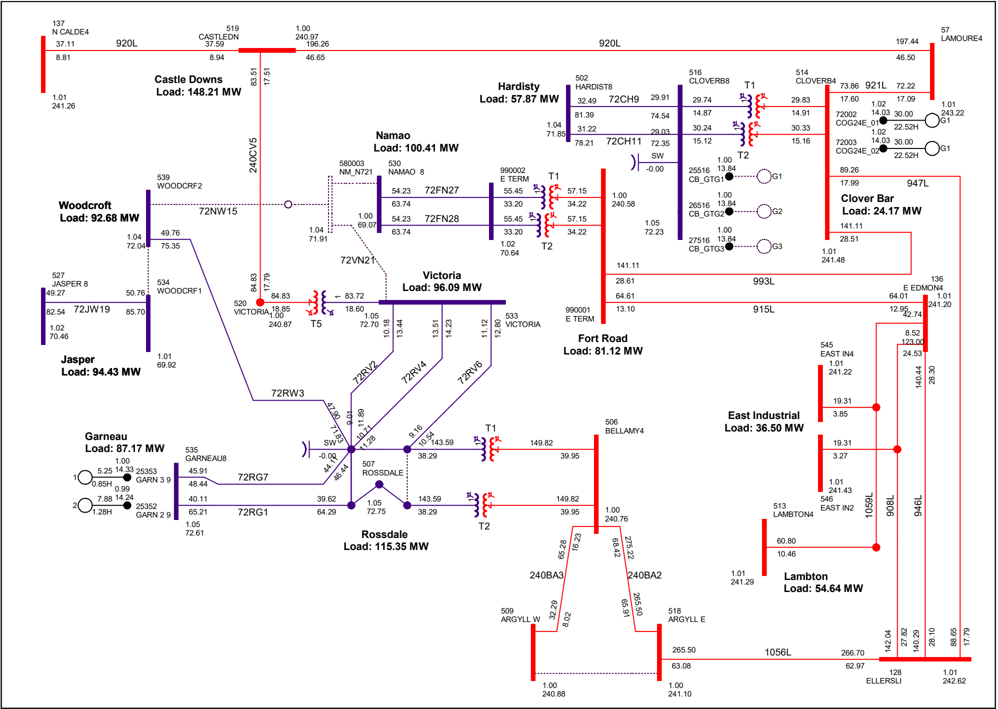
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Winter Peak - Option 4

Figure C-12



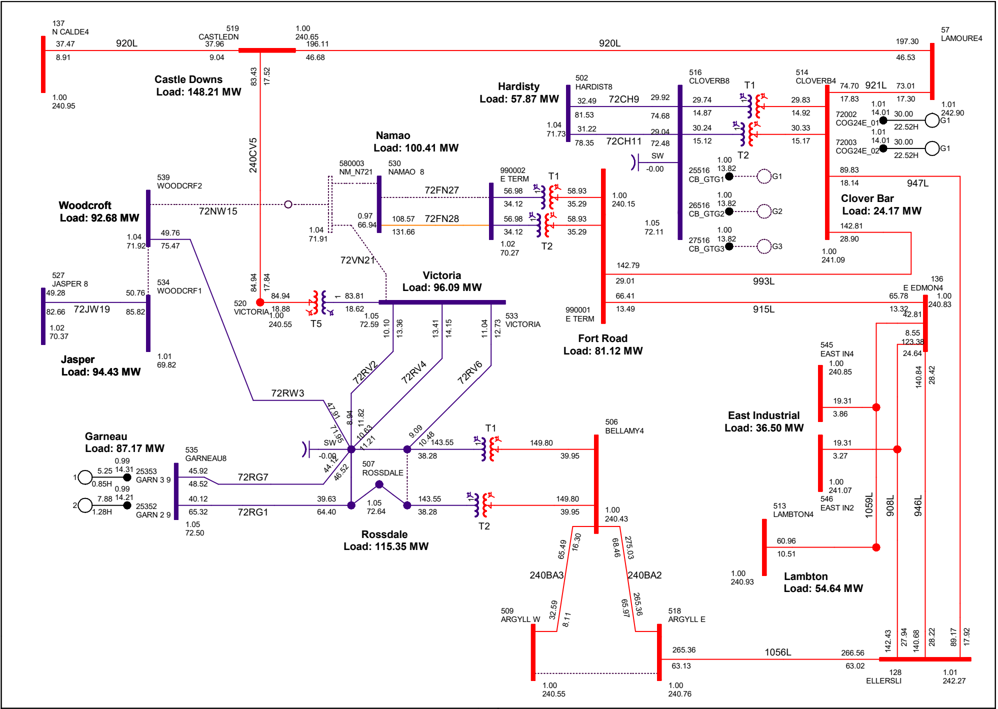
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-13



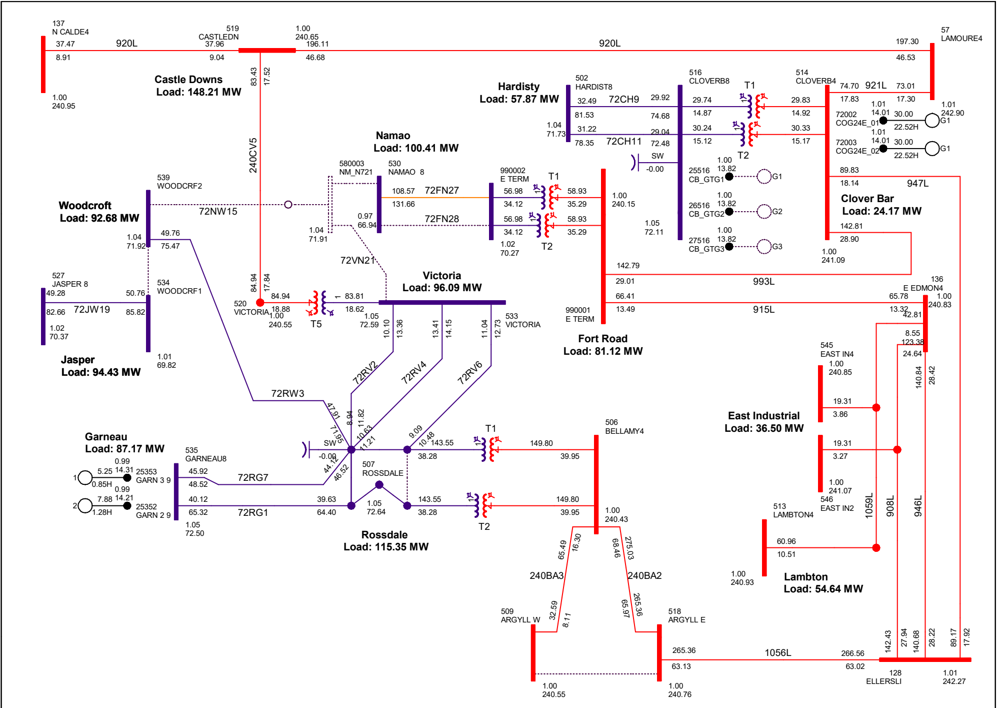
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-14



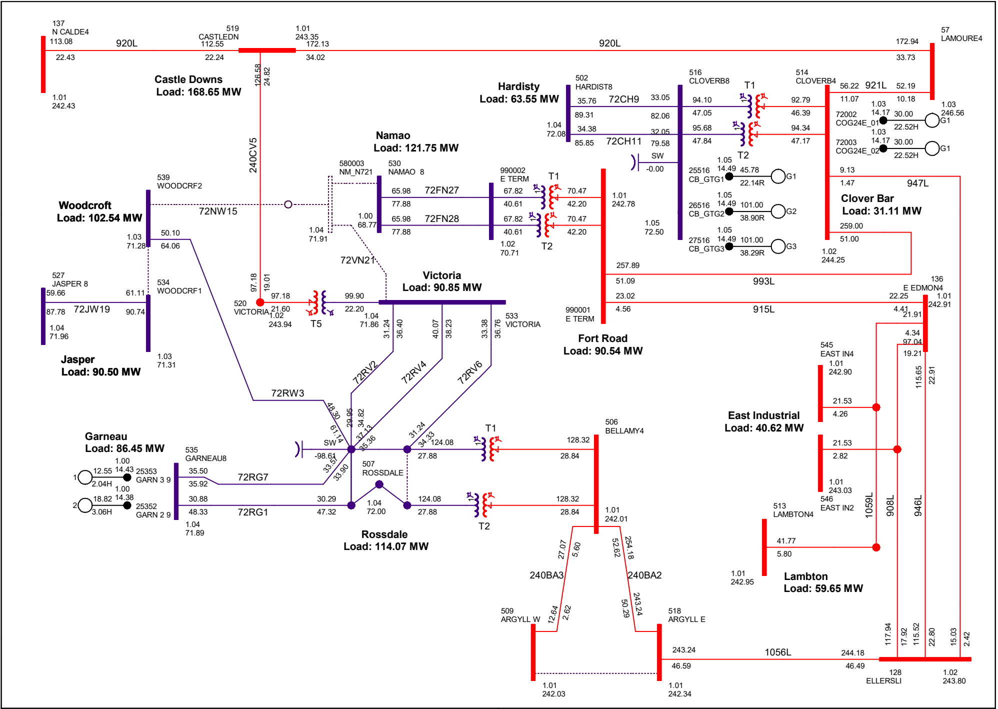
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE1
Equipment - MW/Mvar
99.5%RATE1

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Summer Peak - Option 4

Figure C-15



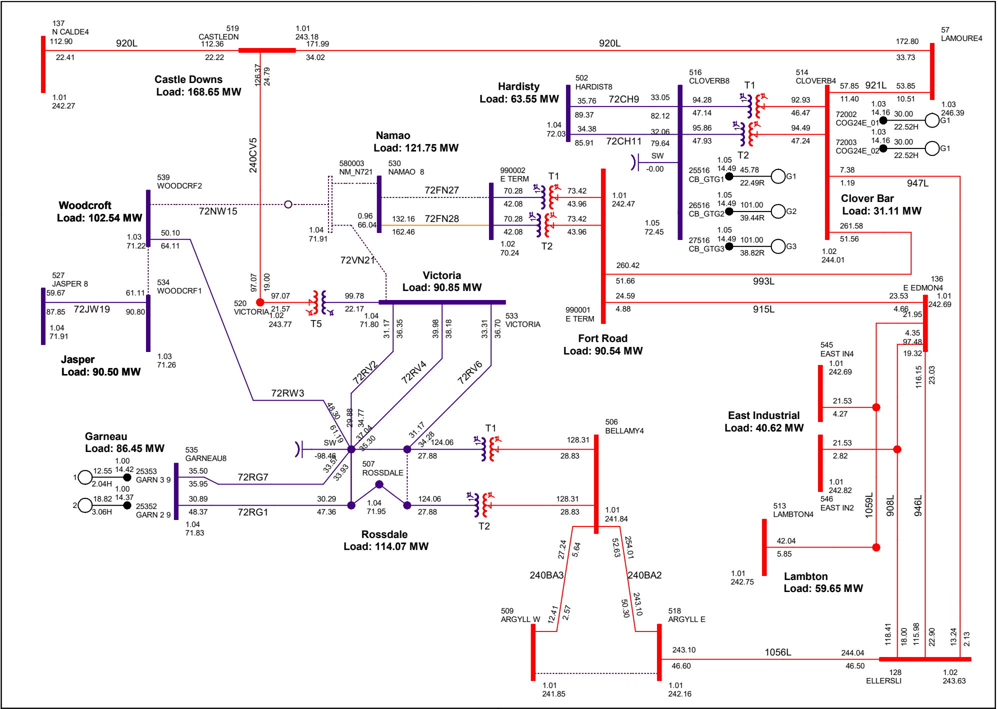
P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Winter Peak - Option 4

Figure C-16



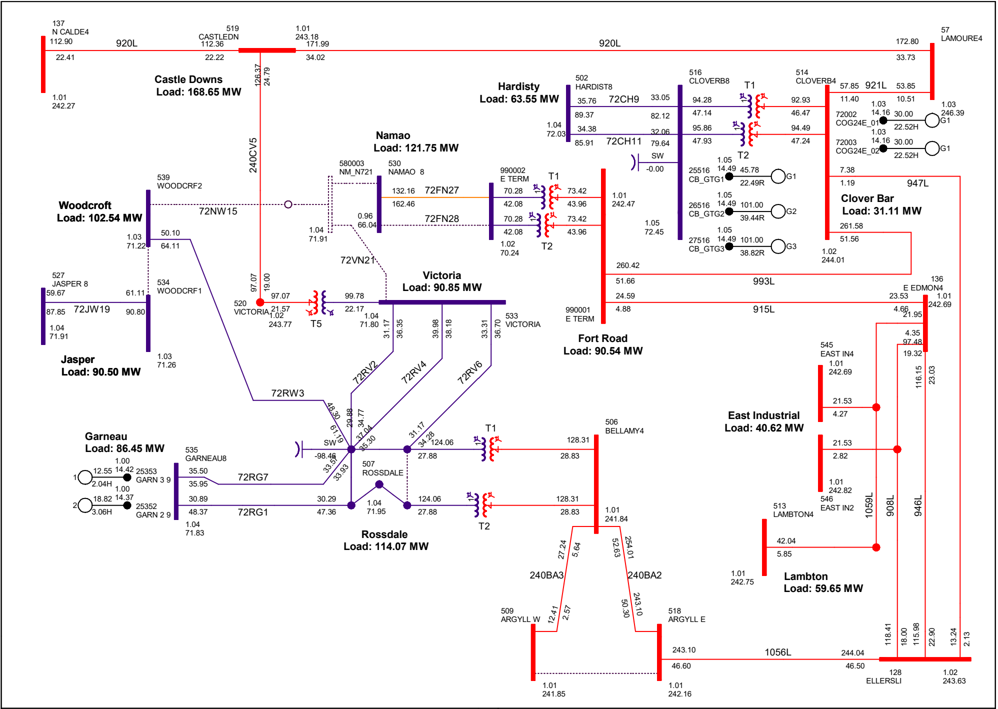
Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

P7078 - City of Edmonton Transmission Reinforcement Project

2043 Winter Peak - Option 4

Figure C-17



P7078 - City of Edmonton Transmission Reinforcement Project

Bus - Voltage (kV/pu)
Branch - MVA/% RATE2
Equipment - MW/Mvar
99.5%RATE2

kV: >0.000 <=25.000 <=72.000 <=144.000 <=240.000 <=500.000

2043 Winter Peak - Option 4

Figure C-18

Attachment D: Voltage Stability (PV) Analysis

D-1 Assumptions

Source system includes generation in the Wabamun area, South and NE regions

Sink system includes Namao and Kennedale in pre project and Namao and Fort Road in post project.

Category B contingencies include all transmission elements rated 69 kV and above in Edmonton area.

Category C5 contingencies are outlined in Table D-1-1.

Table D-1-1 Select Category C5 contingencies

C5 Contingency
1044L (Petrolia – Jasper 805S) and 1045L (Sundance 310P – Jasper 805S)
915L (Clover Bar 987S – East Edmonton 38S) and 947L(Clover Bar 987S – Ellerslie 89S)*
920L (Castle Downs – Lamoureux 71S) and 921L (Clover Bar987S – Lamoureux 71S)
1055L (Petrolia – Argyll) and 1056L (Ellerslie 89S – Argyll)
915L (Fort Road – East Edmonton 38S) and 947L(Clover Bar 987S – Ellerslie 89S)**
993L (Fort Road - Clover Bar 987S) and 947L(Clover Bar 987S – Ellerslie 89S)**
993L (Fort Road - Clover Bar 987S) and 915L (Fort Road – East Edmonton 38S)**

* pre development contingency
** post development contingency

Bus monitored:

- 240kV buses 514, 136, 519, 990001;
- 72kV buses 530, 528, 502, 516, 990002

D-2 PV Plots Summary

Section	Topology	Contingencies
Attachment D-1	Pre-Development	Category B
Attachment D-2	Pre-Development	Category C5
Attachment D-3	Post Development	Category B
Attachment D-4	Post Development	Category C5
Note: The plots only show the 10 worst contingencies (lowest PV margin).		

Attachment D-1

Pre Project Cat. B

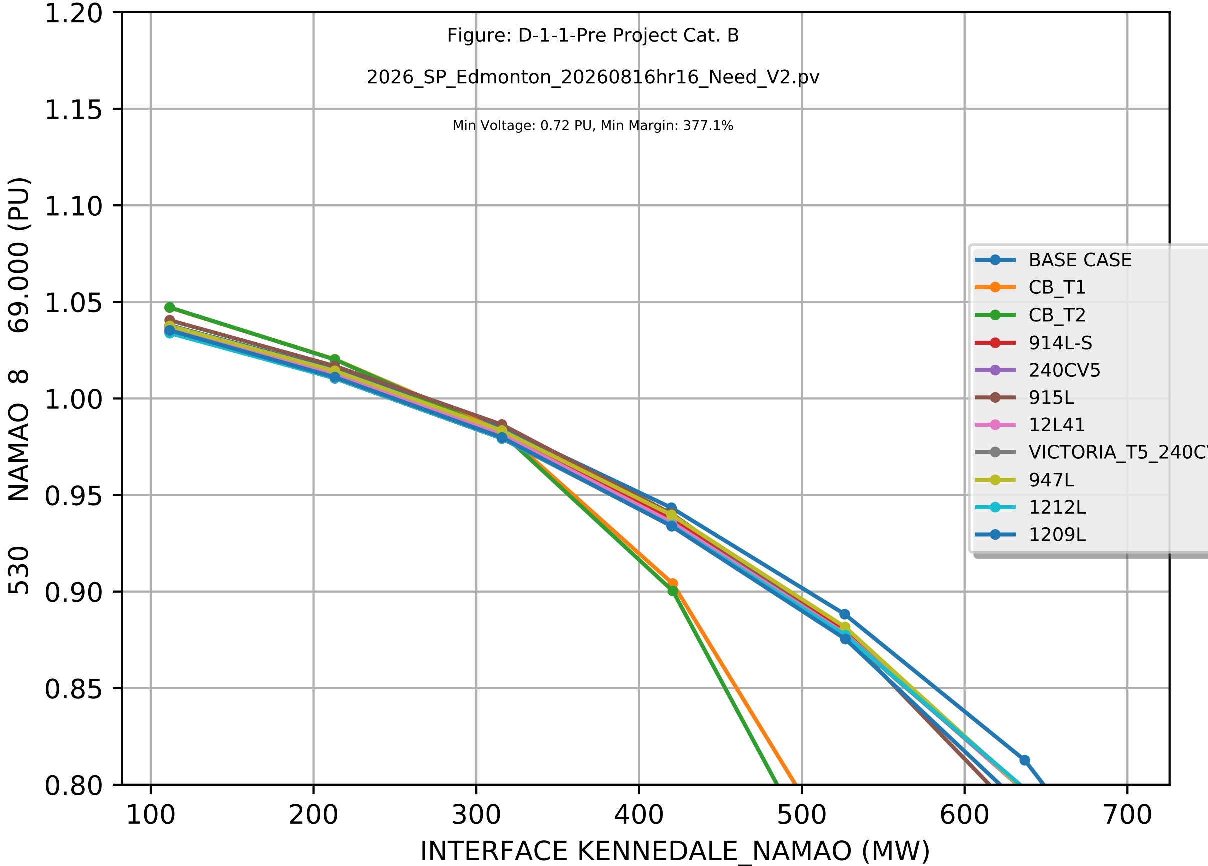


Figure: D-1-1-Pre Project Cat. B
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.72 PU, Min Margin: 377.1%
530 NAMAO 8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
BASE CASE
CB_T1
CB_T2
914L-S
240CV5
915L
12L41
VICTORIA_T5_240CV
947L
1212L
1209L

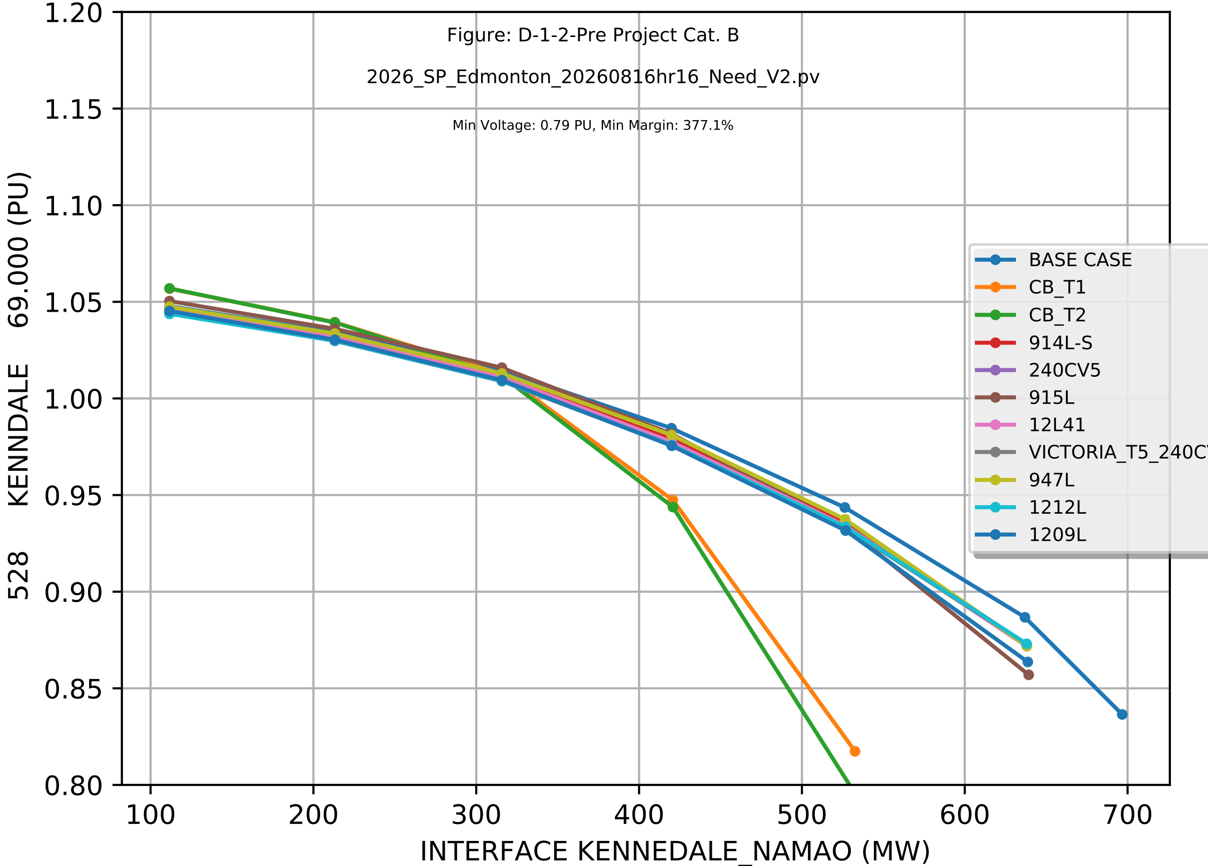


Figure: D-1-2-Pre Project Cat. B
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.79 PU, Min Margin: 377.1%
528 KENNDALE 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
BASE CASE
CB_T1
CB_T2
914L-S
240CV5
915L
12L41
VICTORIA_T5_240C
947L
1212L
1209L

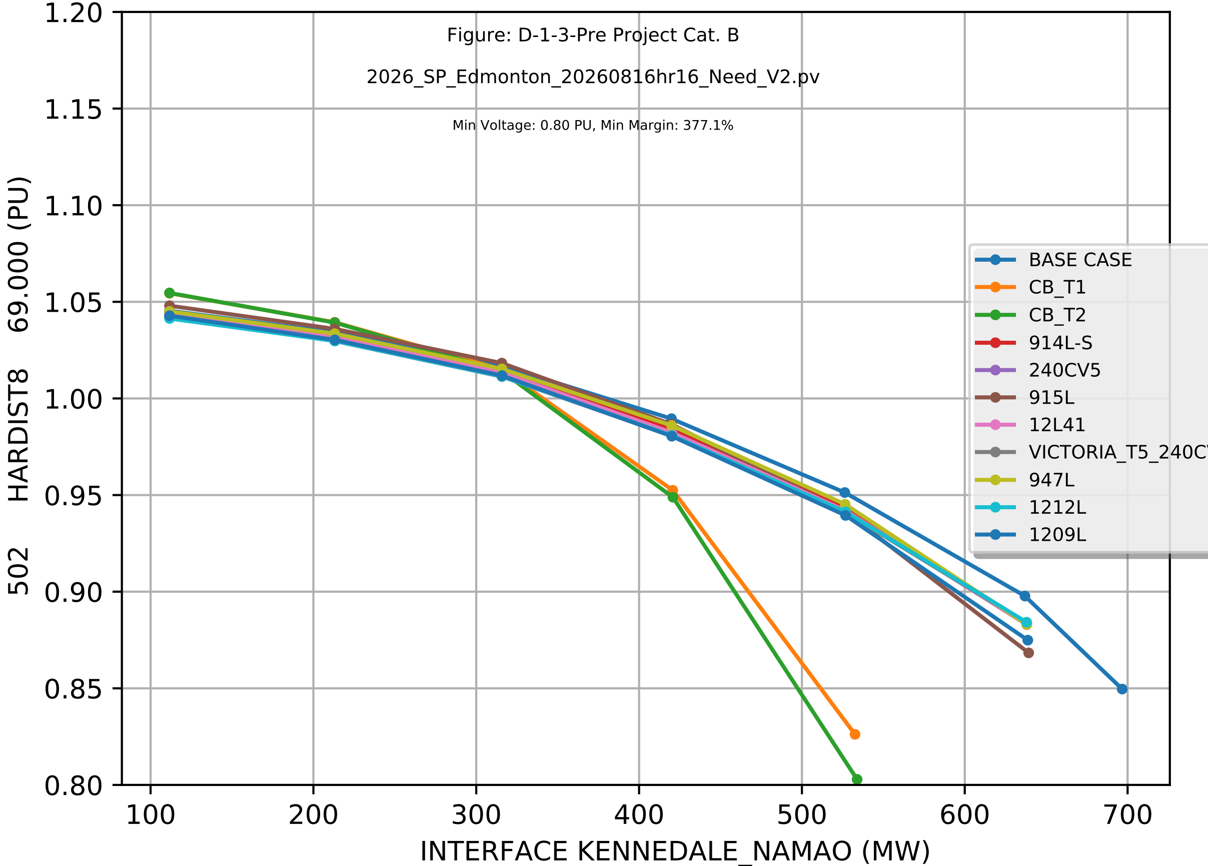


Figure: D-1-3-Pre Project Cat. B
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.80 PU, Min Margin: 377.1%
502 HARDIST8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
BASE CASE
CB_T1
CB_T2
914L-S
240CV5
915L
12L41
VICTORIA_T5_240CV
947L
1212L
1209L

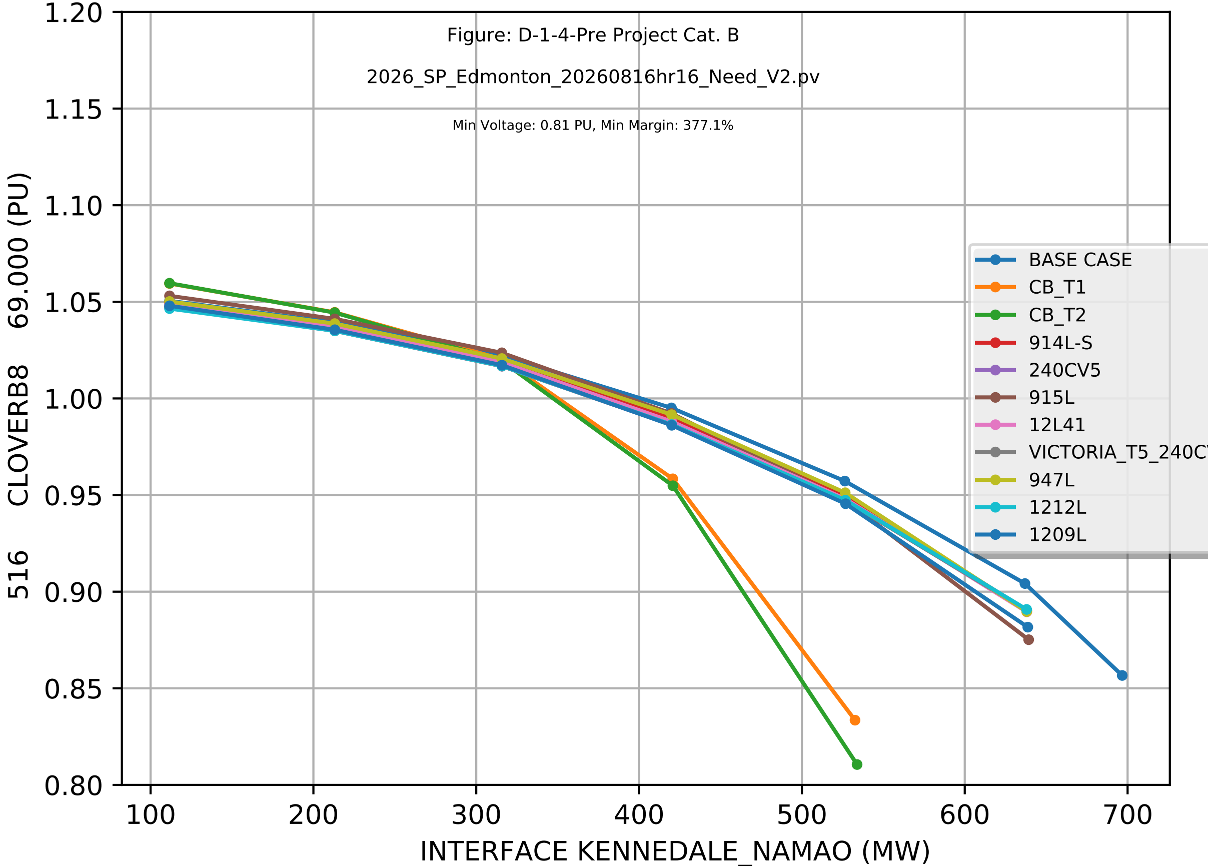


Figure: D-1-4-Pre Project Cat. B
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.81 PU, Min Margin: 377.1%
516 CLOVERB8 69.000 (PU)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
CB_T1
CB_T2
914L-S
240CV5
915L
12L41
VICTORIA_T5_240CV
947L
1212L
1209L

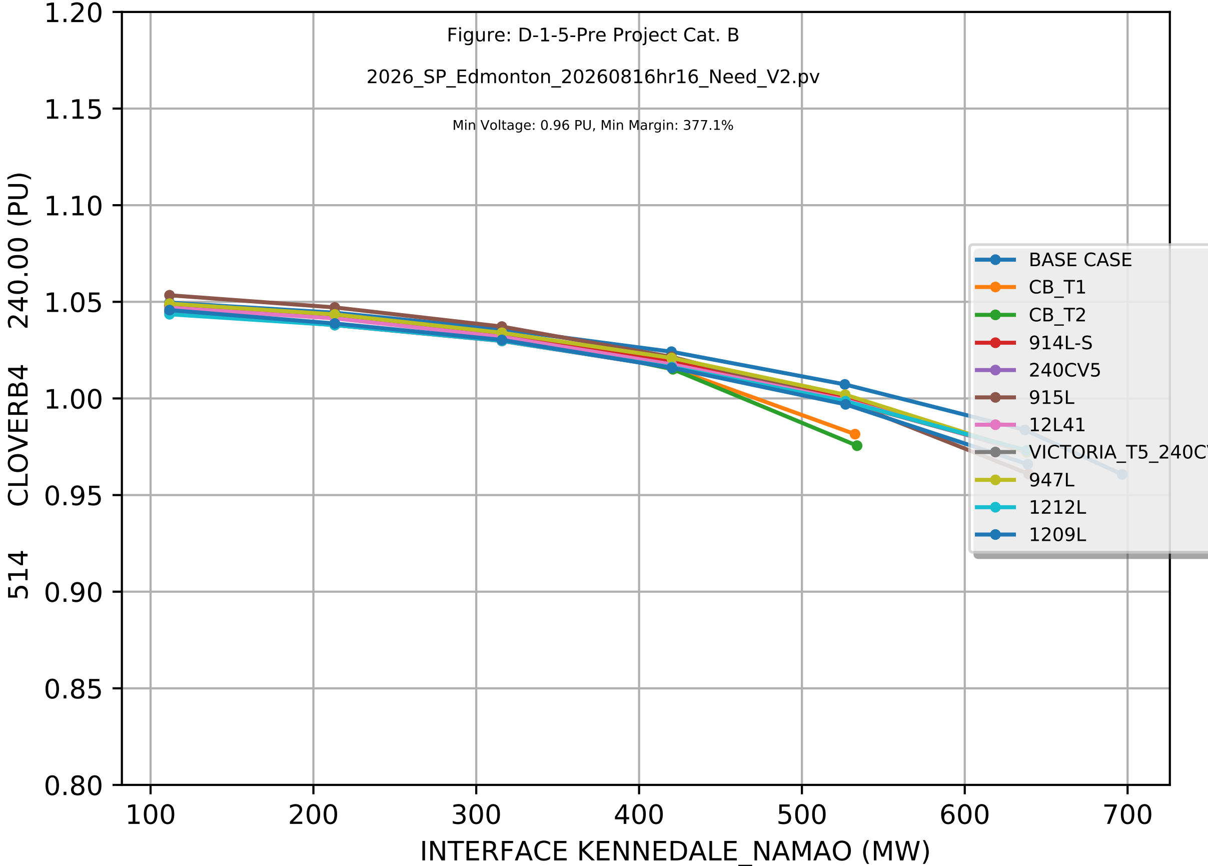


Figure: D-1-5-Pre Project Cat. B
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.96 PU, Min Margin: 377.1%
514 CLOVERB4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
BASE CASE
CB_T1
CB_T2
914L-S
240CV5
915L
12L41
VICTORIA_T5_240CV
947L
1212L
1209L

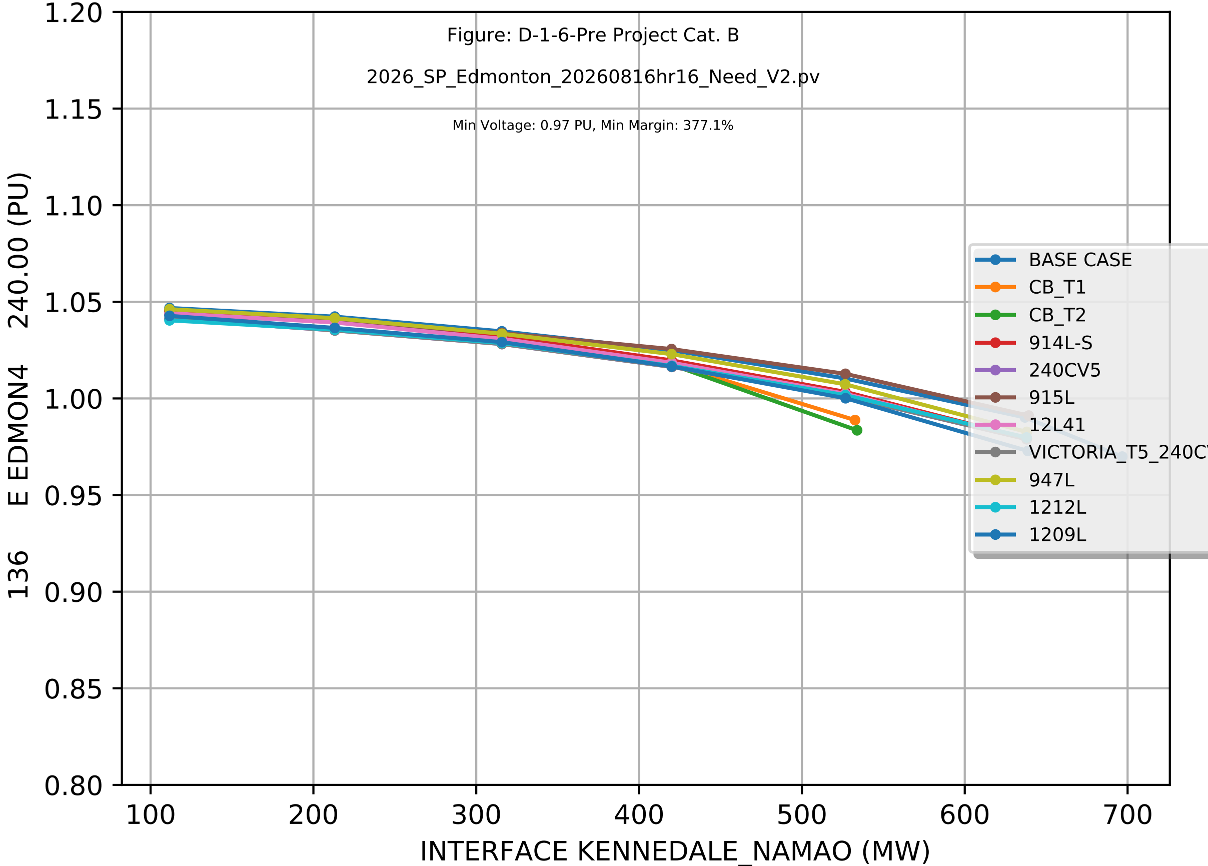


Figure: D-1-6-Pre Project Cat. B
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.97 PU, Min Margin: 377.1%
136 E EDMON4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
BASE CASE
CB_T1
CB_T2
914L-S
240CV5
915L
12L41
VICTORIA_T5_240CV
947L
1212L
1209L

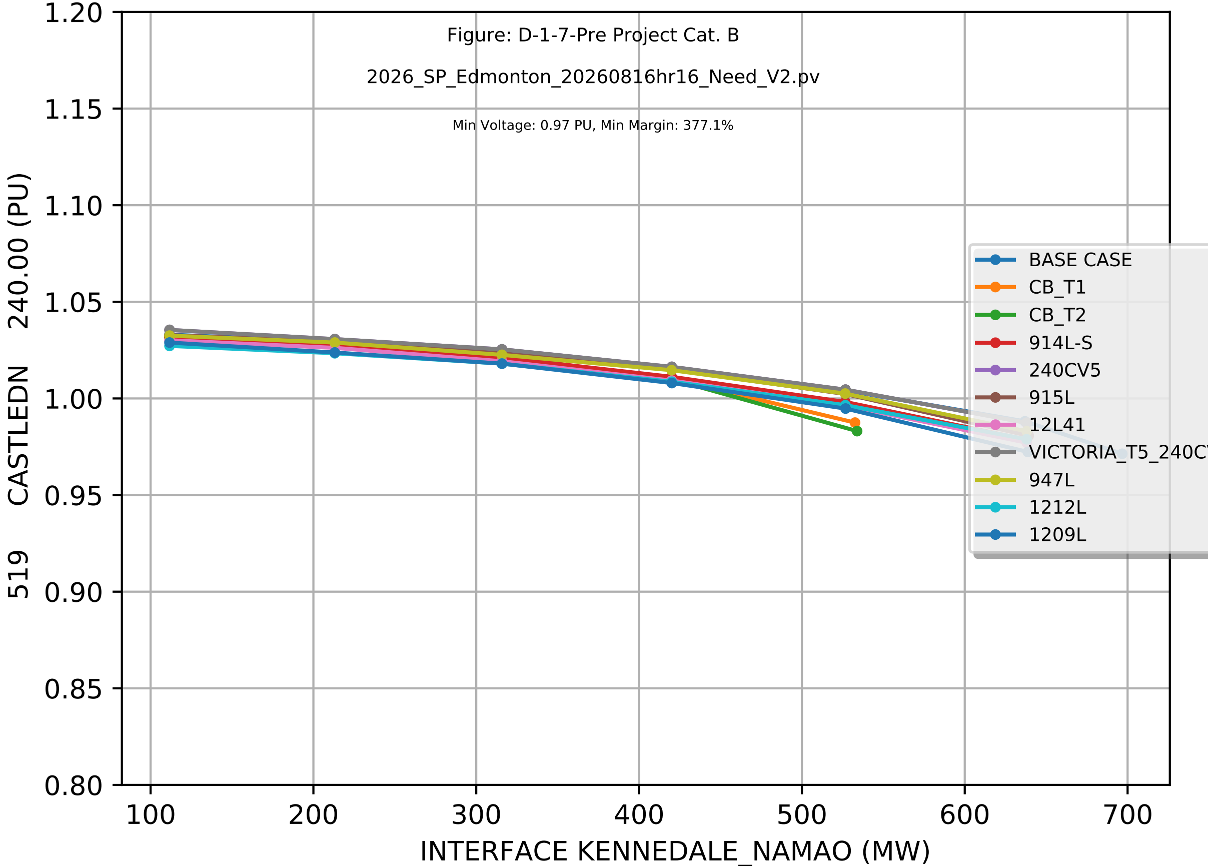


Figure: D-1-7-Pre Project Cat. B
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.97 PU, Min Margin: 377.1%
519 CASTLEDN 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
BASE CASE
CB_T1
CB_T2
914L-S
240CV5
915L
12L41
VICTORIA_T5_240CV
947L
1212L
1209L

Attachment D-2

Pre Project Cat. C

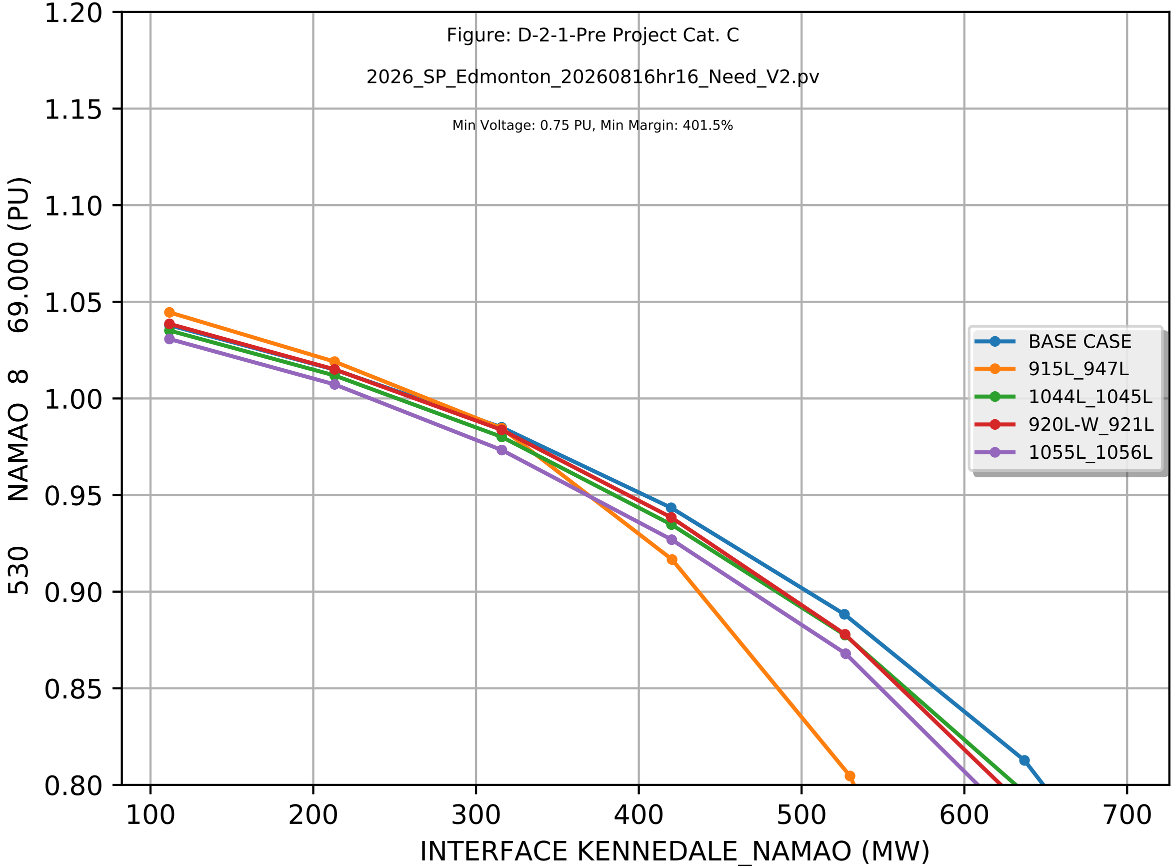


Figure: D-2-1-Pre Project Cat. C
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.75 PU, Min Margin: 401.5%
530 NAMAO 8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
BASE CASE
915L_947L
1044L_1045L
920L-W_921L
1055L_1056L

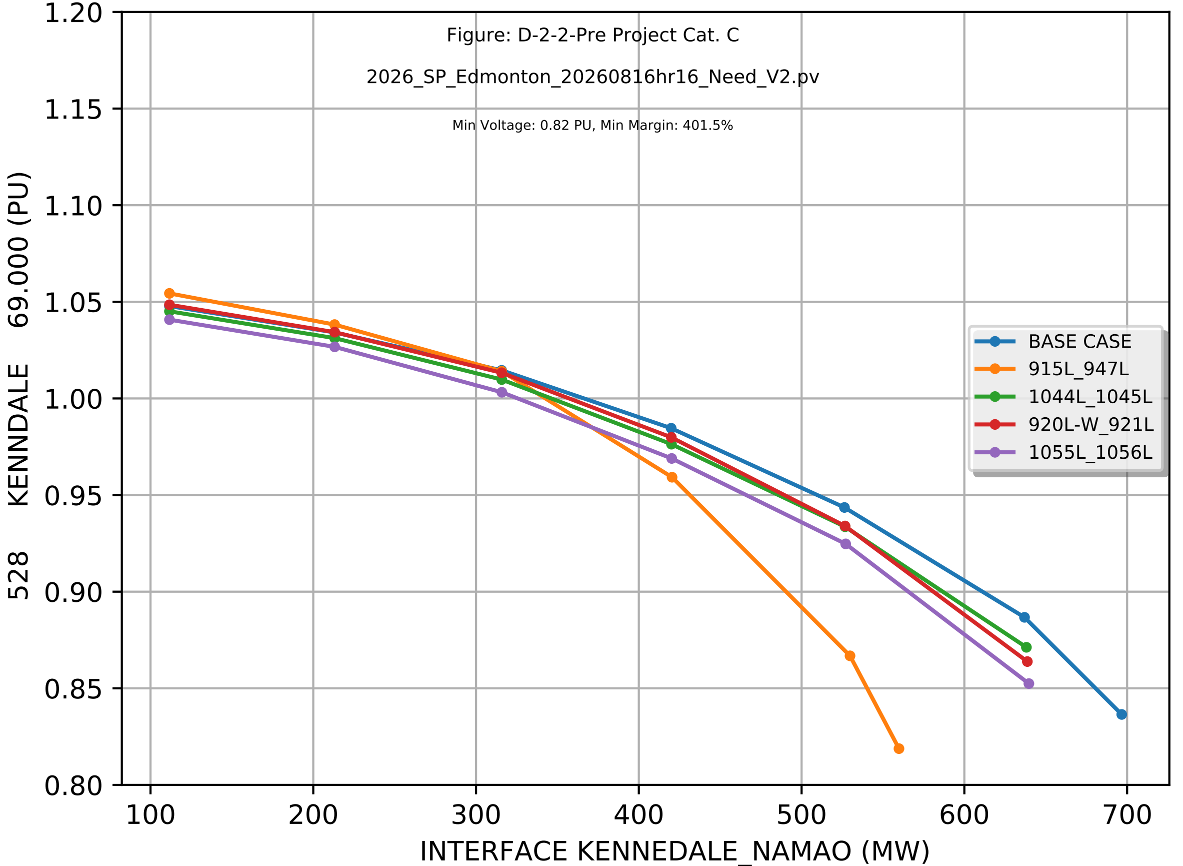


Figure: D-2-2-Pre Project Cat. C
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.82 PU, Min Margin: 401.5%
528 KENNDALE 69.000 (PU)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
1044L_1045L
920L-W_921L
1055L_1056L

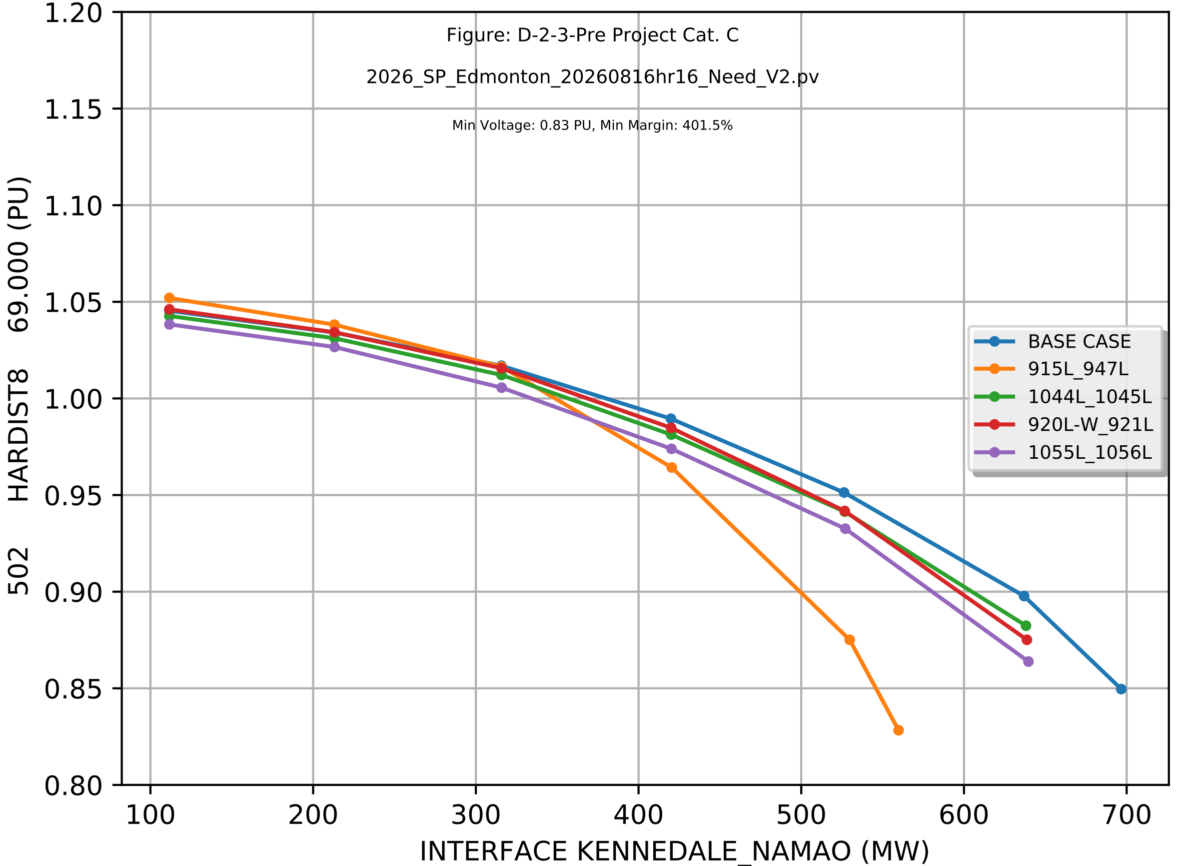


Figure: D-2-3-Pre Project Cat. C
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.83 PU, Min Margin: 401.5%
502 HARDIST8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
1044L_1045L
920L-W_921L
1055L_1056L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700

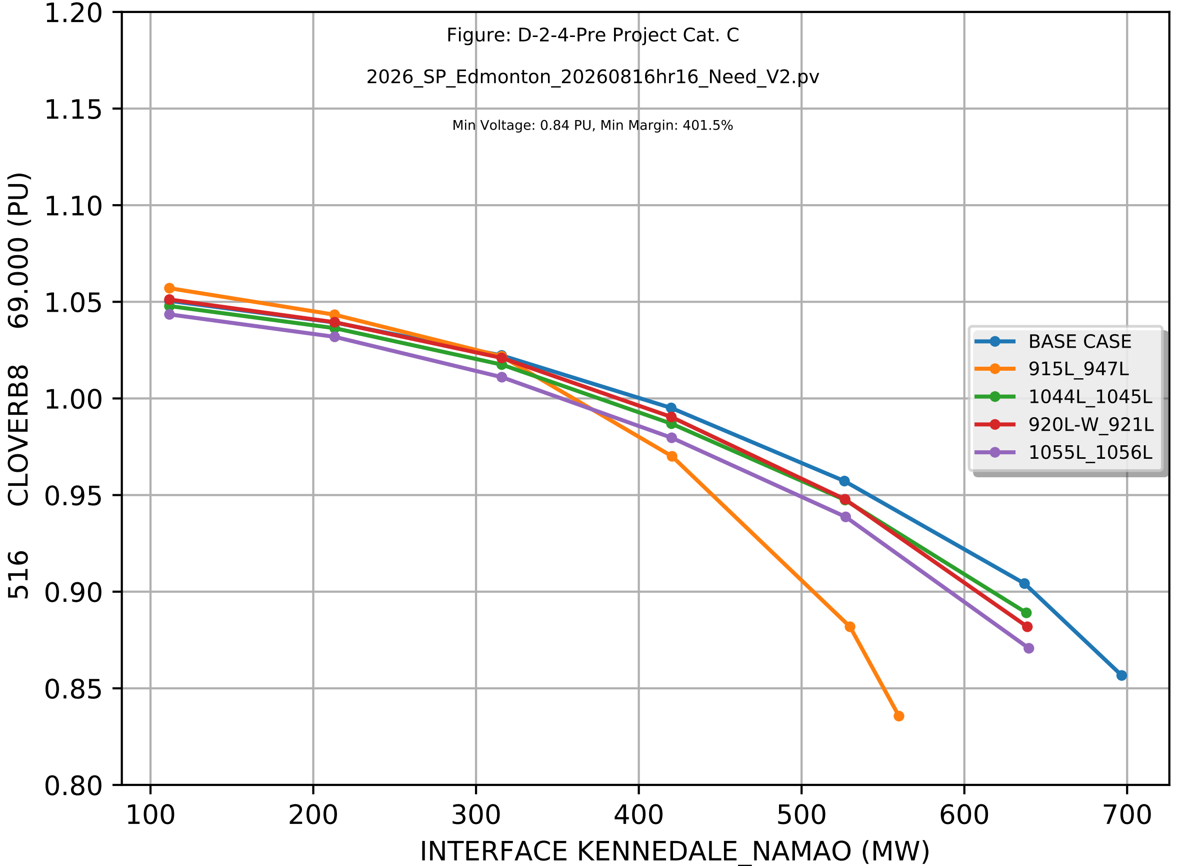


Figure: D-2-4-Pre Project Cat. C
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.84 PU, Min Margin: 401.5%
516 CLOVERB8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
1044L_1045L
920L-W_921L
1055L_1056L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700

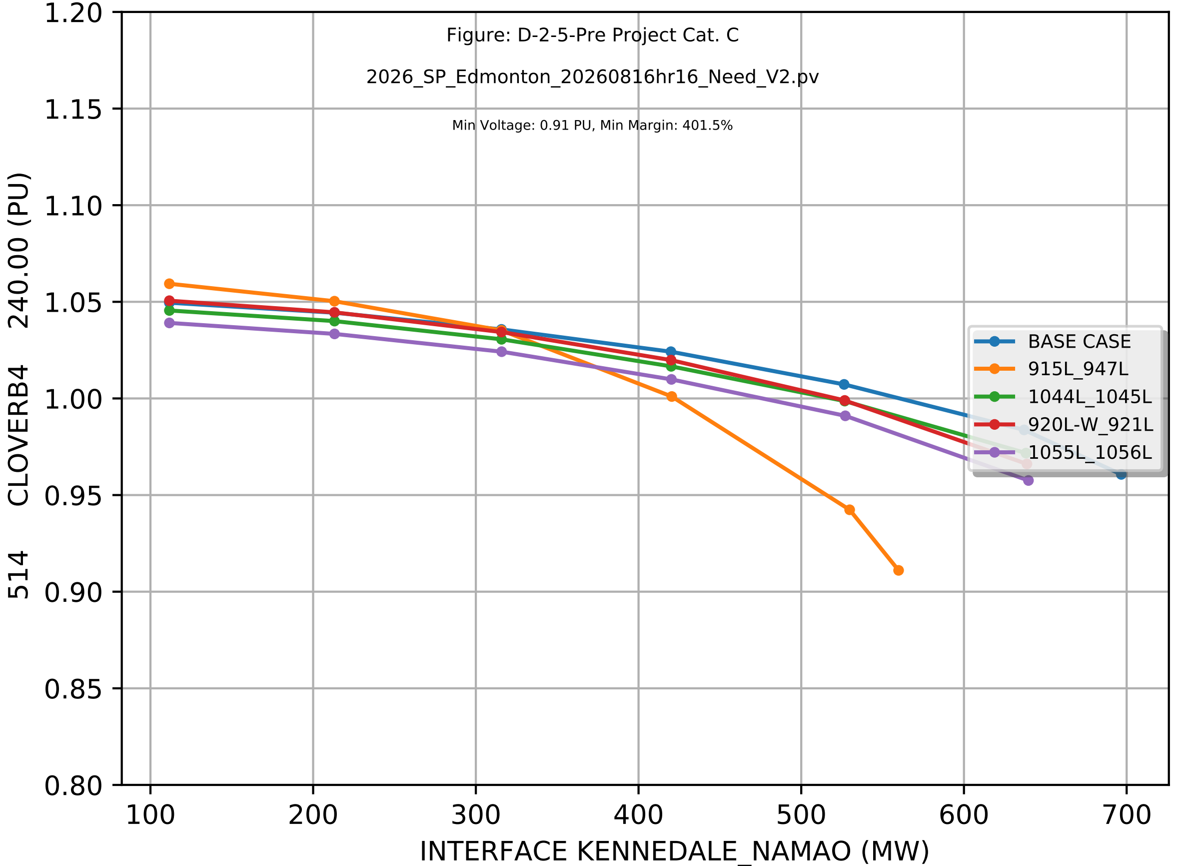


Figure: D-2-5-Pre Project Cat. C
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.91 PU, Min Margin: 401.5%
514 CLOVERB4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
1044L_1045L
920L-W_921L
1055L_1056L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700

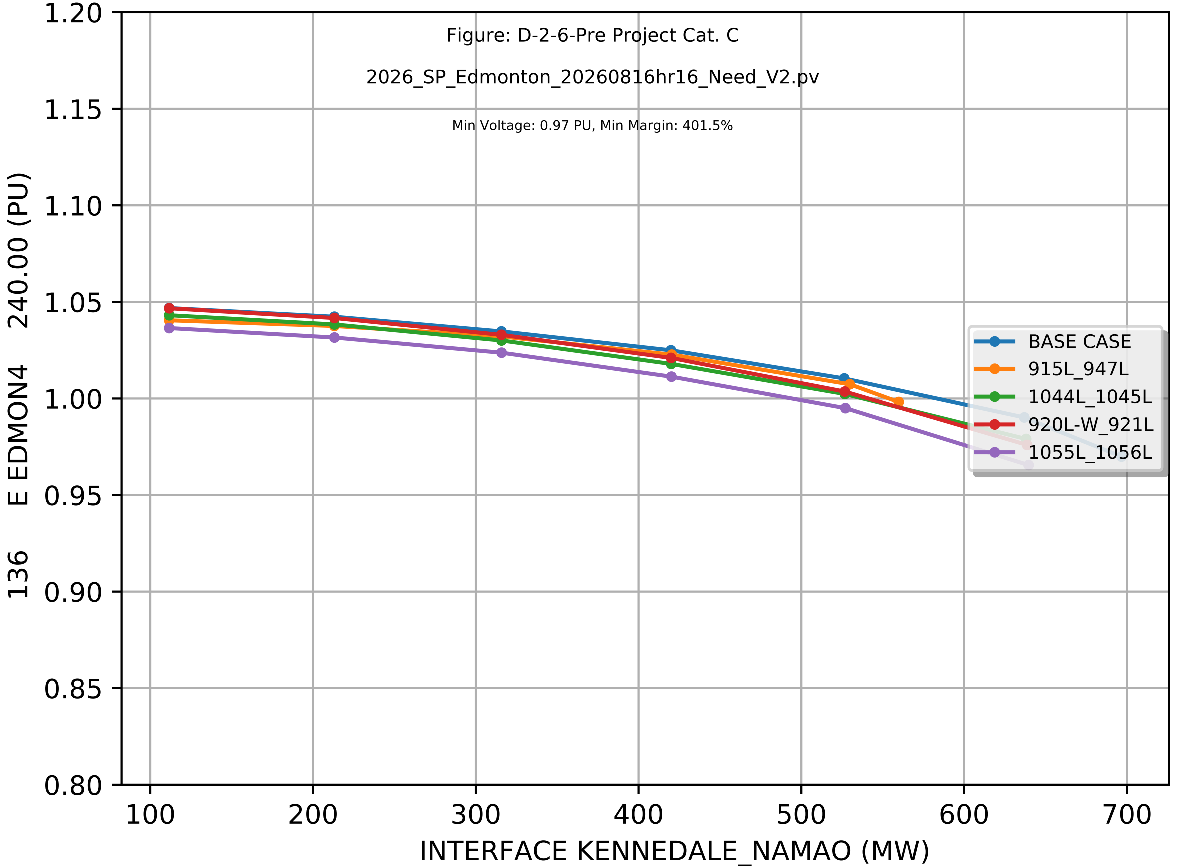


Figure: D-2-6-Pre Project Cat. C
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.97 PU, Min Margin: 401.5%
136 E EDMON4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
1044L_1045L
920L-W_921L
1055L_1056L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700

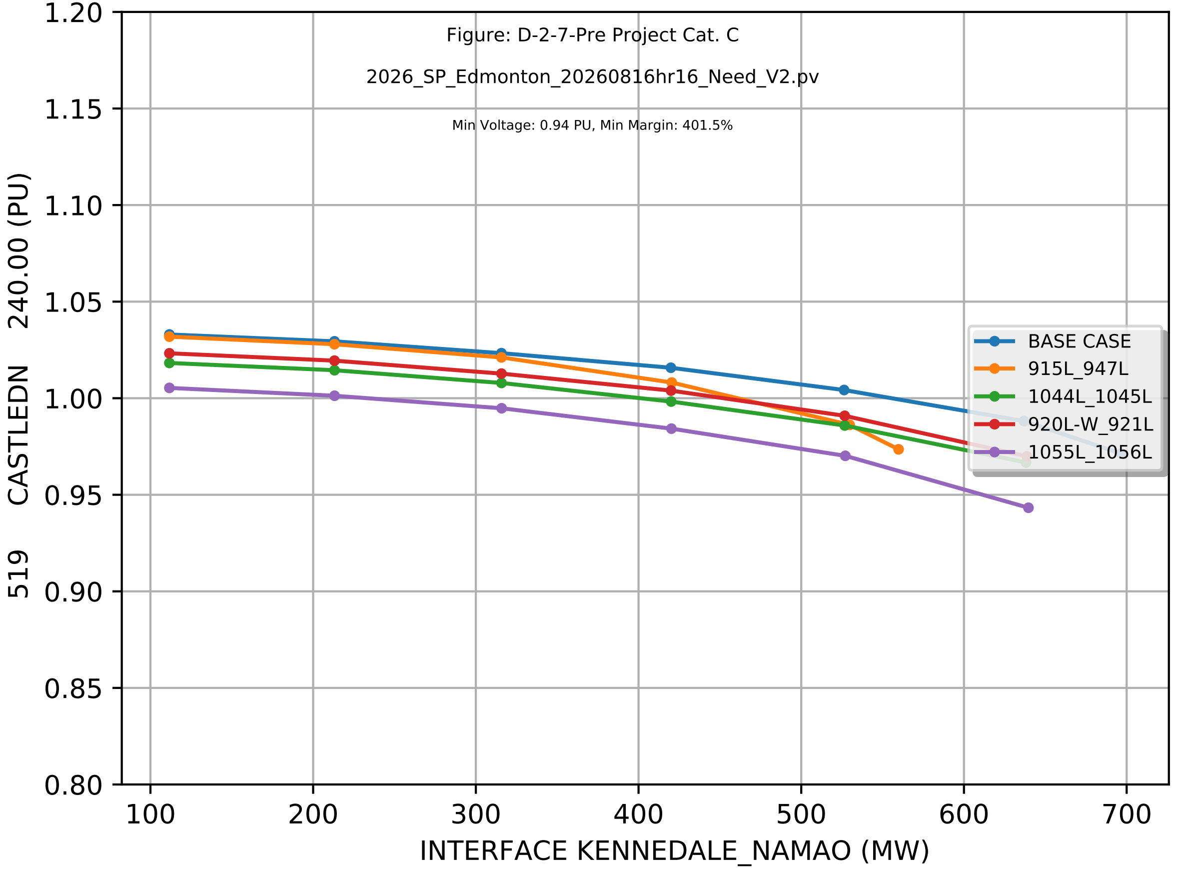


Figure: D-2-7-Pre Project Cat. C
2026_SP_Edmonton_20260816hr16_Need_V2.pv
Min Voltage: 0.94 PU, Min Margin: 401.5%
519 CASTLEDN 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
1044L_1045L
920L-W_921L
1055L_1056L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
700

Attachment D-3

Post Project Cat. B

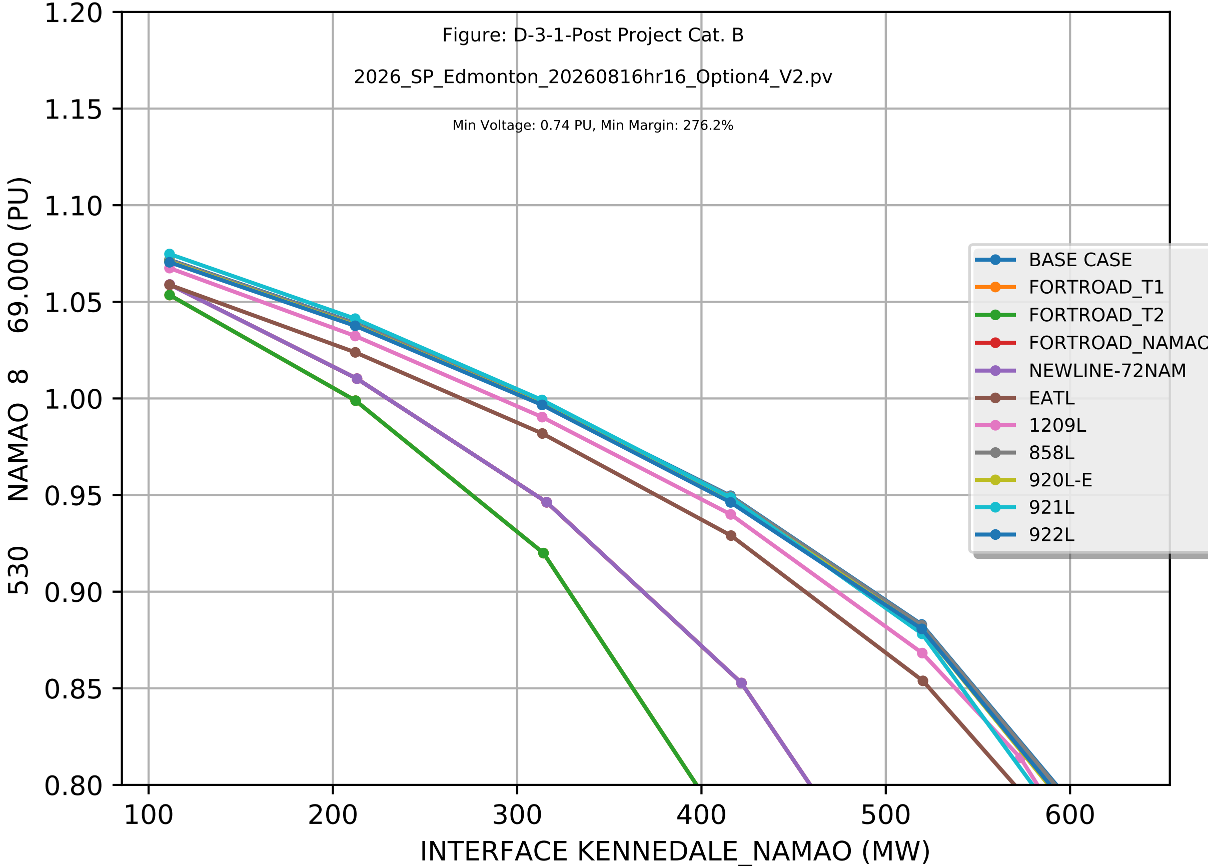


Figure: D-3-1-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.74 PU, Min Margin: 276.2%
530 NAMAO 8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

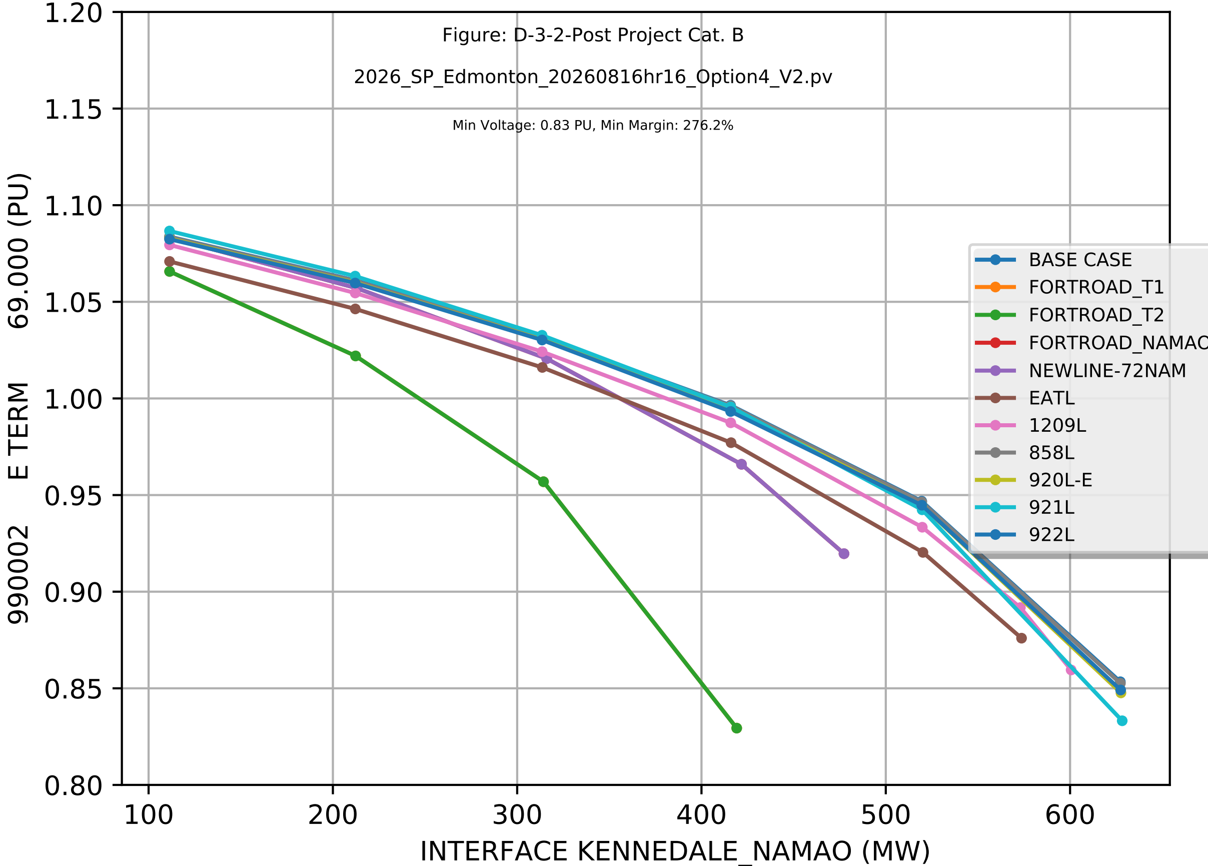


Figure: D-3-2-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.83 PU, Min Margin: 276.2%
990002 E TERM 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

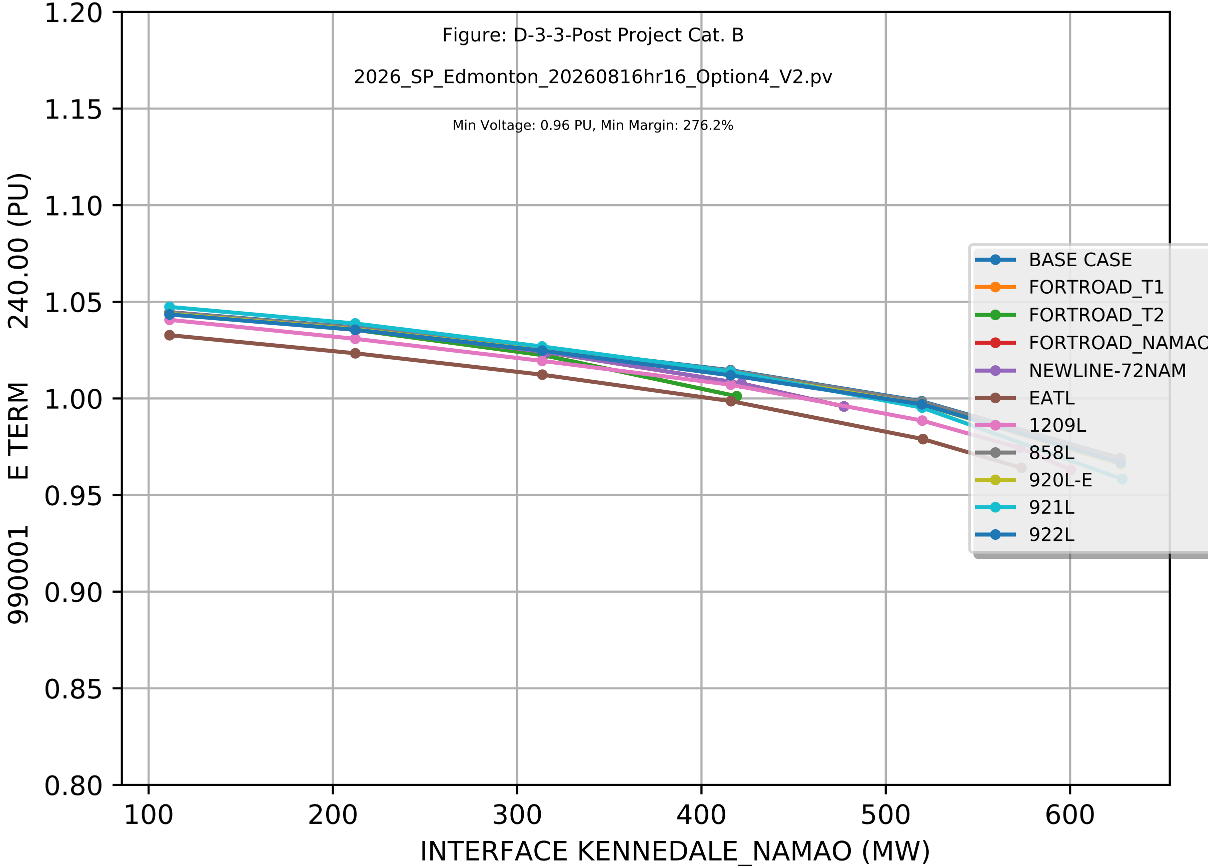


Figure: D-3-3-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.96 PU, Min Margin: 276.2%
990001 E TERM 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

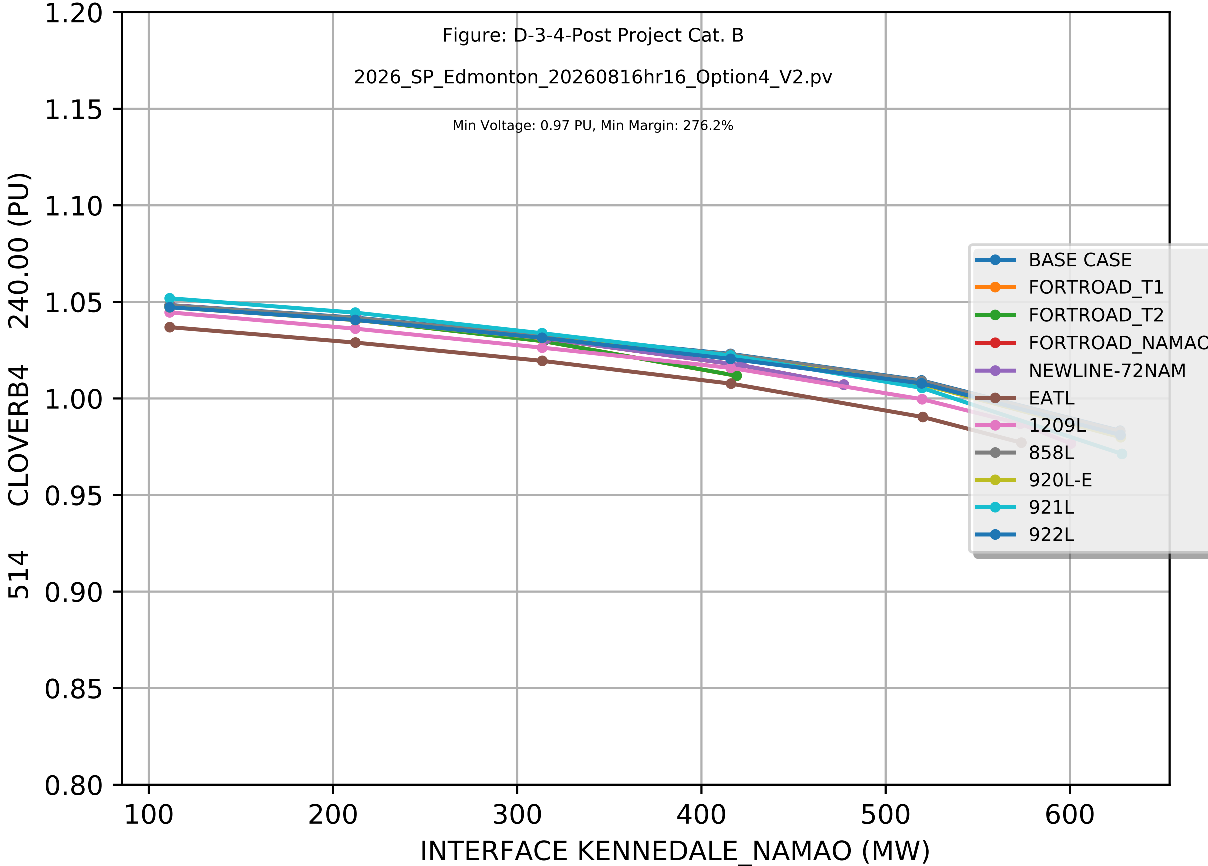


Figure: D-3-4-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.97 PU, Min Margin: 276.2%
514 CLOVERB4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

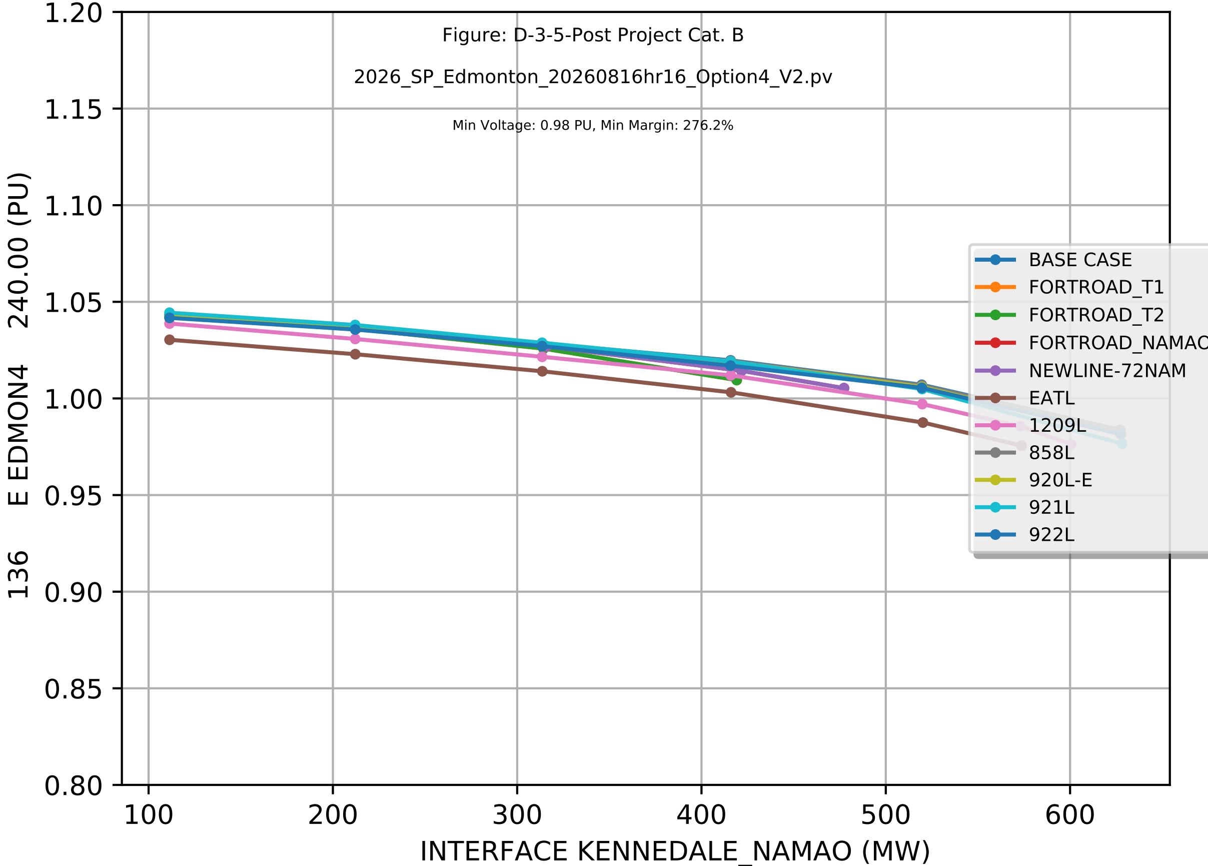


Figure: D-3-5-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.98 PU, Min Margin: 276.2%
136 E EDMON4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

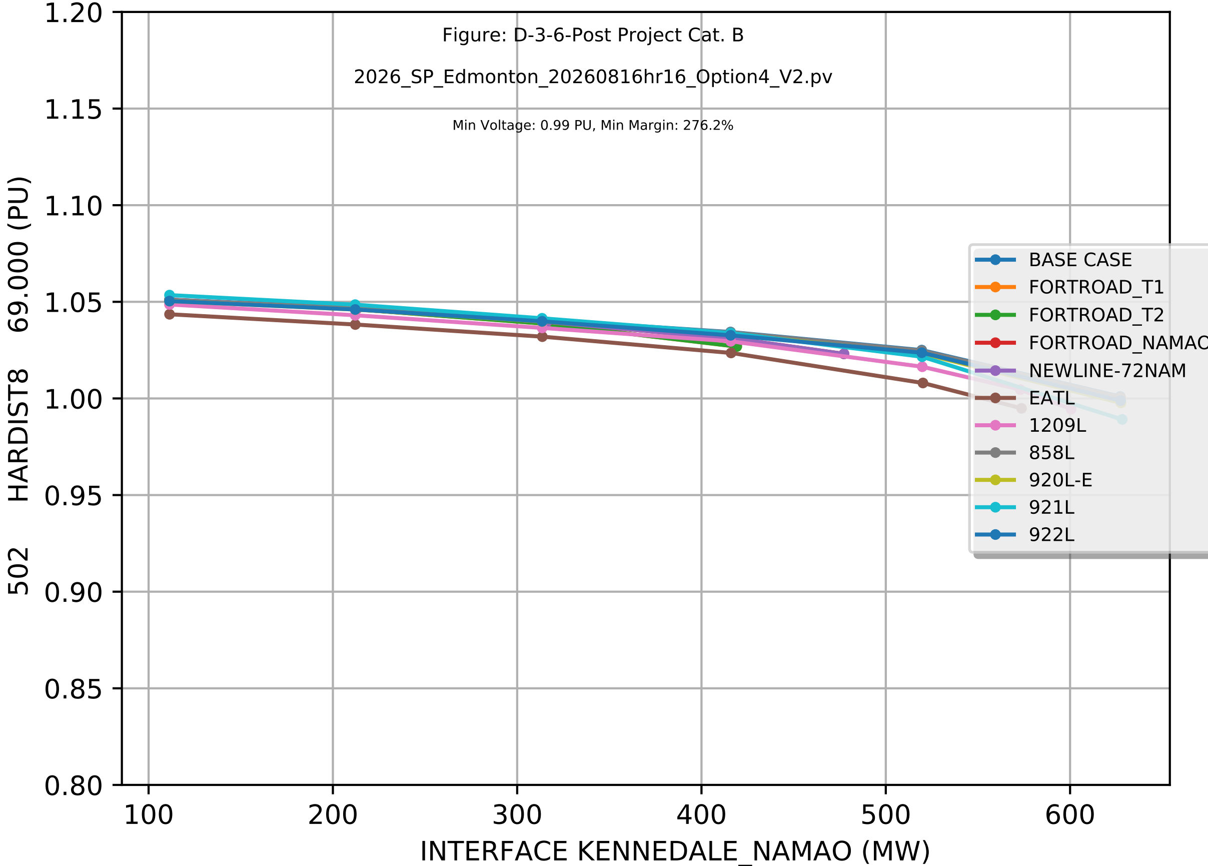


Figure: D-3-6-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.99 PU, Min Margin: 276.2%
502 HARDIST8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

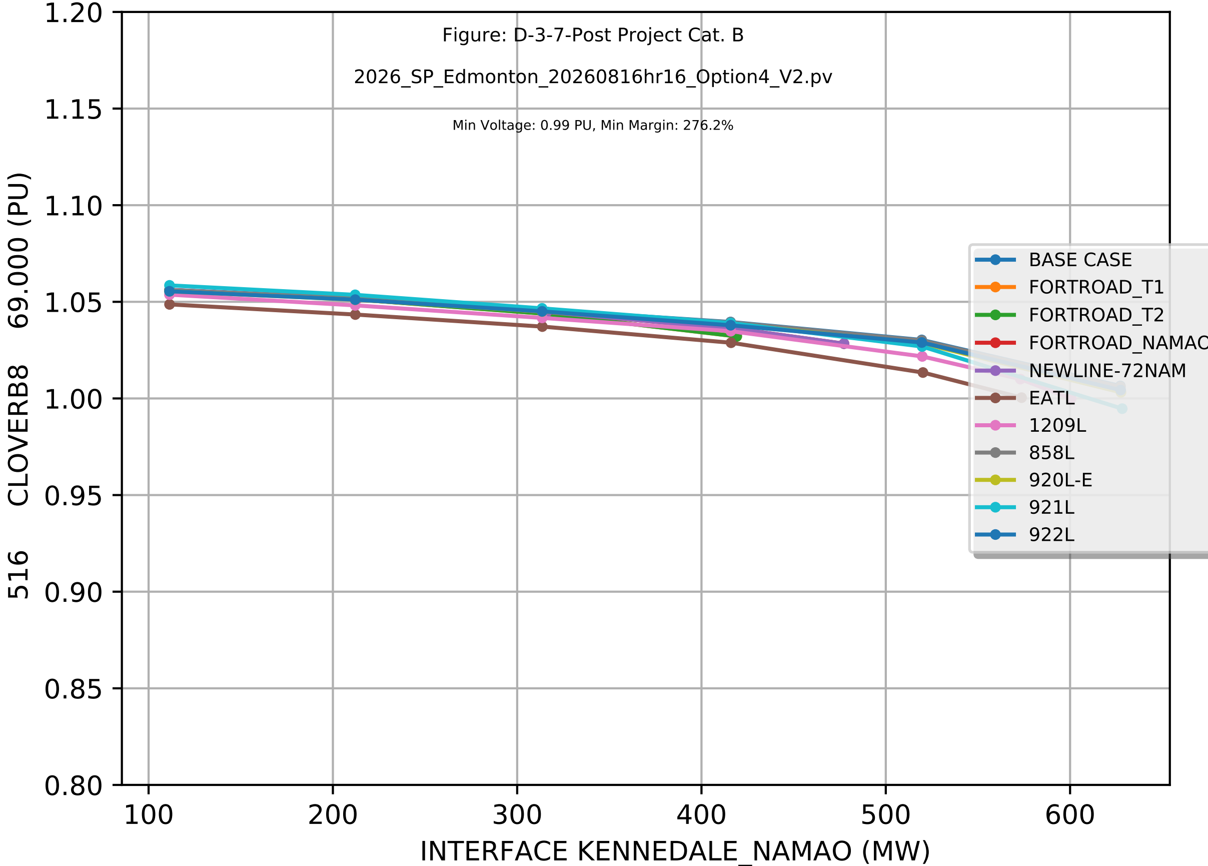


Figure: D-3-7-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.99 PU, Min Margin: 276.2%
516 CLOVERB8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

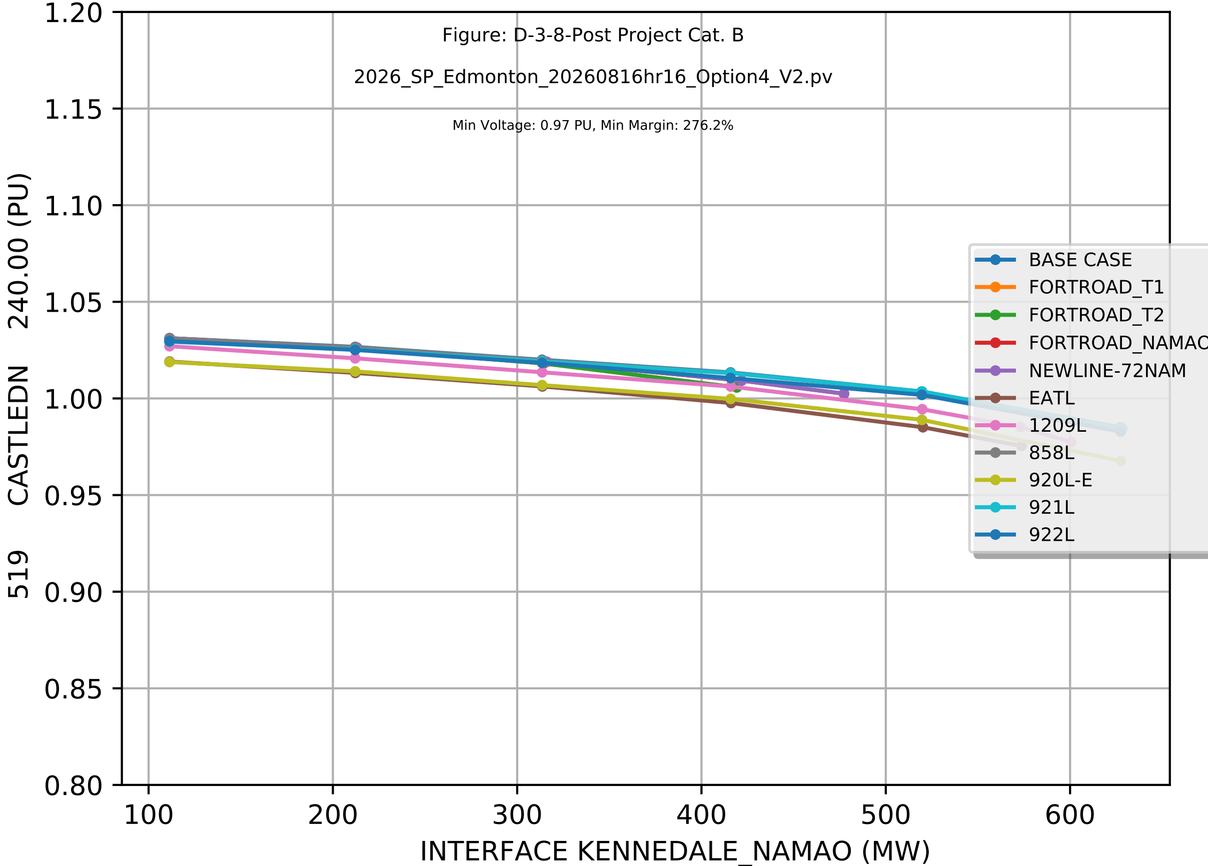


Figure: D-3-8-Post Project Cat. B
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.97 PU, Min Margin: 276.2%
519 CASTLEDN 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
FORTROAD_T1
FORTROAD_T2
FORTROAD_NAMAO
NEWLINE-72NAM
EATL
1209L
858L
920L-E
921L
922L

Attachment D-4

Post Project Cat. C

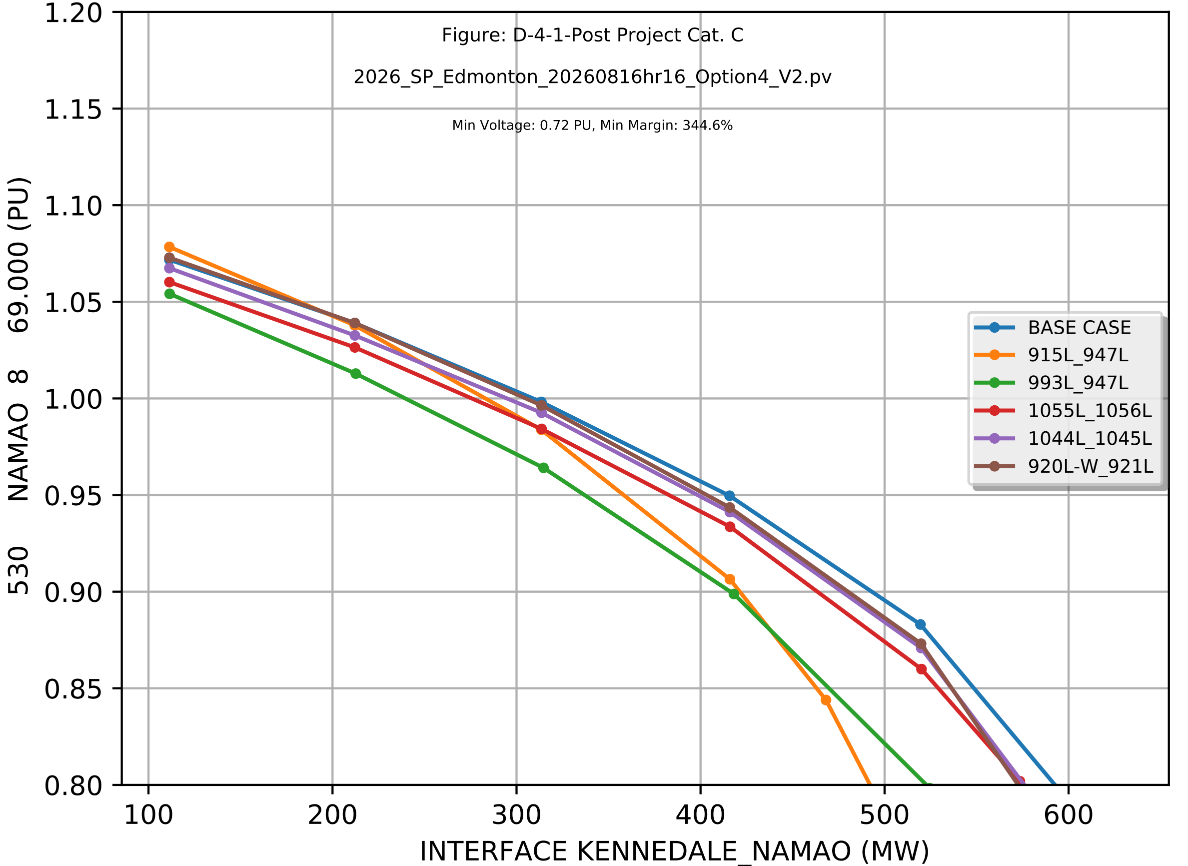


Figure: D-4-1-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.72 PU, Min Margin: 344.6%
530 NAMAO 8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600

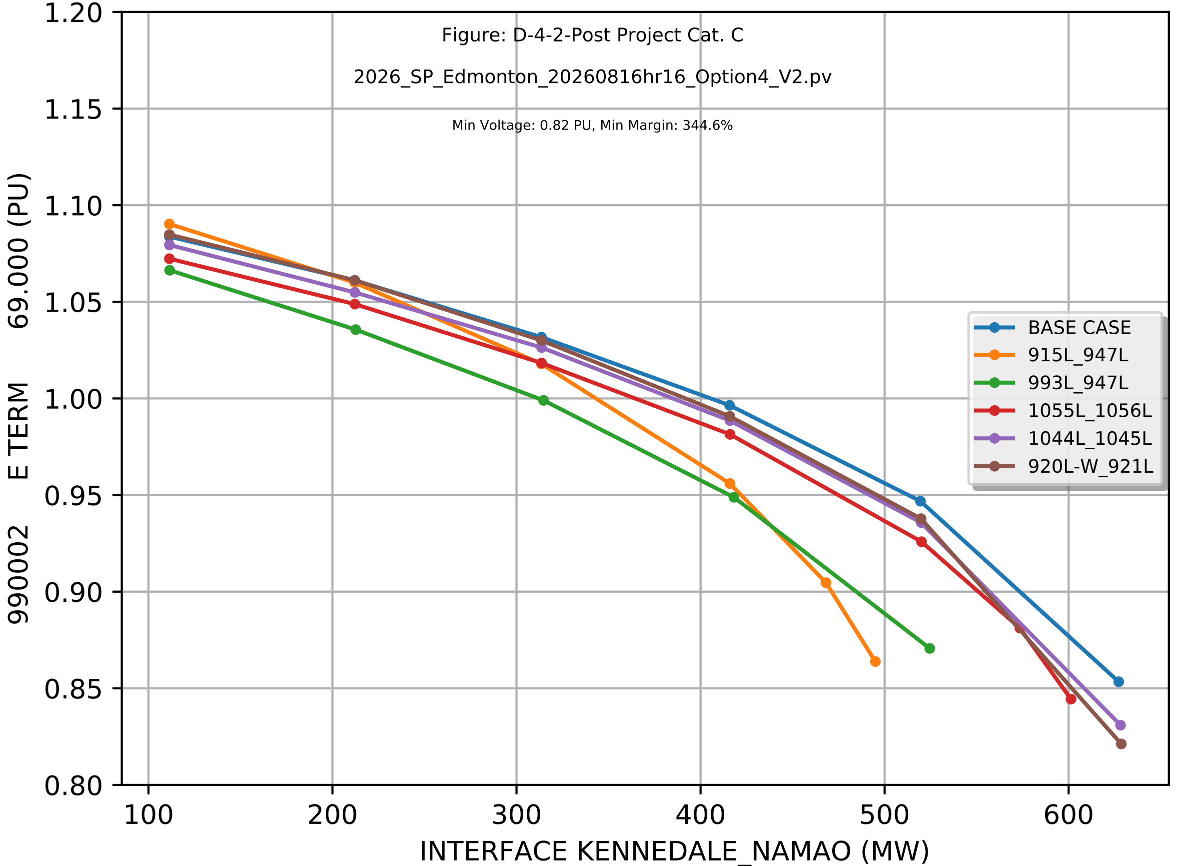


Figure: D-4-2-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.82 PU, Min Margin: 344.6%
990002 E TERM 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600

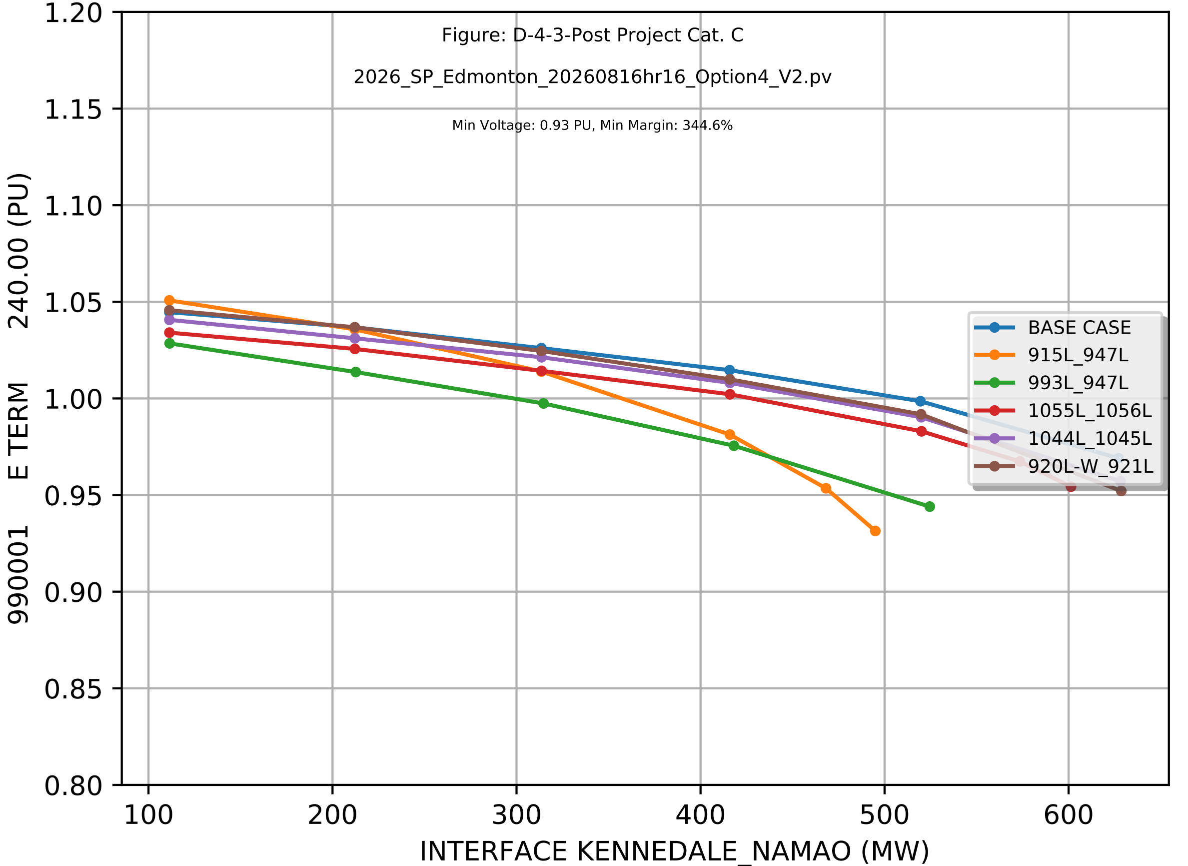


Figure: D-4-3-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.93 PU, Min Margin: 344.6%
990001 E TERM 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600

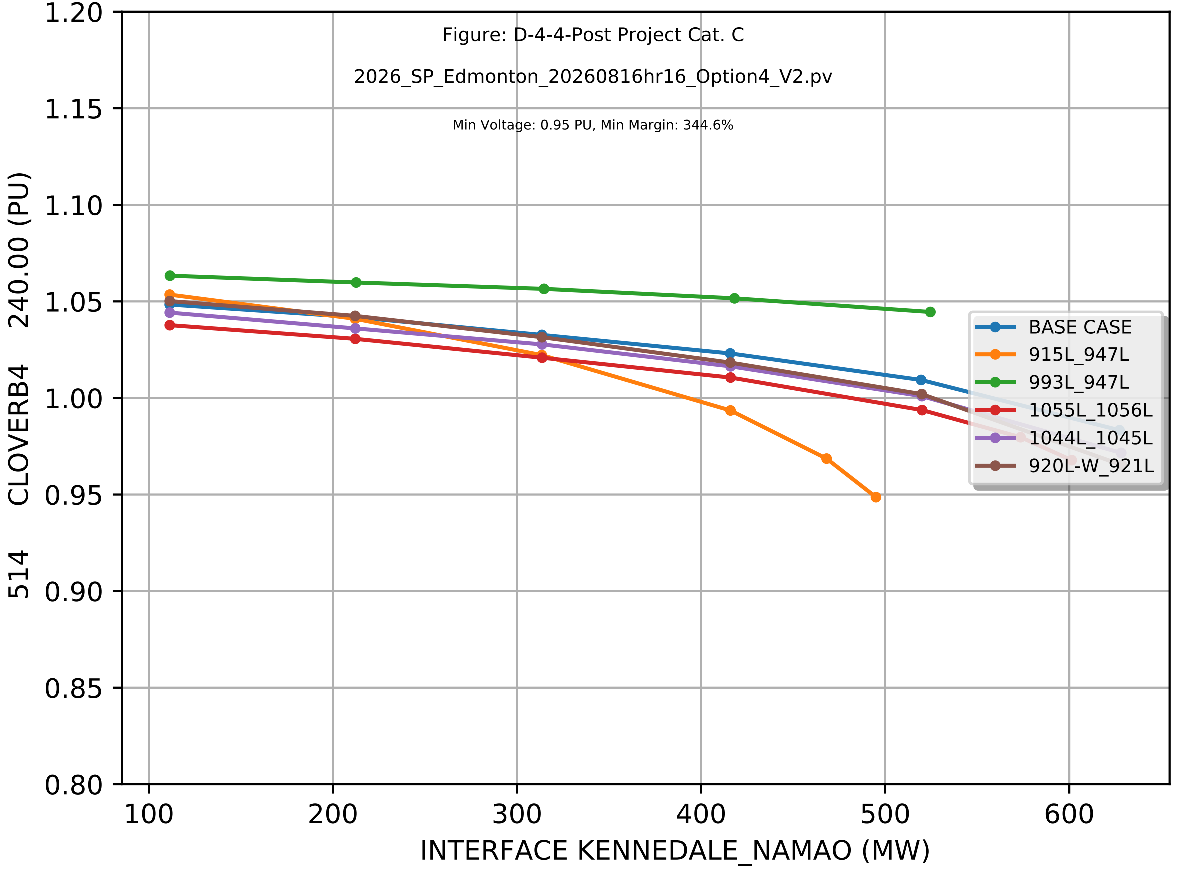


Figure: D-4-4-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.95 PU, Min Margin: 344.6%
514 CLOVERB4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L

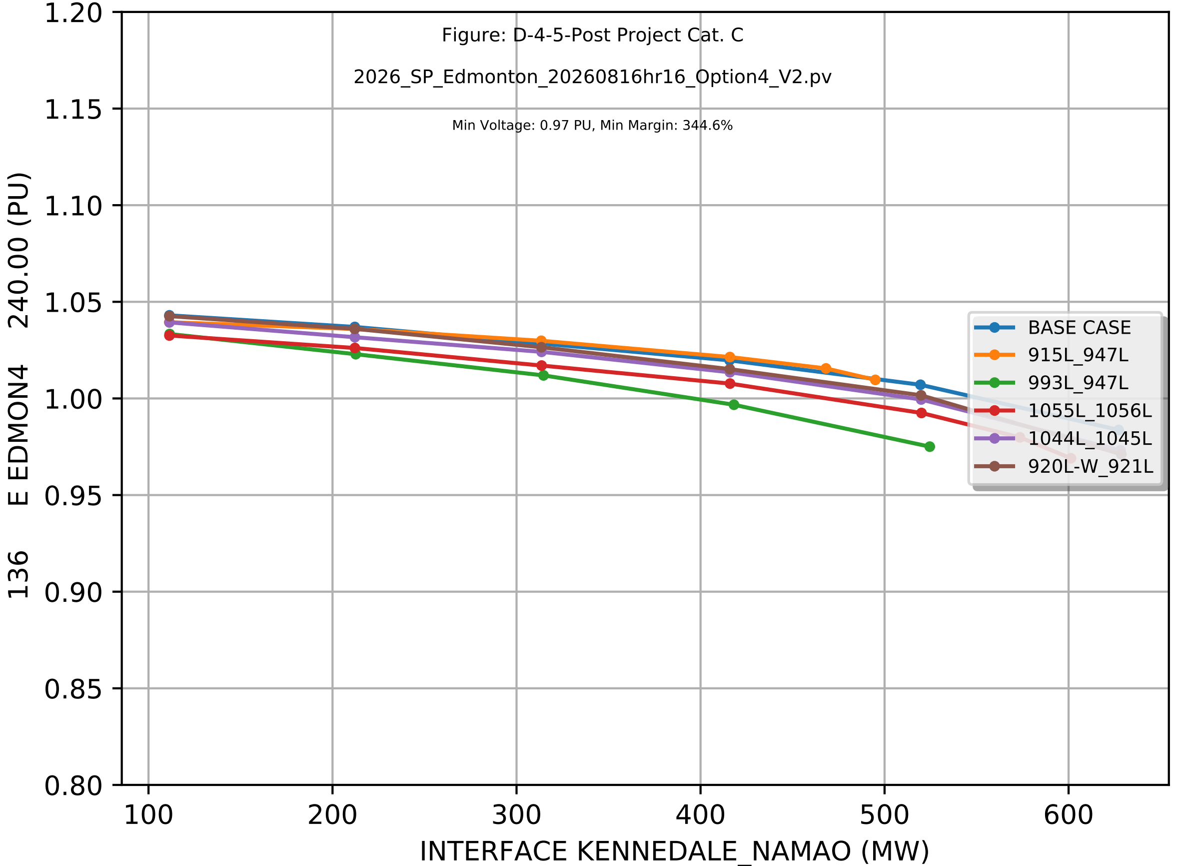


Figure: D-4-5-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.97 PU, Min Margin: 344.6%
136 E EDMON4 240.00 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L

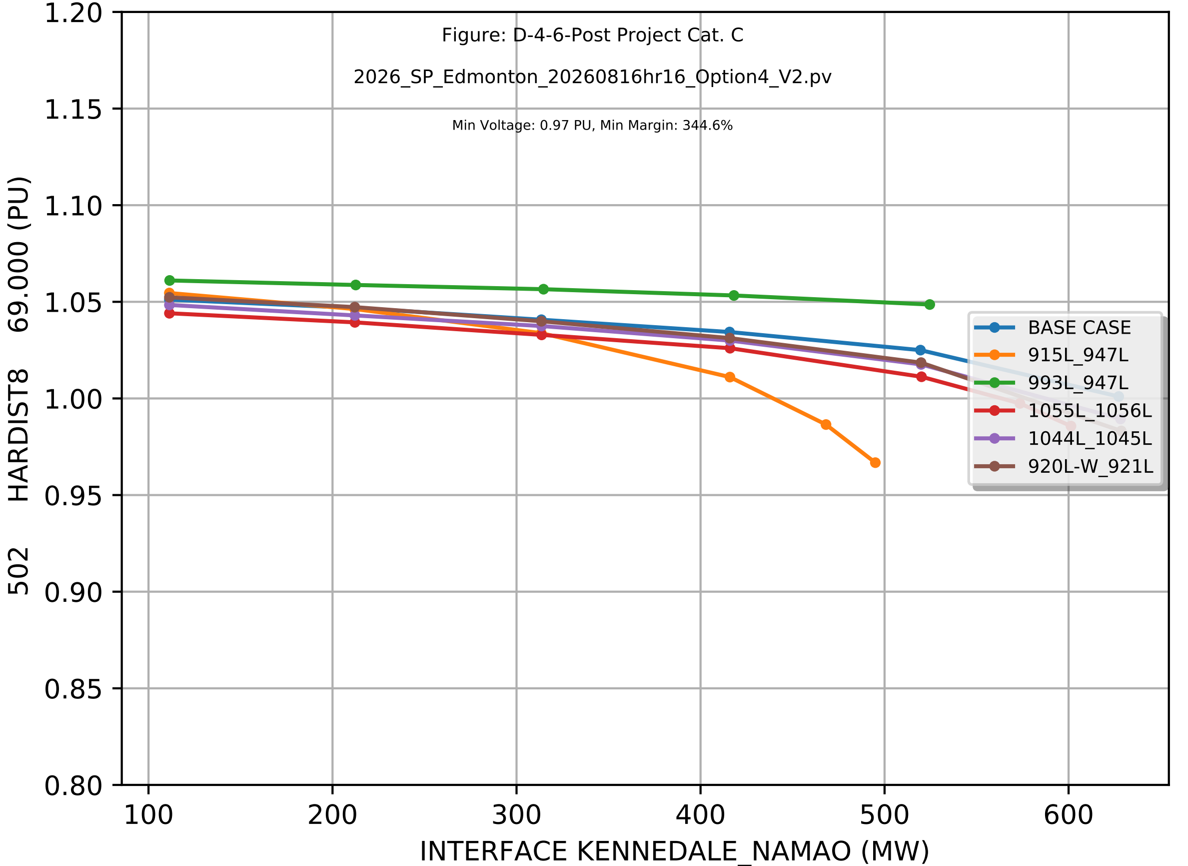


Figure: D-4-6-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.97 PU, Min Margin: 344.6%
502 HARDIST8 69.000 (PU)
INTERFACE KENNEDALE_NAMAO (MW)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L

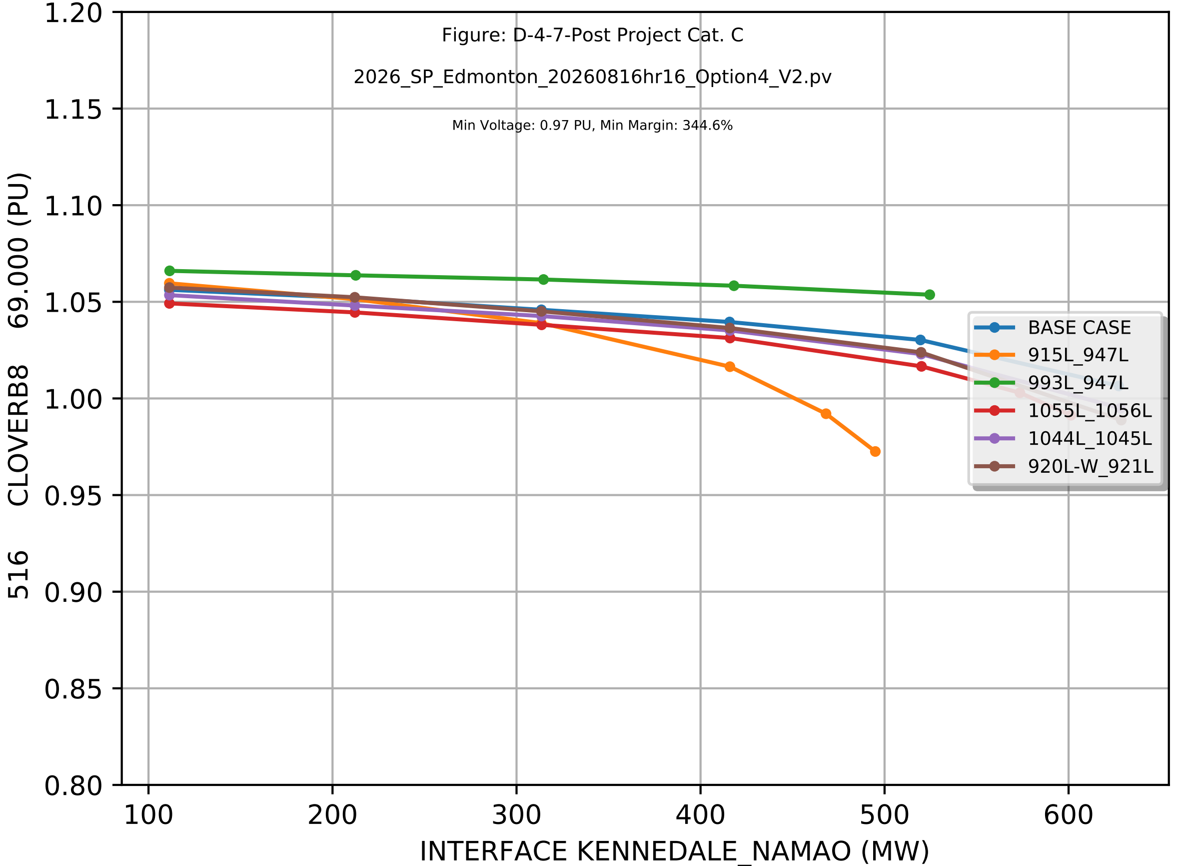


Figure: D-4-7-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.97 PU, Min Margin: 344.6%
516 CLOVERB8 69.000 (PU)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L

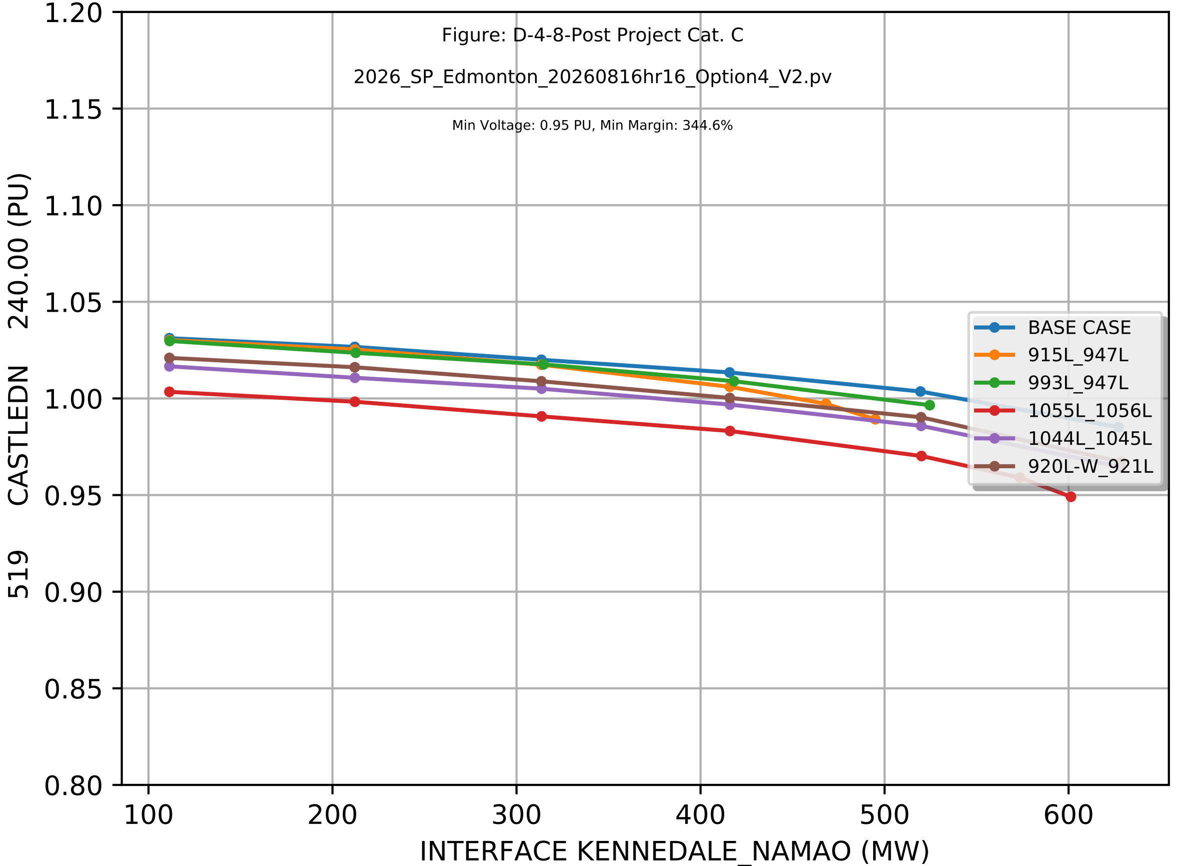


Figure: D-4-8-Post Project Cat. C
2026_SP_Edmonton_20260816hr16_Option4_V2.pv
Min Voltage: 0.95 PU, Min Margin: 344.6%
519 CASTLEDN 240.00 (PU)
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
100
200
300
400
500
600
INTERFACE KENNEDALE_NAMAO (MW)
BASE CASE
915L_947L
993L_947L
1055L_1056L
1044L_1045L
920L-W_921L

Attachment E: Transient Stability Analysis

E-1 Contingency List and Fault Clearing Times

E-1-1: Select Category B Contingencies and Fault Clearing Times

Contingency	Fault Location	Clearing Time (Cycles)	
		Near End	Far End
915L (Clover Bar to East Edmonton)	Clover Bar	4.02	4.506
	East Edmonton	4.02	4.506
915L (Fort Road to East Edmonton)	Fort Road	5	6
	East Edmonton	5	6
920L (Castle Downs to Lamoureux)	Castle Downs	5	6
	Lamoureux	5	6
921L (Clover Bar to Lamoureux)	Clover Bar	4.02	4.506
	Lamoureux	4.02	4.506
947L (Clover Bar to Ellerslie)	Clover Bar	4.02	4.77
	Ellerslie	4.02	4.77
993L (Clover Bar to Fort Road)	Clover Bar	5	6
	Fort Road	5	6
240CV5 (Castle Downs to Victoria)	Castle Downs	4.02	4.578
	Victoria	4.02	4.578
72CK12 (Clover Bar to Kennedale)	Clover Bar	3.45	3.45
	Kennedale	3.498	3.498
72CK13 (Clover Bar to Kennedale)	Clover Bar	3.648	3.648
	Kennedale	3.546	3.546
72CN10 (Clover Bar to Namao)	Clover Bar	3.42	3.42
	Namao	3.588	3.588
72FN27 (Fort Road to Namao)	Fort Road	6	8
	Namao	6	8
72FN28 (Fort Road to Namao)	Fort Road	6	8
	Namao	6	8
72CH9 (Clover Bar to Hardisty)	Clover Bar	3.468	3.468
	Hardisty	3.48	3.48
72CH11 (Clover Bar to Hardisty)	Clover Bar	3.426	3.426
	Hardisty	3.522	3.522
Clover Bar T1	Clover Bar	6	6
Clover Bar T2	Clover Bar	6	6
Clover Bar G1 (ENC1)	Clover Bar	6	NA
Clover Bar G2 (ENC2)	Clover Bar	6	NA
Clover Bar G3 (ENC3)	Clover Bar	6	NA
Fort Road T1	Fort Road	6	6
Fort Road T2	Fort Road	6	6

E-1-2: Select Category B Contingencies and Fault Clearing Times

C5 Contingency	Fault Location	Clearing Time (Cycles)	
		Far End	Near End
920L (Castle Downs to Lamoureux) and 921L (Clover Bar to Lamoureux)	Lamoureux	5	6
915L (Clover Bar to East Edmonton) and 947L (Clover Bar to Ellerslie)	Castle Downs	4.02	4.77
	East Edmonton	4.02	4.77
915L (Fort Road to East Edmonton) and 947L (Clover Bar to Ellerslie)	East Edmonton	5	6
993L (Clover Bar to Fort Road) and 947L (Clover Bar to Ellerslie)	Clover Bar	5	6
993L (Clover Bar to Fort Road) and 915L (Fort Road to East Edmonton)	Fort Road	5	6

E-2 Transient Stability Analysis Results Summary

E-2-1 2026 Pre-CETR Transmission System

Table E-2-1: Transient Stability Results under Category B Contingencies – Pre-CETR (2026)

Contingency	Fault Location	Fault Type	Transient Stability
915L (Clover Bar to East Edmonton)	Clover Bar	Three Phase to Ground	Stable
	East Edmonton	Three Phase to Ground	Stable
920L (Castle Downs to Lamoureux)	Castle Downs	Three Phase to Ground	Stable
	Lamoureux	Three Phase to Ground	Stable
921L (Clover Bar to Lamoureux)	Clover Bar	Three Phase to Ground	Stable
	Lamoureux	Three Phase to Ground	Stable
947L (Clover Bar to Ellerslie)	Clover Bar	Three Phase to Ground	Stable
	Ellerslie	Three Phase to Ground	Stable
240CV5 (Castle Downs to Victoria)	Castle Downs	Three Phase to Ground	Stable
	Victoria	Three Phase to Ground	Stable
72CK12 (Clover Bar to Kennedale)	Clover Bar	Three Phase to Ground	Stable
	Kennedale	Three Phase to Ground	Stable
72CK13 (Clover Bar to Kennedale)	Clover Bar	Three Phase to Ground	Stable
	Kennedale	Three Phase to Ground	Stable
72CN10 (Clover Bar to Namao)	Clover Bar	Three Phase to Ground	Stable
	Namao	Three Phase to Ground	Stable
72CH9 (Clover Bar to Hardisty)	Clover Bar	Three Phase to Ground	Stable
	Hardisty	Three Phase to Ground	Stable
72CH11 (Clover Bar to Hardisty)	Clover Bar	Three Phase to Ground	Stable
	Hardisty	Three Phase to Ground	Stable
Clover Bar T1	Clover Bar	Three Phase to Ground	Stable
Clover Bar T2	Clover Bar	Three Phase to Ground	Stable
Clover Bar G1 (ENC1)	Clover Bar	Three Phase to Ground	Stable
Clover Bar G2 (ENC2)	Clover Bar	Three Phase to Ground	Stable

Clover Bar G3 (ENC3)	Clover Bar	Three Phase to Ground	Stable

Table E-2-2: Transient Stability Results under Category C Contingencies – Pre-CETR (2026)

Contingency	Fault Location	Fault Type	Transient Stability
920L (Castle Downs to Lamoureux) and 921L (Clover Bar to Lamoureux)	Lamoureux	Three Phase to Ground	Stable
915L (Clover Bar to East Edmonton) and 947L (Clover Bar to Ellerslie)	Castle Downs	Three Phase to Ground	Stable
	East Edmonton	Three Phase to Ground	Stable

E-2-2 2026 Post-CETR Transmission System

Table E-2-3: Transient Stability Results under Category B Contingencies – Post-CETR (2026)

Contingency	Fault Location	Fault Type	Transient Stability
915L (Fort Road to East Edmonton)	Fort Road	Three Phase to Ground	Stable
	East Edmonton	Three Phase to Ground	Stable
920L (Castle Downs to Lamoureux)	Castle Downs	Three Phase to Ground	Stable
	Lamoureux	Three Phase to Ground	Stable
921L (Clover Bar to Lamoureux)	Clover Bar	Three Phase to Ground	Stable
	Lamoureux	Three Phase to Ground	Stable
947L (Clover Bar to Ellerslie)	Clover Bar	Three Phase to Ground	Stable
	Ellerslie	Three Phase to Ground	Stable
993L (Clover Bar to Fort Road)	Clover Bar	Three Phase to Ground	Stable
	Fort Road	Three Phase to Ground	Stable
240CV5 (Castle Downs to Victoria)	Castle Downs	Three Phase to Ground	Stable
	Victoria	Three Phase to Ground	Stable
72FN27 (Fort Road to Namao)	Fort Road	Three Phase to Ground	Stable
	Namao	Three Phase to Ground	Stable
72FN28 (Fort Road to Namao)	Fort Road	Three Phase to Ground	Stable
	Namao	Three Phase to Ground	Stable
72CH9 (Clover Bar to Hardisty)	Clover Bar	Three Phase to Ground	Stable

	Hardisty	Three Phase to Ground	Stable
72CH11 (Clover Bar to Hardisty)	Clover Bar	Three Phase to Ground	Stable
	Hardisty	Three Phase to Ground	Stable
Clover Bar T1	Clover Bar	Three Phase to Ground	Stable
Clover Bar T2	Clover Bar	Three Phase to Ground	Stable
Clover Bar G1 (ENC1)	Clover Bar	Three Phase to Ground	Stable
Clover Bar G2 (ENC2)	Clover Bar	Three Phase to Ground	Stable
Clover Bar G3 (ENC3)	Clover Bar	Three Phase to Ground	Stable
Fort Road T1	Fort Road	Three Phase to Ground	Stable
Fort Road T2	Fort Road	Three Phase to Ground	Stable

Table E-2-4: Transient Stability Results under Category C Contingencies – Post-CETR (2026)

Contingency	Fault Location	Fault Type	Transient Stability
920L (Castle Downs to Lamoureux) and 921L (Clover Bar to Lamoureux)	Lamoureux	Three Phase to Ground	Stable
915L (Fort Road to East Edmonton) and 947L (Clover Bar to Ellerslie)	East Edmonton	Three Phase to Ground	Stable
993L (Clover Bar to Fort Road) and 947L (Clover Bar to Ellerslie)	Clover Bar	Three Phase to Ground	Stable
993L (Clover Bar to Fort Road) and 915L (Fort Road to East Edmonton)	Fort Road	Three Phase to Ground	Stable

E-2-3 2043 Post-CETR Transmission System

Table E-2-5: Transient Stability Results under Category B Contingencies – Post-CETR (2043)

Contingency	Fault Location	Fault Type	Transient Stability
915L (Fort Road to East Edmonton)	Fort Road	Three Phase to Ground	Stable
	East Edmonton	Three Phase to Ground	Stable
920L (Castle Downs to Lamoureux)	Castle Downs	Three Phase to Ground	Stable
	Lamoureux	Three Phase to Ground	Stable
921L (Clover Bar to Lamoureux)	Clover Bar	Three Phase to Ground	Stable
	Lamoureux	Three Phase to Ground	Stable
947L (Clover Bar to Ellerslie)	Clover Bar	Three Phase to Ground	Stable

	Ellerslie	Three Phase to Ground	Stable
993L (Clover Bar to Fort Road)	Clover Bar	Three Phase to Ground	Stable
	Fort Road	Three Phase to Ground	Stable
240CV5 (Castle Downs to Victoria)	Castle Downs	Three Phase to Ground	Stable
	Victoria	Three Phase to Ground	Stable
72FN27 (Fort Road to Namao)	Fort Road	Three Phase to Ground	Stable
	Namao	Three Phase to Ground	Stable
72FN28 (Fort Road to Namao)	Fort Road	Three Phase to Ground	Stable
	Namao	Three Phase to Ground	Stable
72CH9 (Clover Bar to Hardisty)	Clover Bar	Three Phase to Ground	Stable
	Hardisty	Three Phase to Ground	Stable
72CH11 (Clover Bar to Hardisty)	Clover Bar	Three Phase to Ground	Stable
	Hardisty	Three Phase to Ground	Stable
Clover Bar T1	Clover Bar	Three Phase to Ground	Stable
Clover Bar T2	Clover Bar	Three Phase to Ground	Stable
Clover Bar G1 (ENC1)	Clover Bar	Three Phase to Ground	Stable
Clover Bar G2 (ENC2)	Clover Bar	Three Phase to Ground	Stable
Clover Bar G3 (ENC3)	Clover Bar	Three Phase to Ground	Stable
Fort Road T1	Fort Road	Three Phase to Ground	Stable
Fort Road T2	Fort Road	Three Phase to Ground	Stable

Table E-2-6: Transient Stability Results under Category C Contingencies – Post-CETR (2043)

Contingency	Fault Location	Fault Type	Transient Stability
920L (Castle Downs to Lamoureux) and 921L (Clover Bar to Lamoureux)	Lamoureux	Three Phase to Ground	Stable
915L (Fort Road to East Edmonton) and 947L (Clover Bar to Ellerslie)	East Edmonton	Three Phase to Ground	Stable
993L (Clover Bar to Fort Road) and 947L (Clover Bar to Ellerslie)	Clover Bar	Three Phase to Ground	Stable
993L (Clover Bar to Fort Road) and 915L (Fort Road to East Edmonton)	Fort Road	Three Phase to Ground	Stable

E-3 Transient Stability Analysis Results Summary

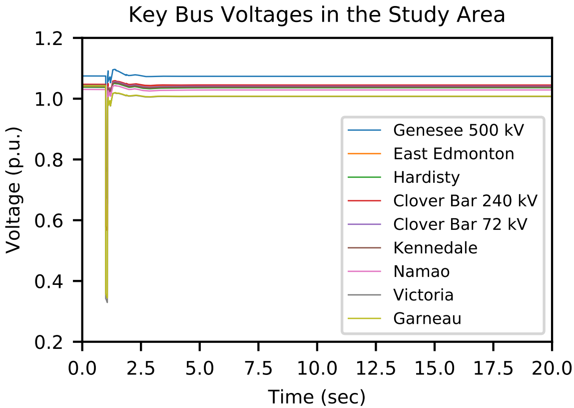
Section	Study Year	Topology
E-1	2026	Pre-CETR
E-2		Post-CETR
E-3	2043	Post-CETR

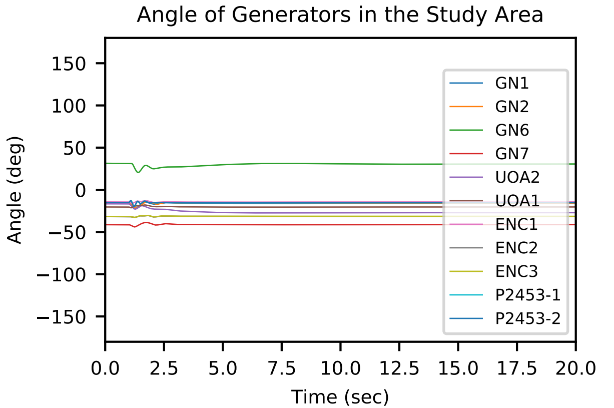
Attachment E

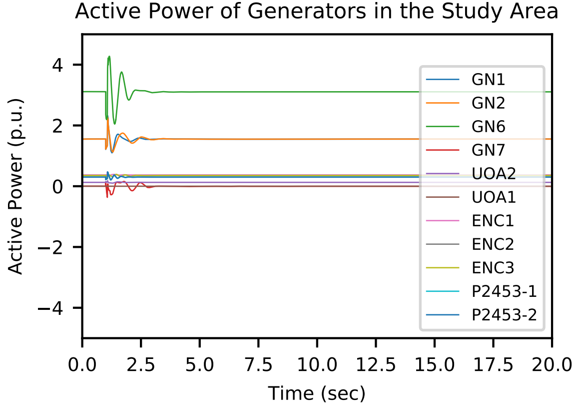
Transient Simulation Results

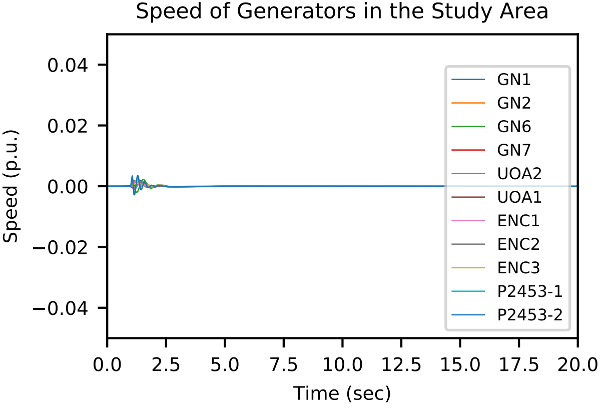
Section: E-1

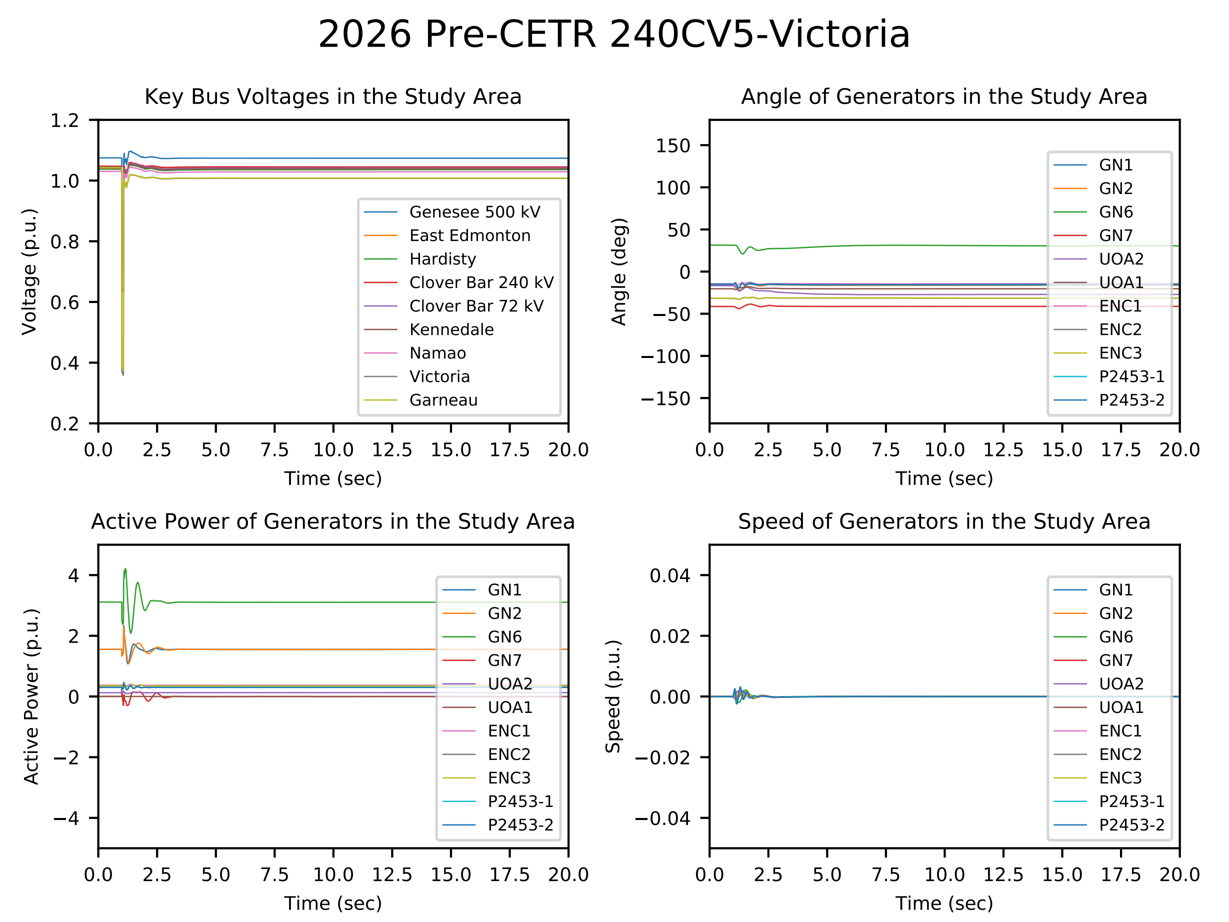
2026 Pre-CETR 240CV5-CastleDowns



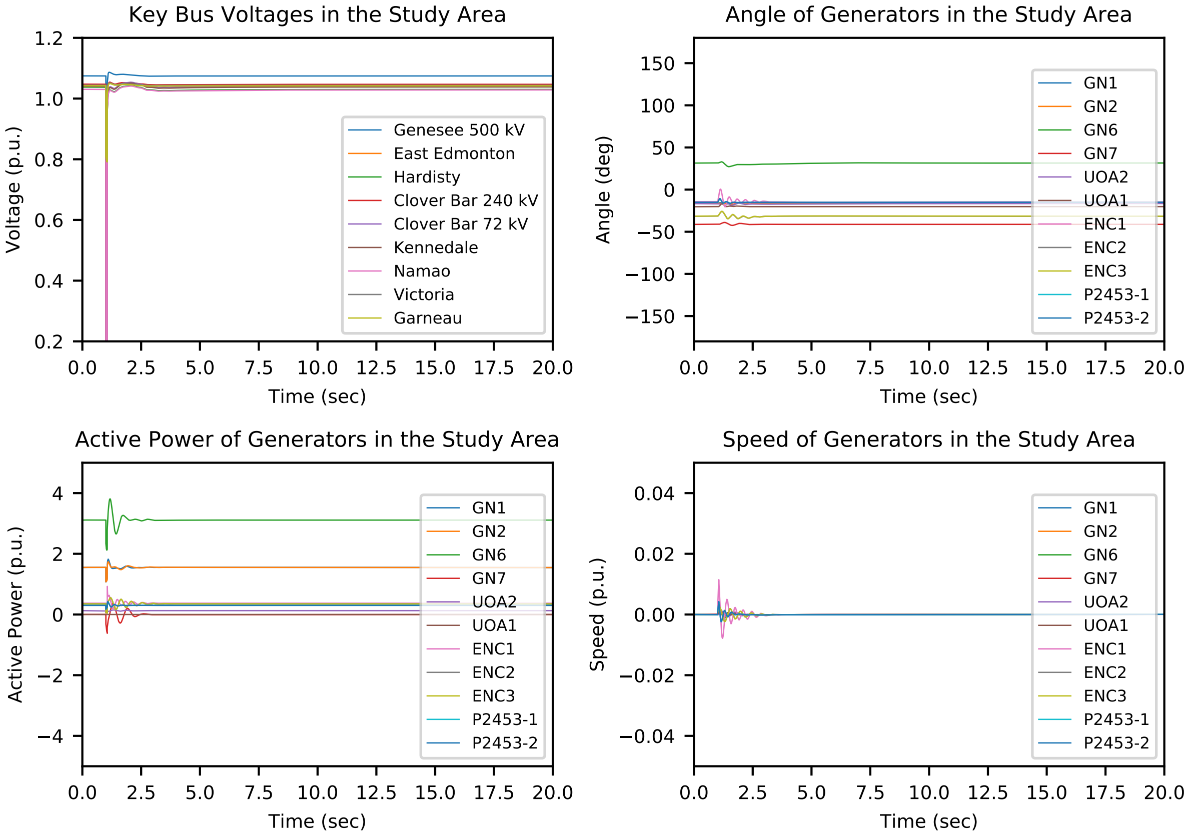




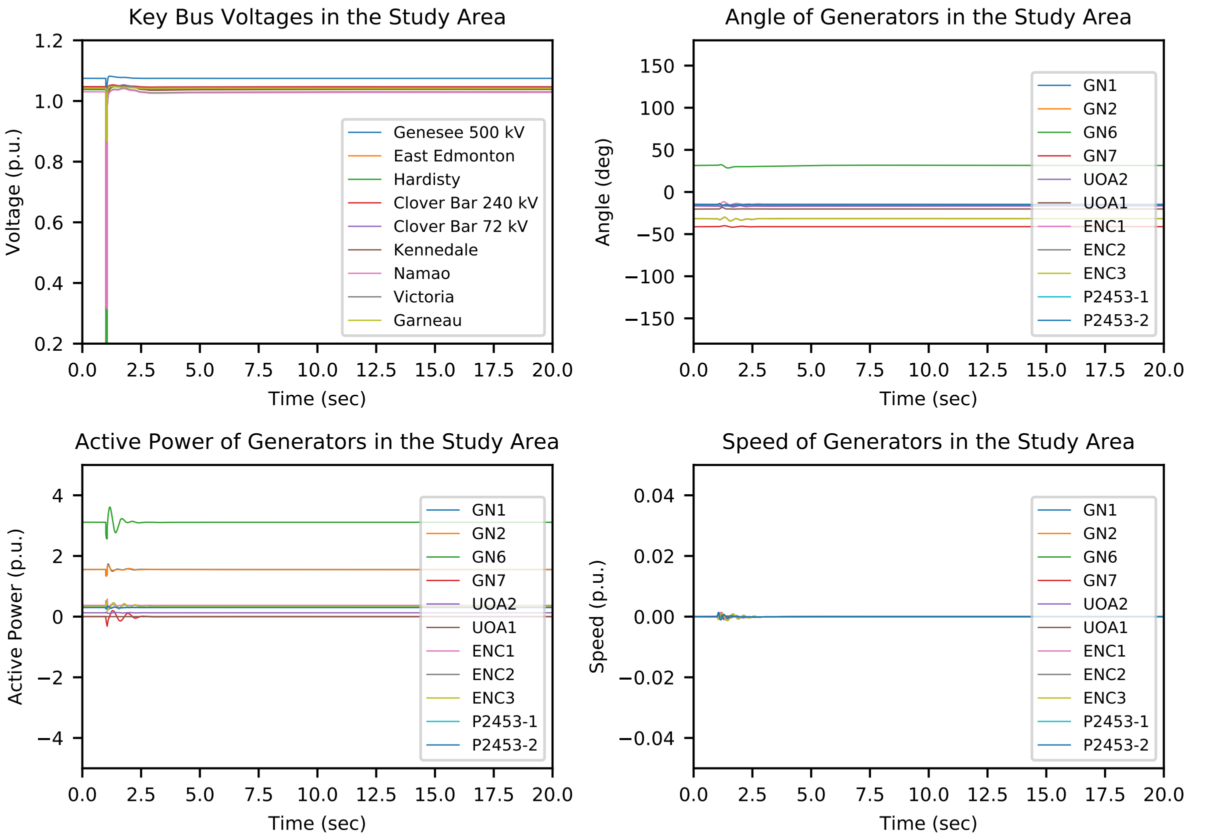



2026 Pre-CETR 240CV5-Victoria
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)

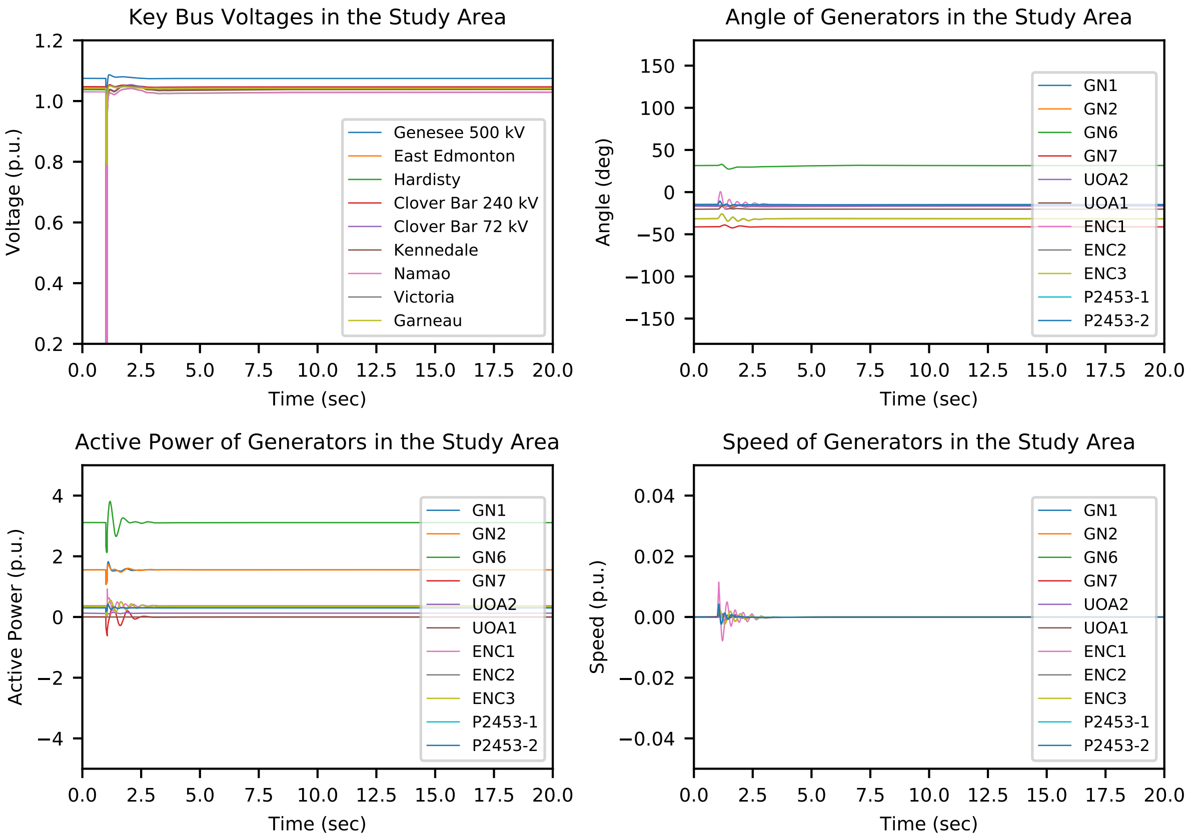
2026 Pre-CETR 72CH11-CloverBar



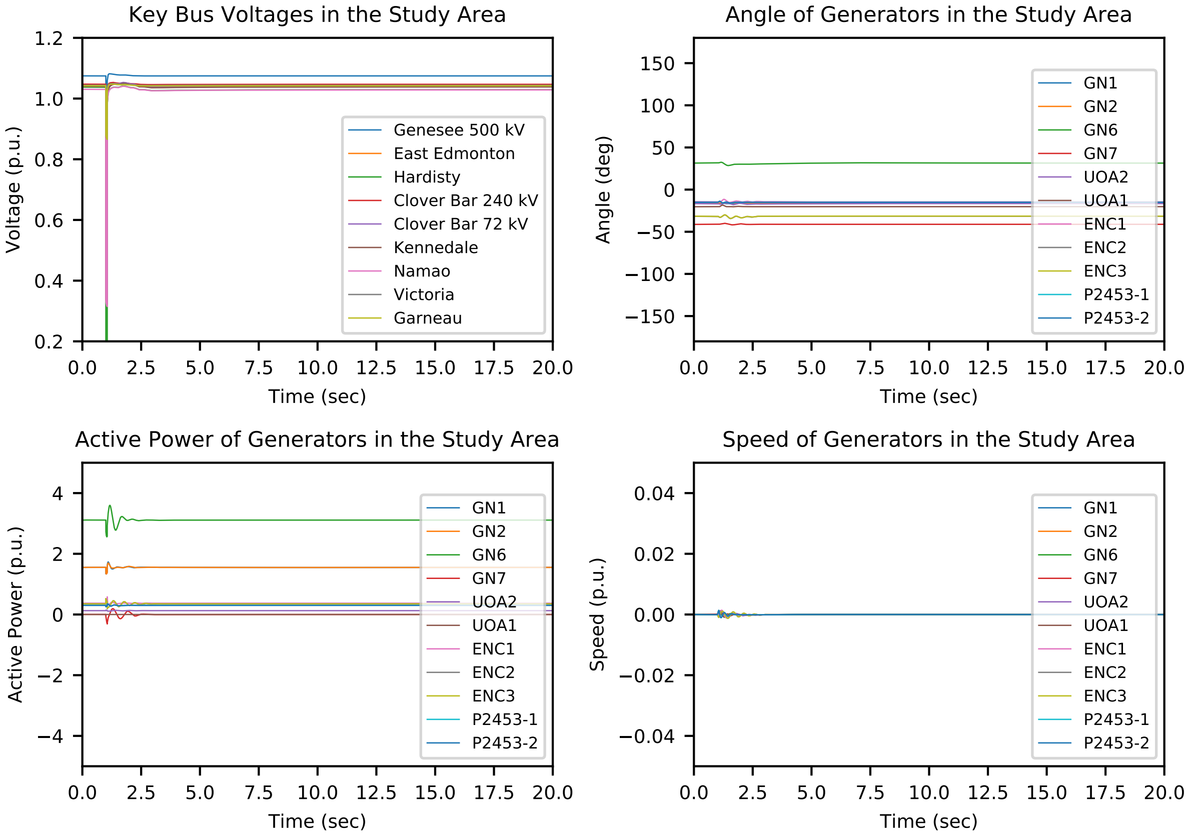
2026 Pre-CETR 72CH11-Hardisty

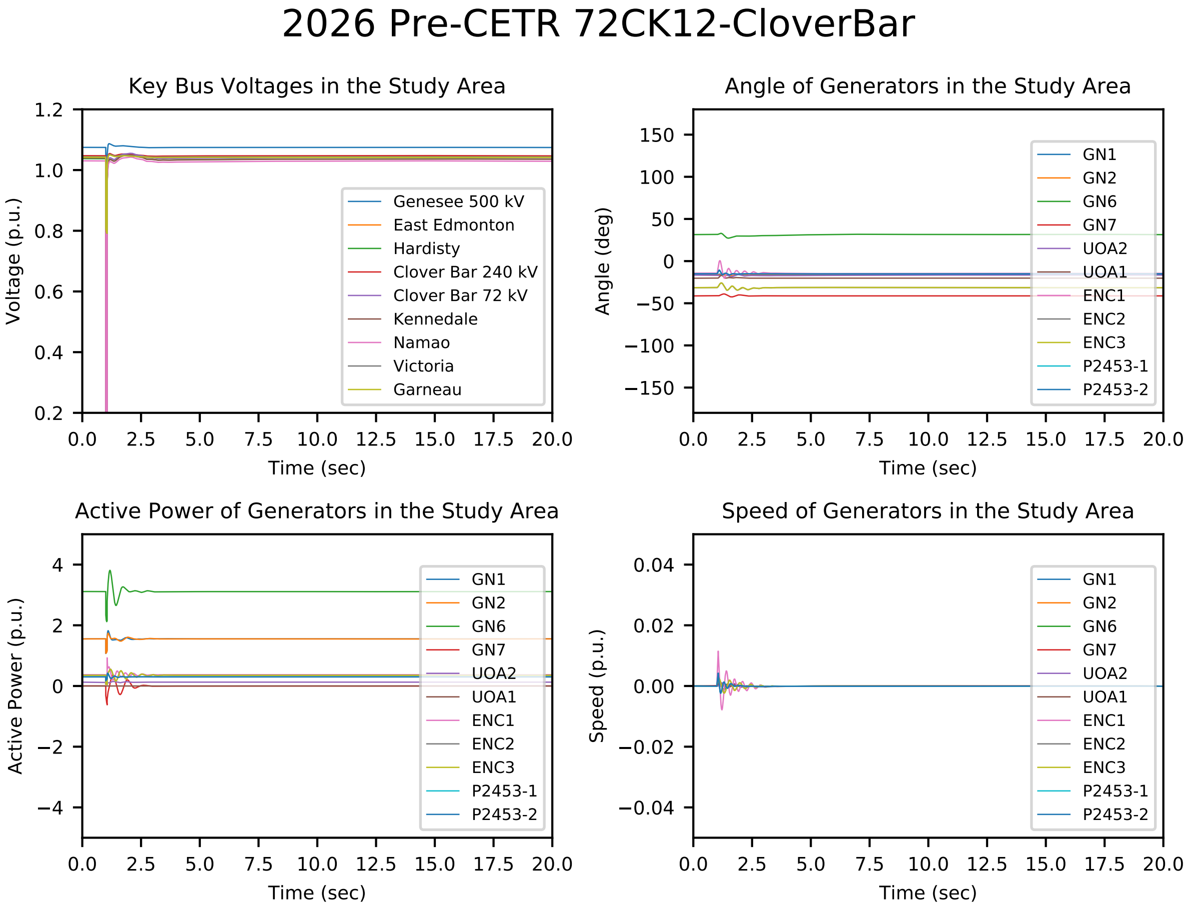


2026 Pre-CETR 72CH9-CloverBar

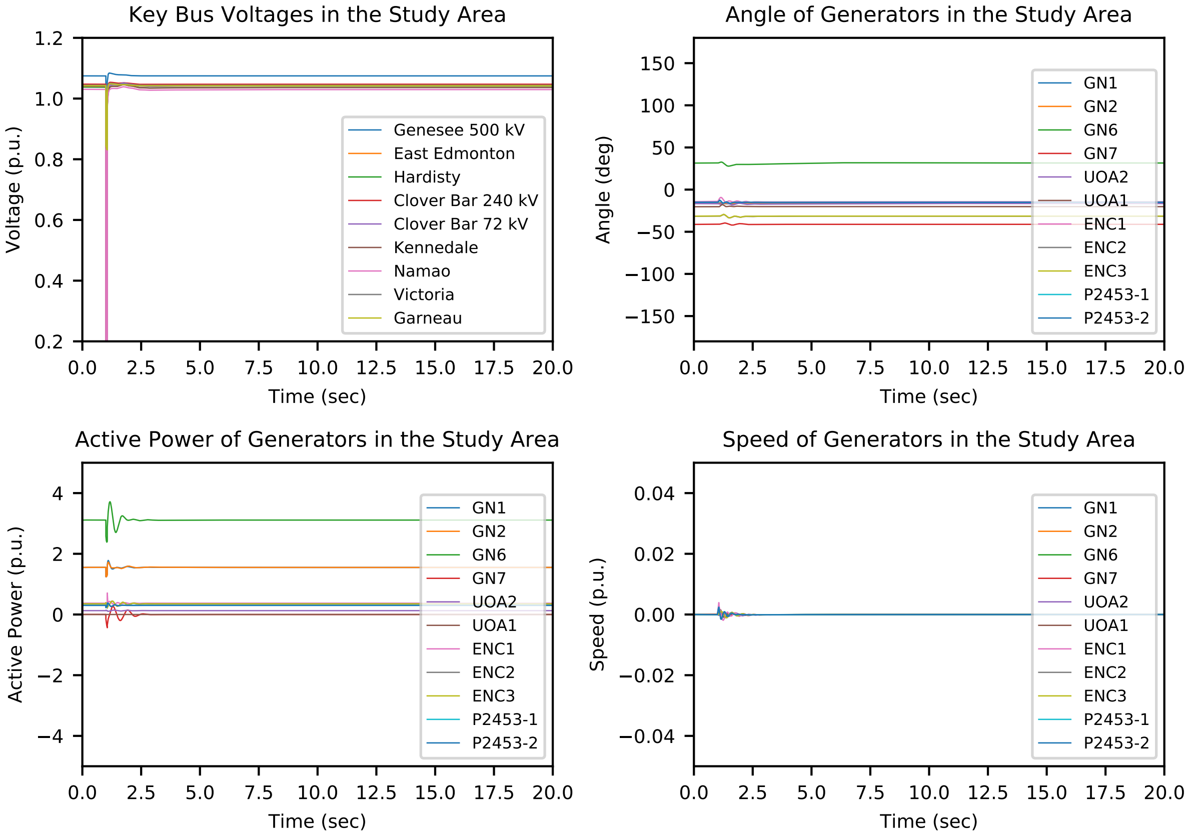


2026 Pre-CETR 72CH9-Hardisty

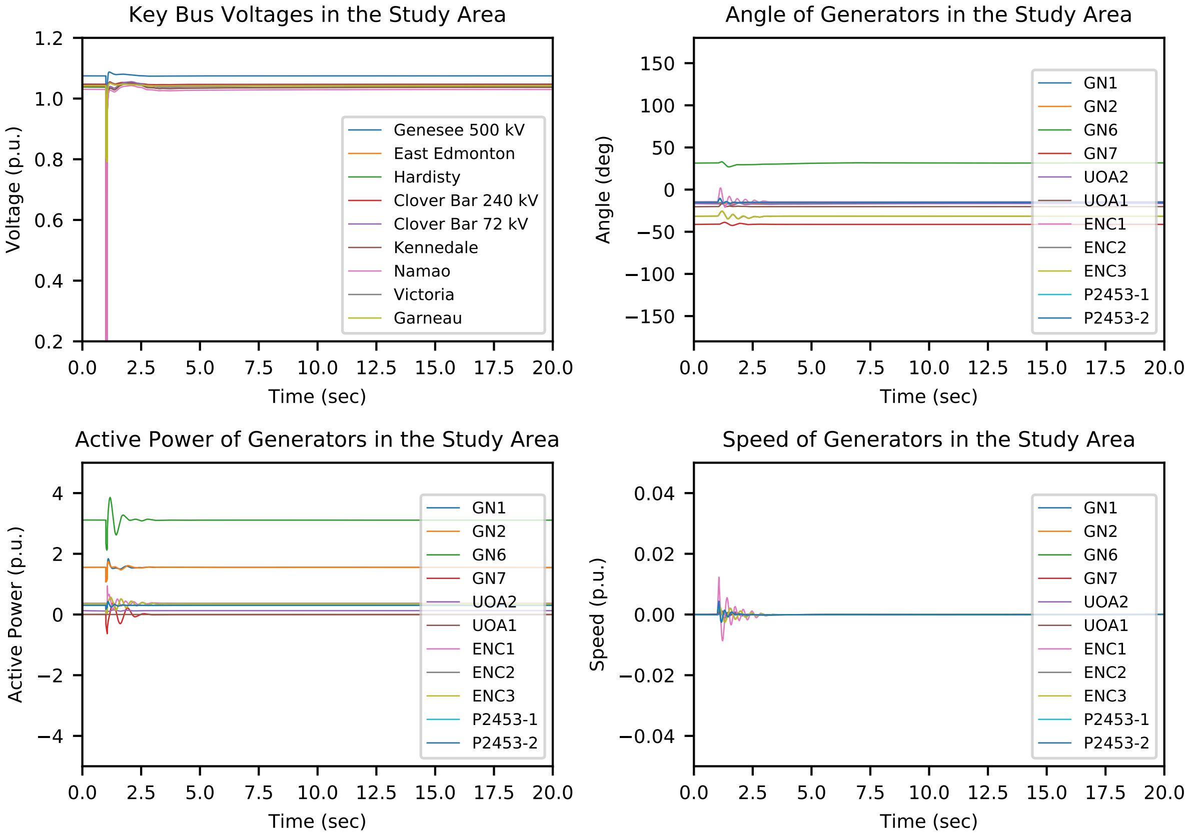


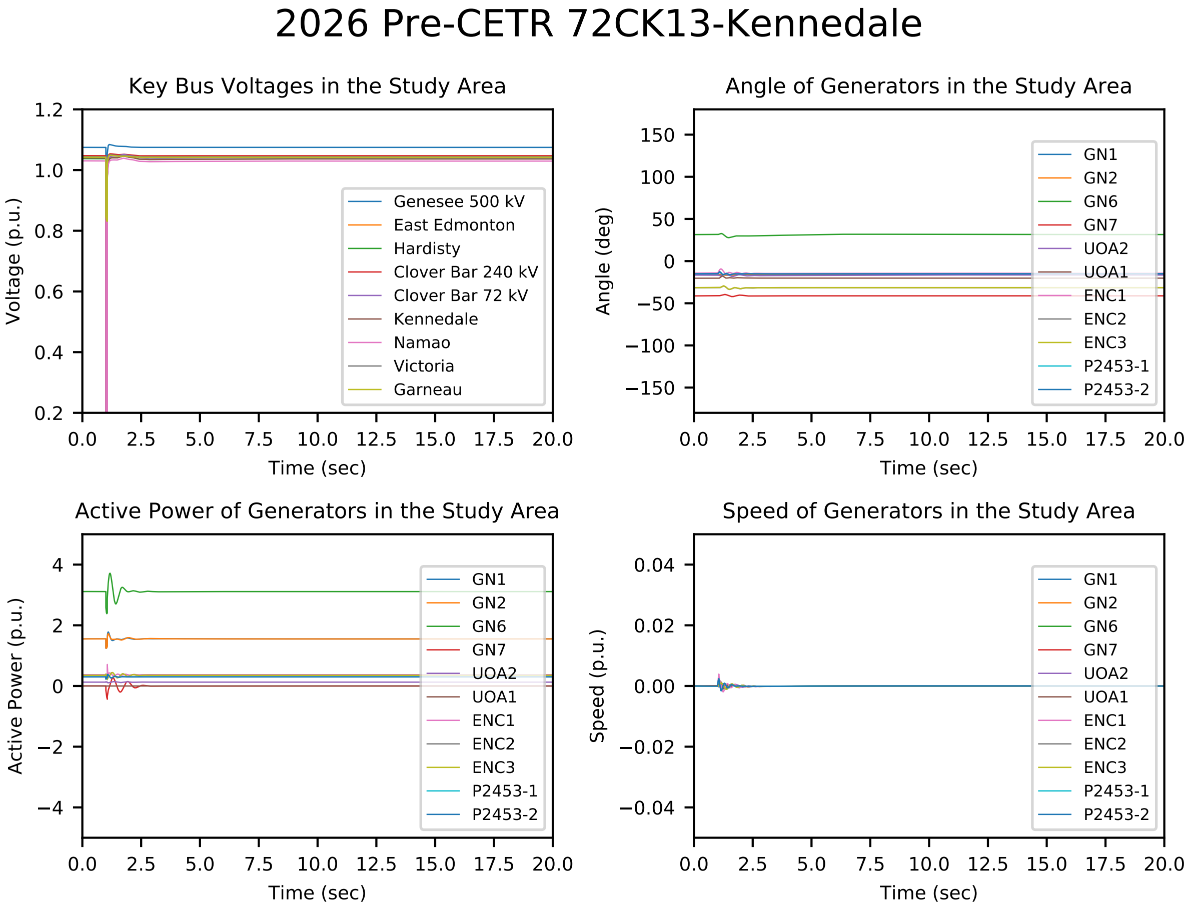

2026 Pre-CETR 72CK12-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)

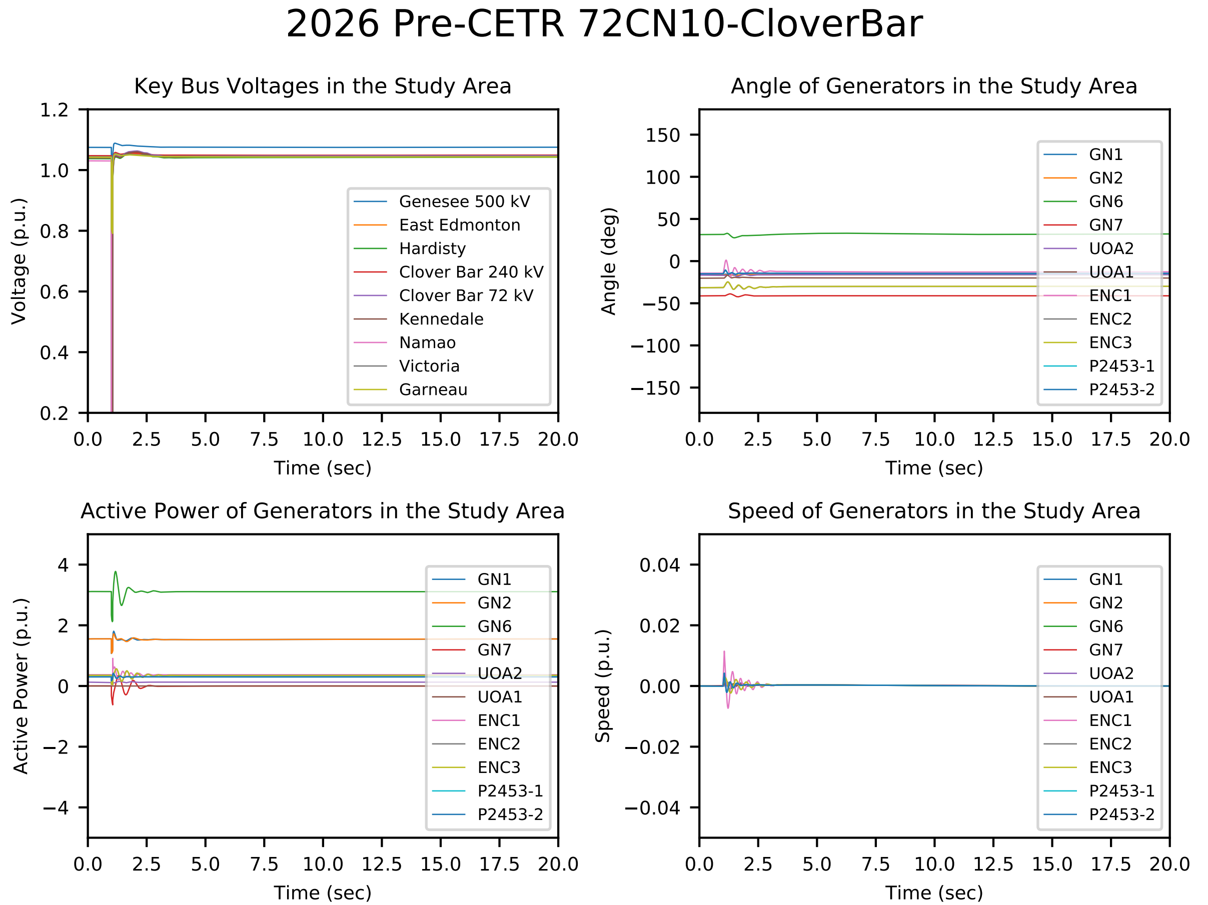
2026 Pre-CETR 72CK12-Kennedale



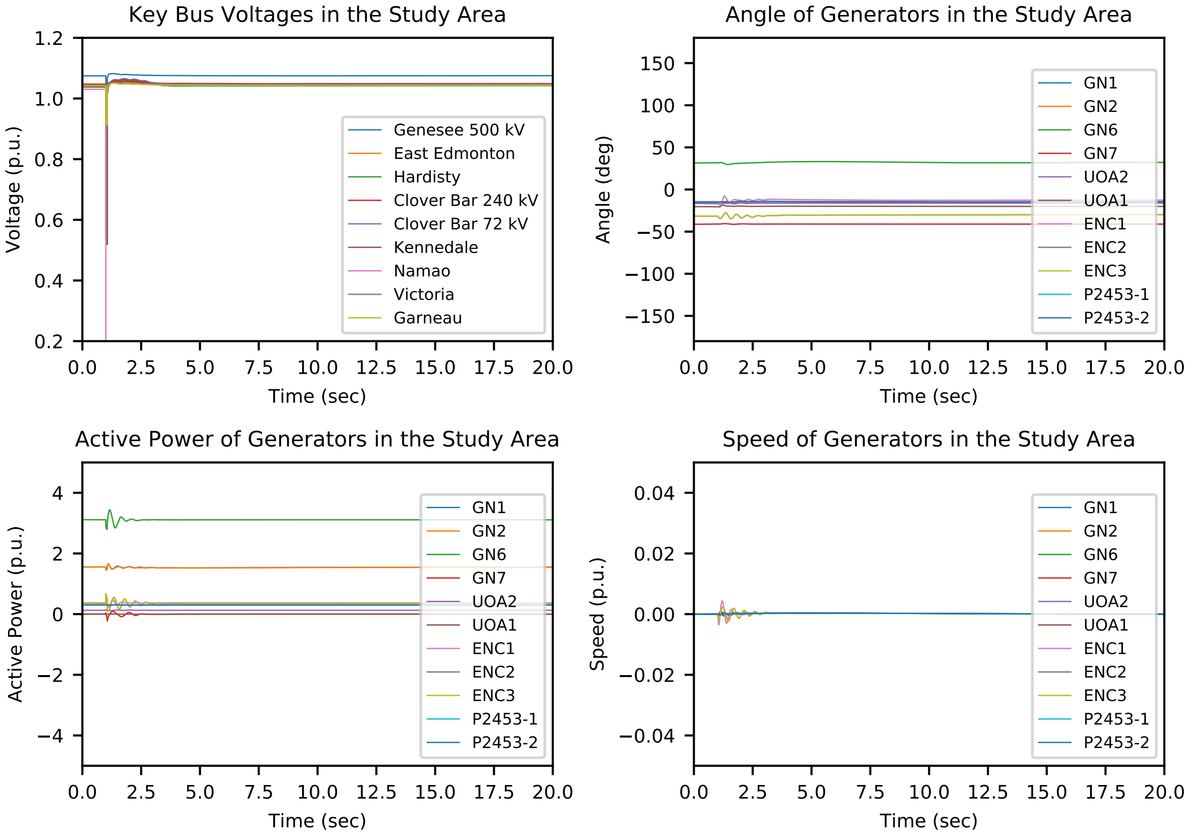
2026 Pre-CETR 72CK13-CloverBar



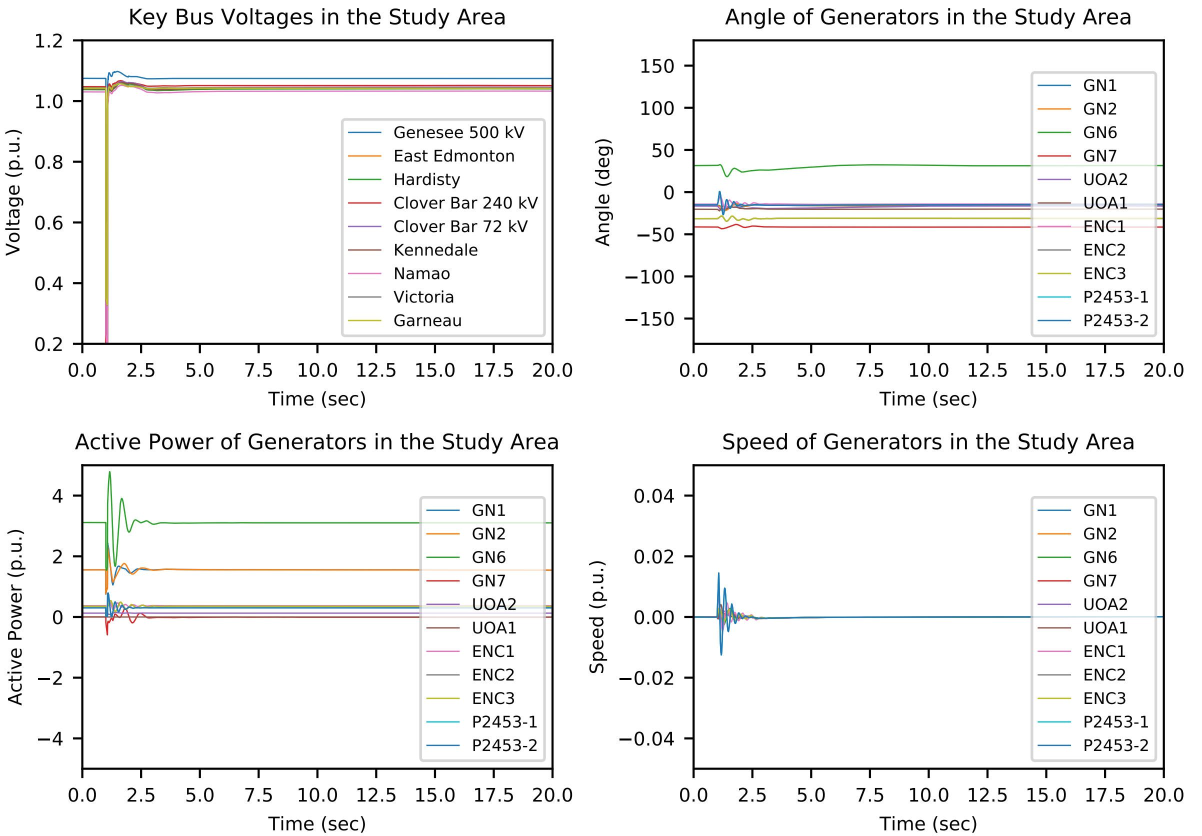

2026 Pre-CETR 72CK13-Kennedale
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

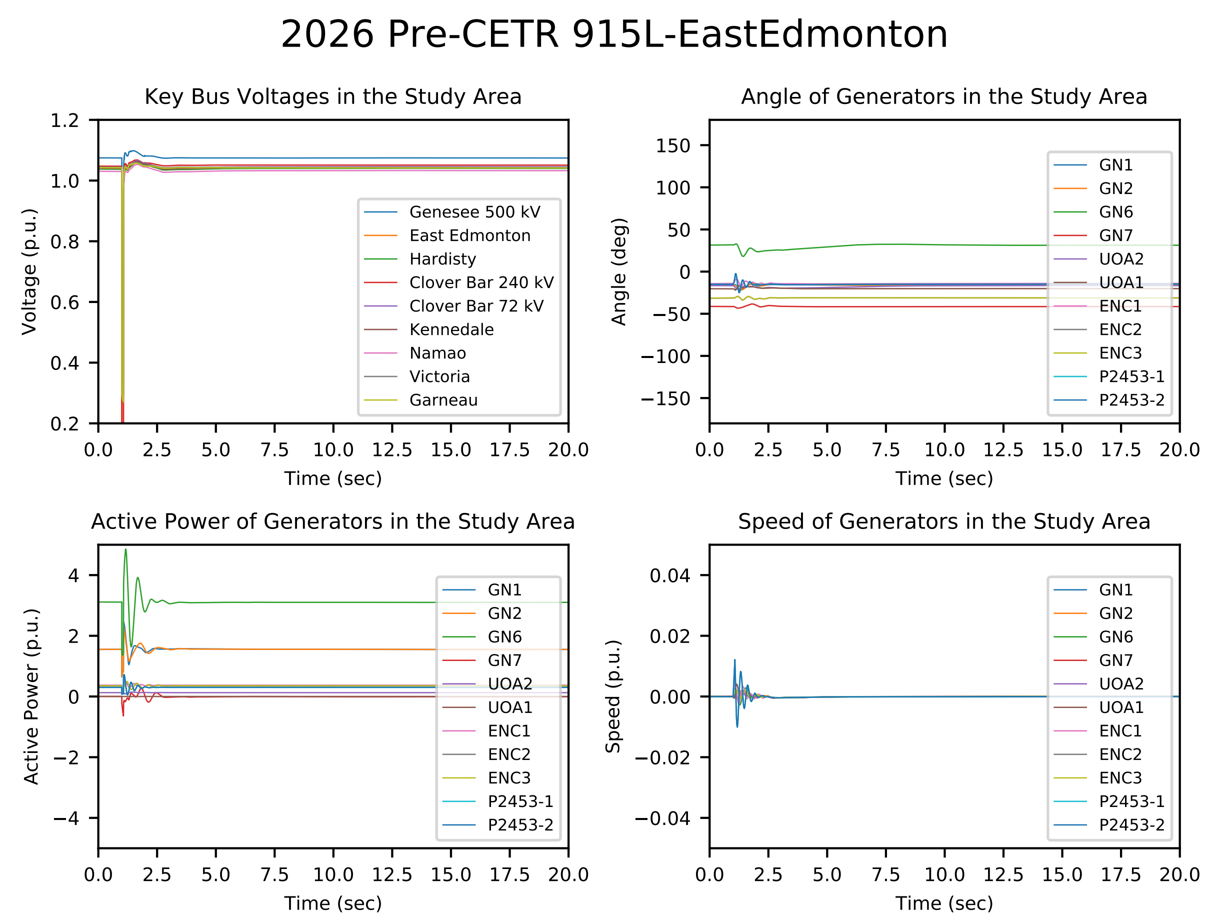

2026 Pre-CETR 72CN10-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

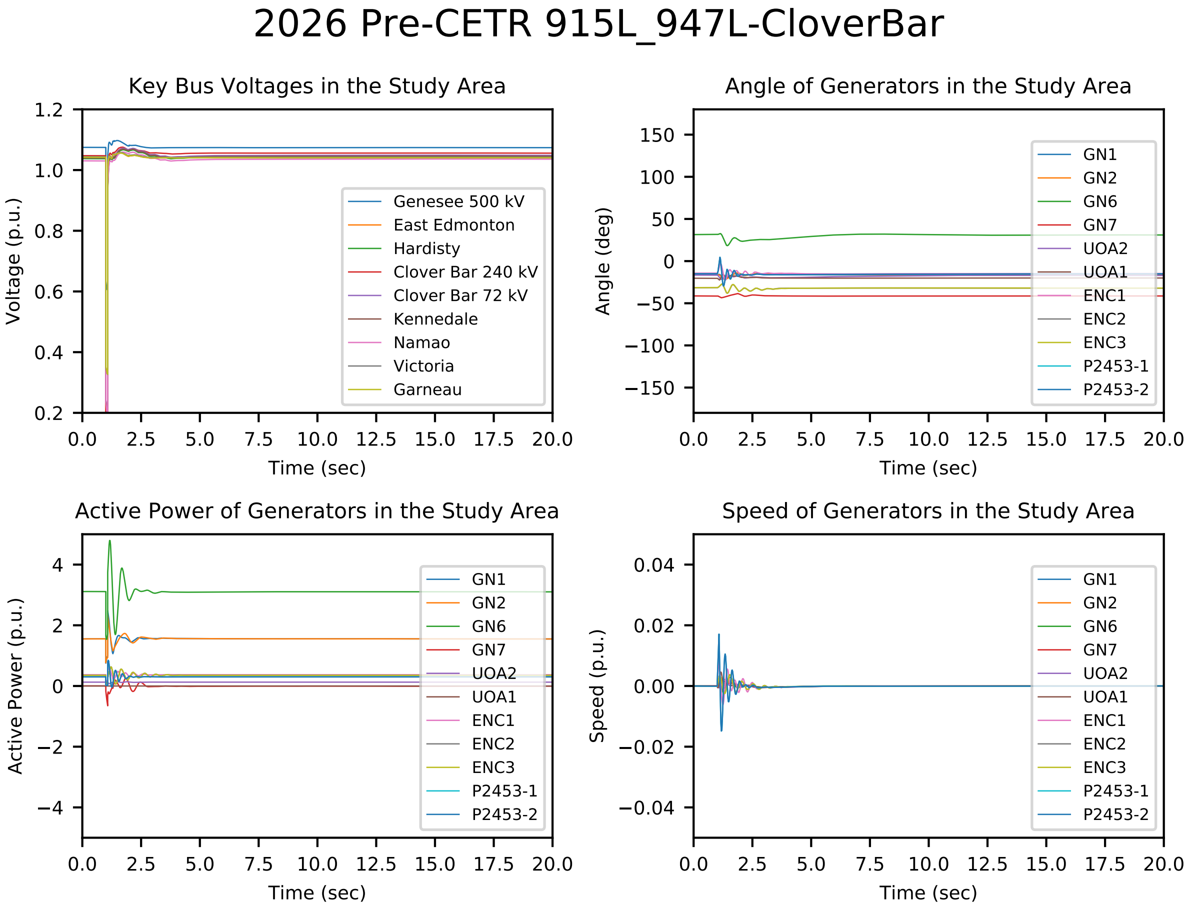
2026 Pre-CETR 72CN10-Namao



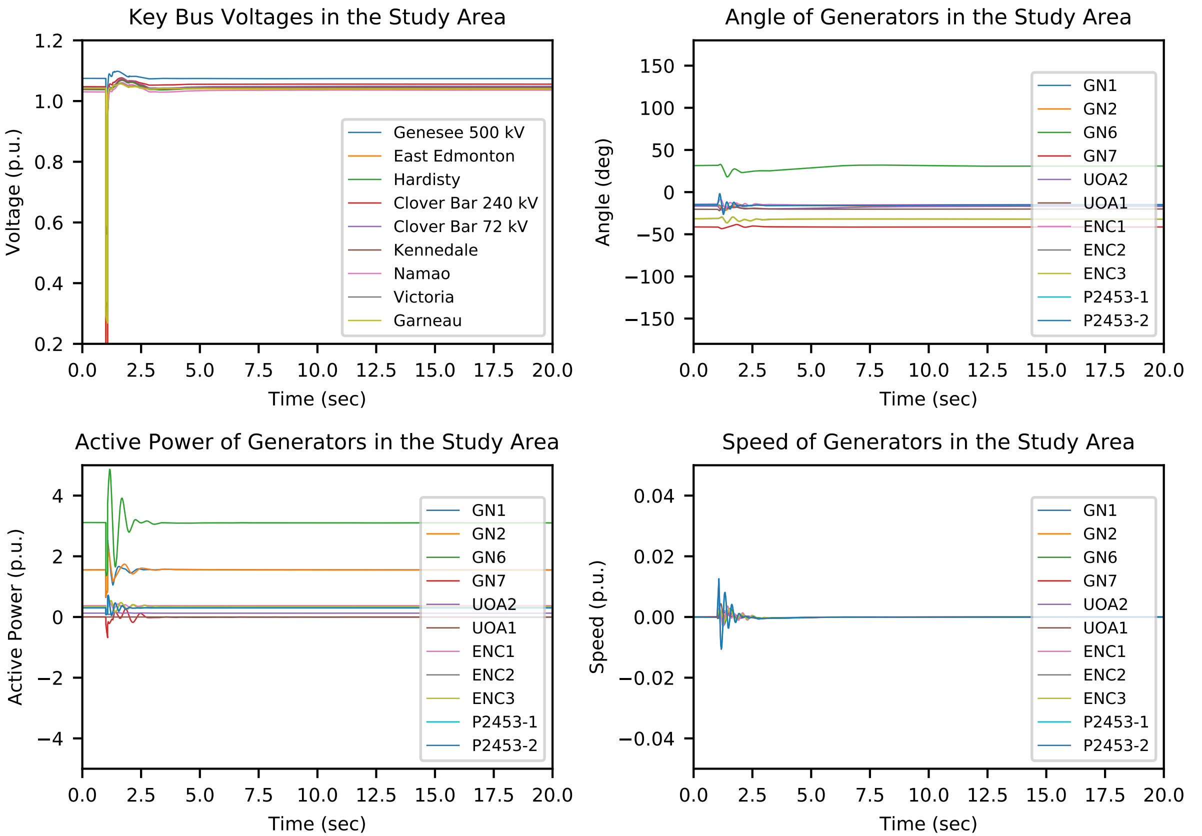
2026 Pre-CETR 915L-CloverBar

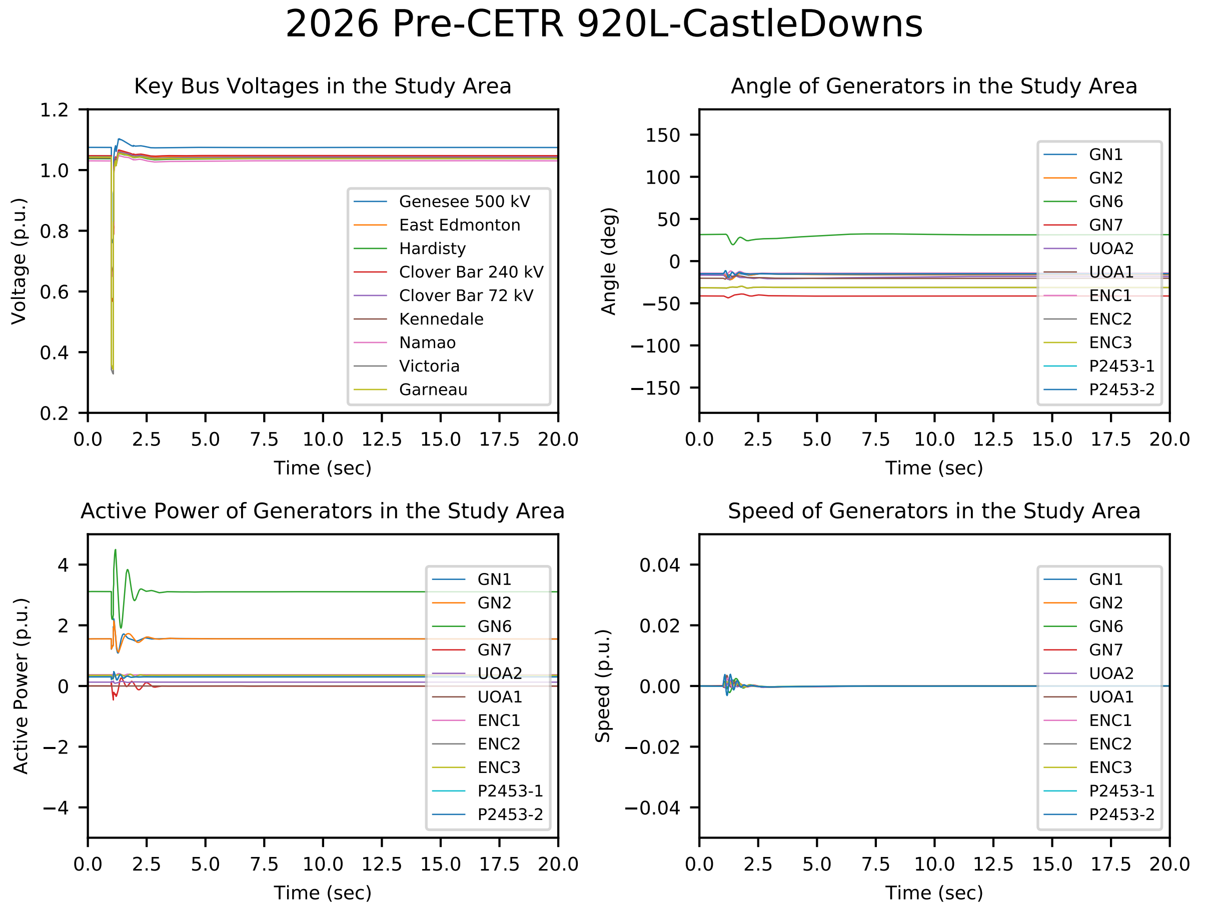



2026 Pre-CETR 915L-EastEdmonton
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

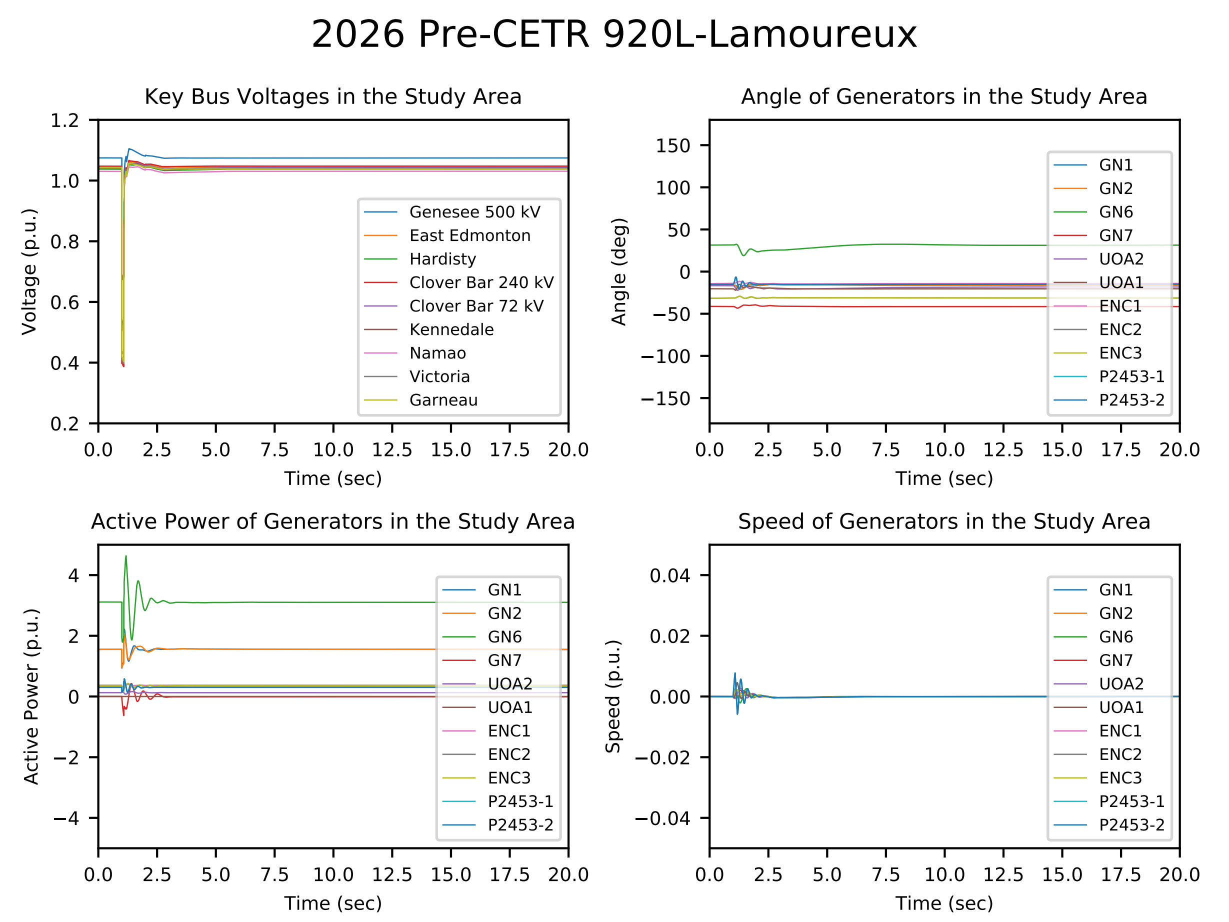

2026 Pre-CETR 915L_947L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)

2026 Pre-CETR 915L_947L-EastEdmonton

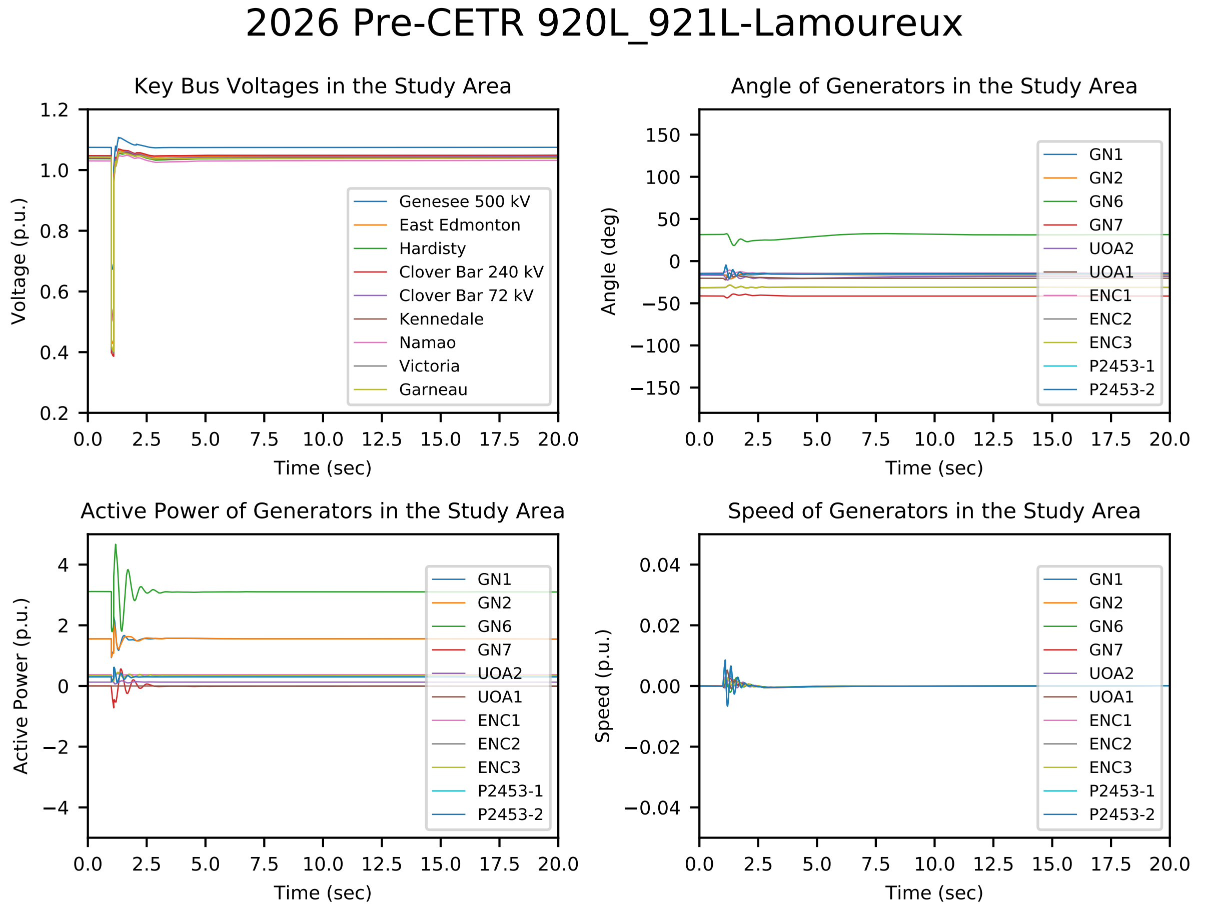


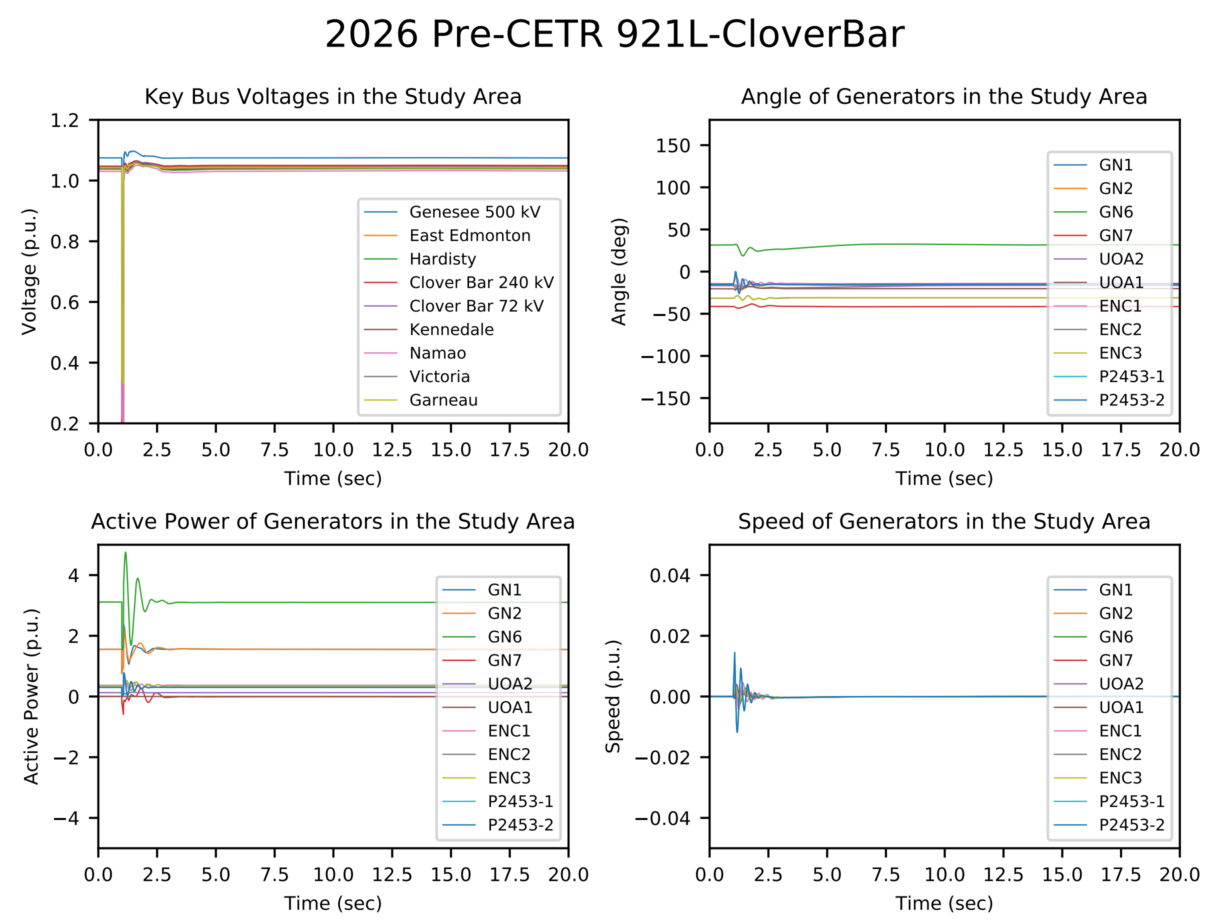


2026 Pre-CETR 920L-CastleDowns
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)

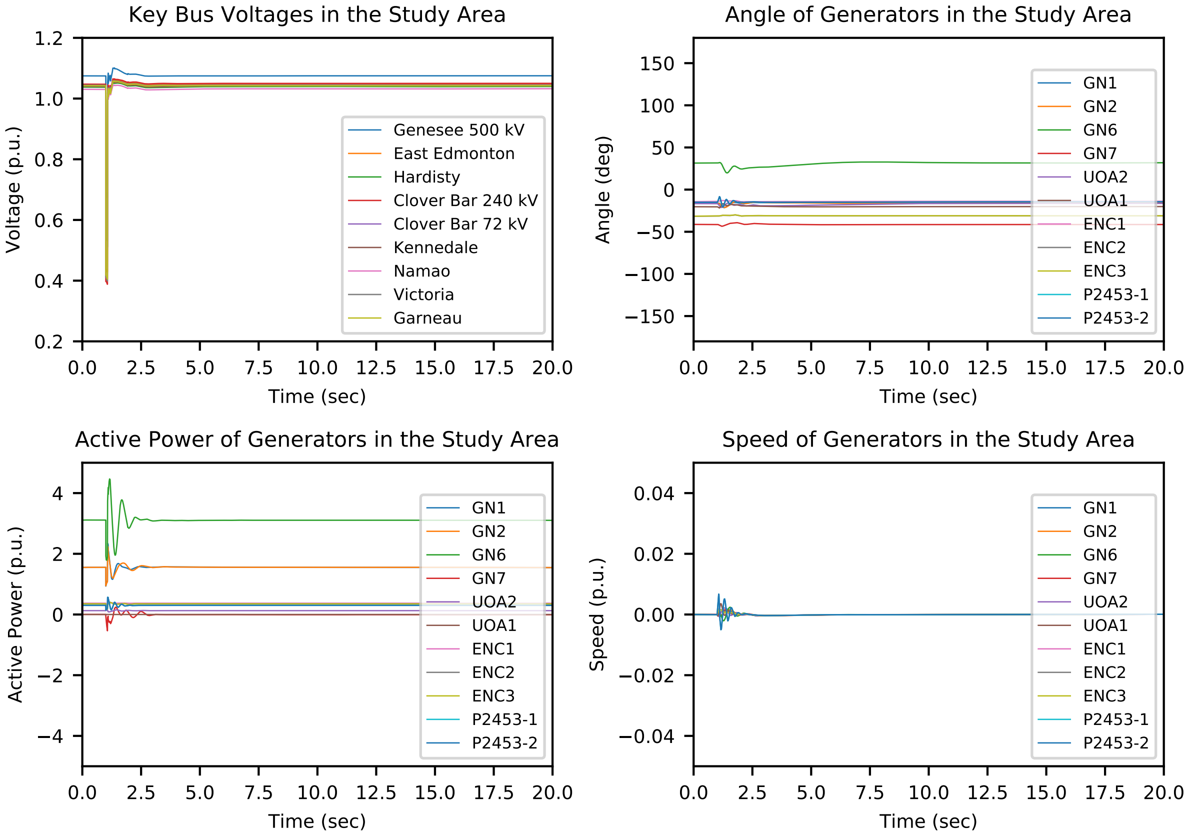


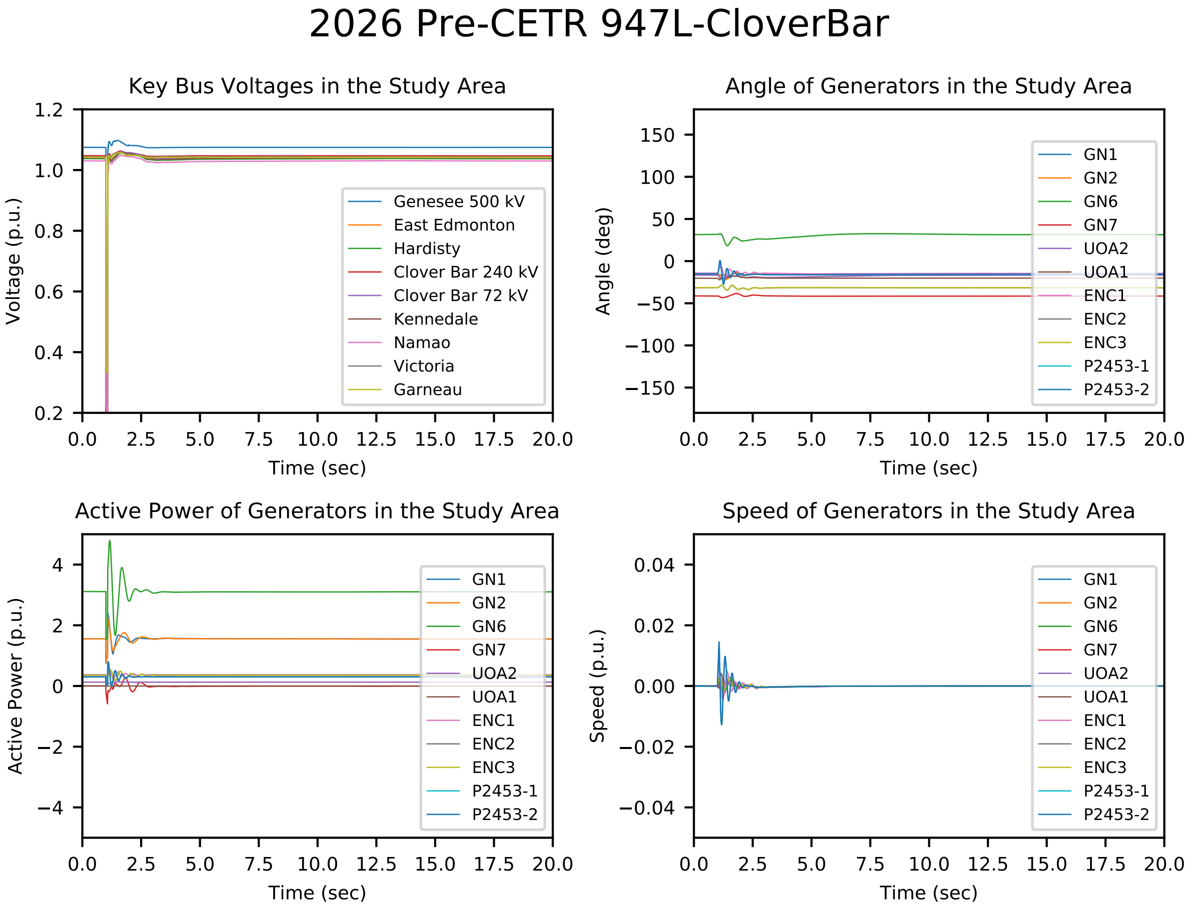
2026 Pre-CETR 920L-Lamoureux
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2


2026 Pre-CETR 920L_921L-Lamoureux
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)


2026 Pre-CETR 921L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

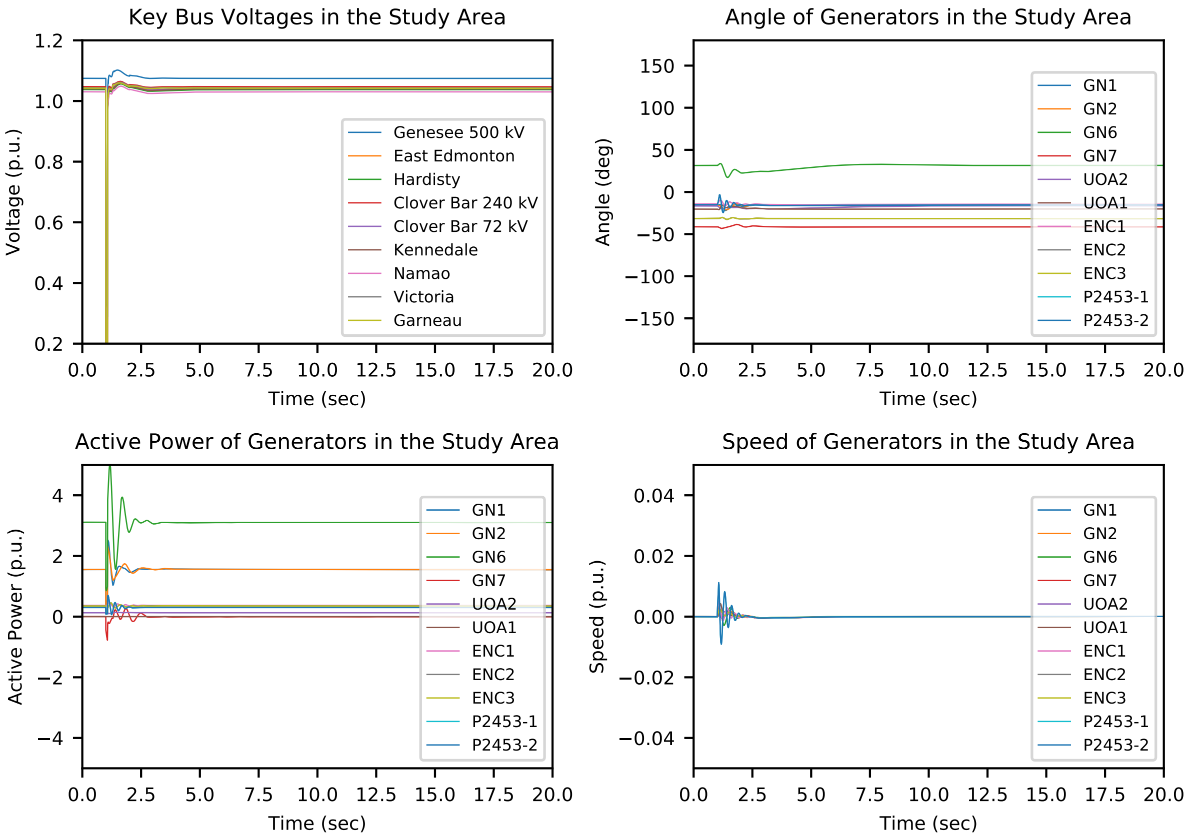
2026 Pre-CETR 921L-Lamoureux

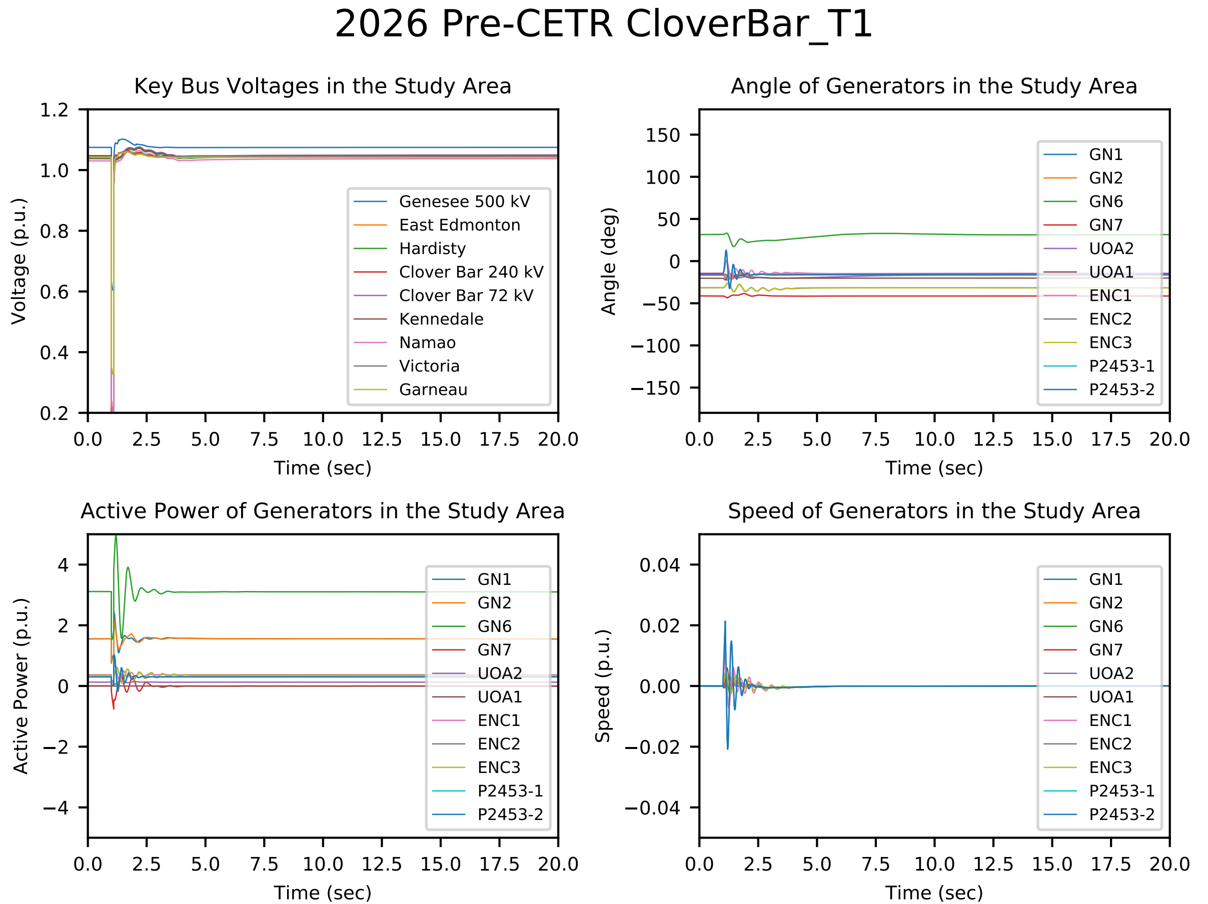




2026 Pre-CETR 947L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)

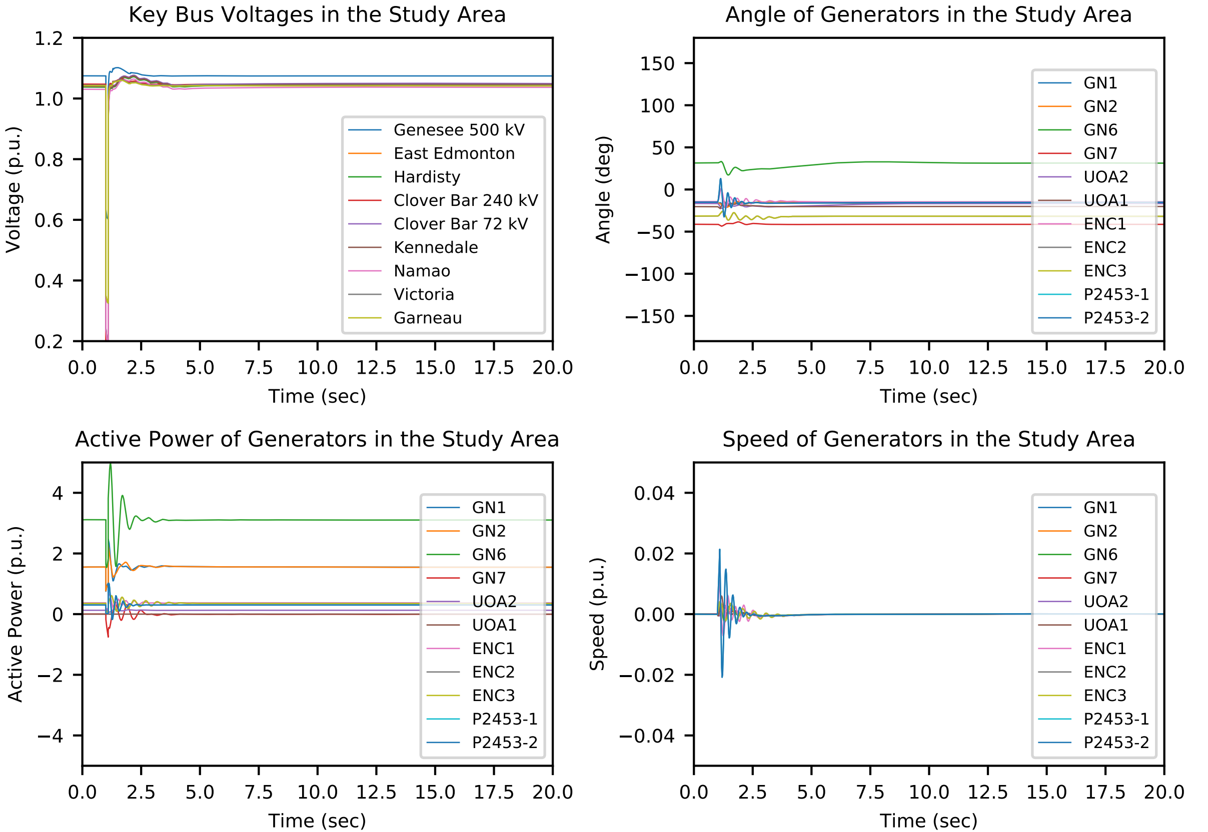
2026 Pre-CETR 947L-Ellerslie

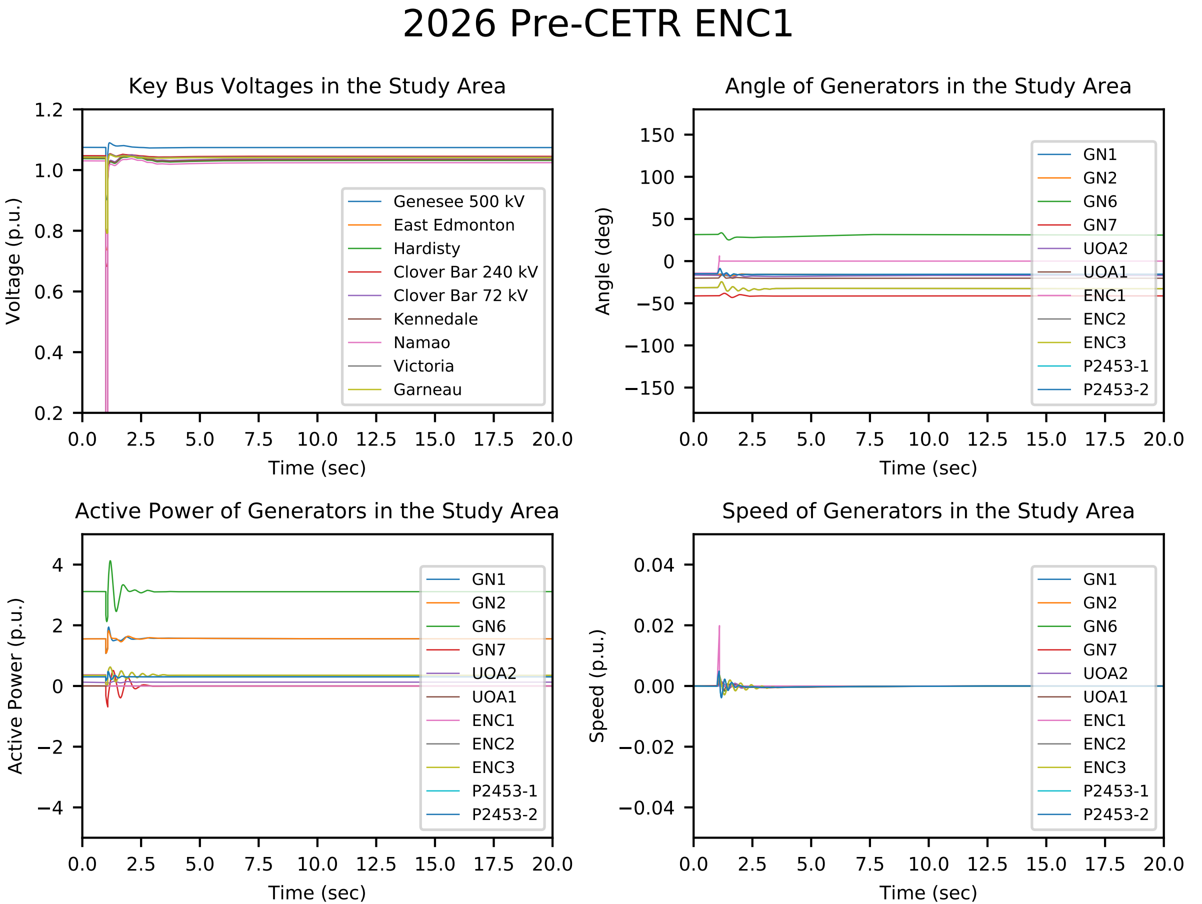




2026 Pre-CETR CloverBar_T1
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

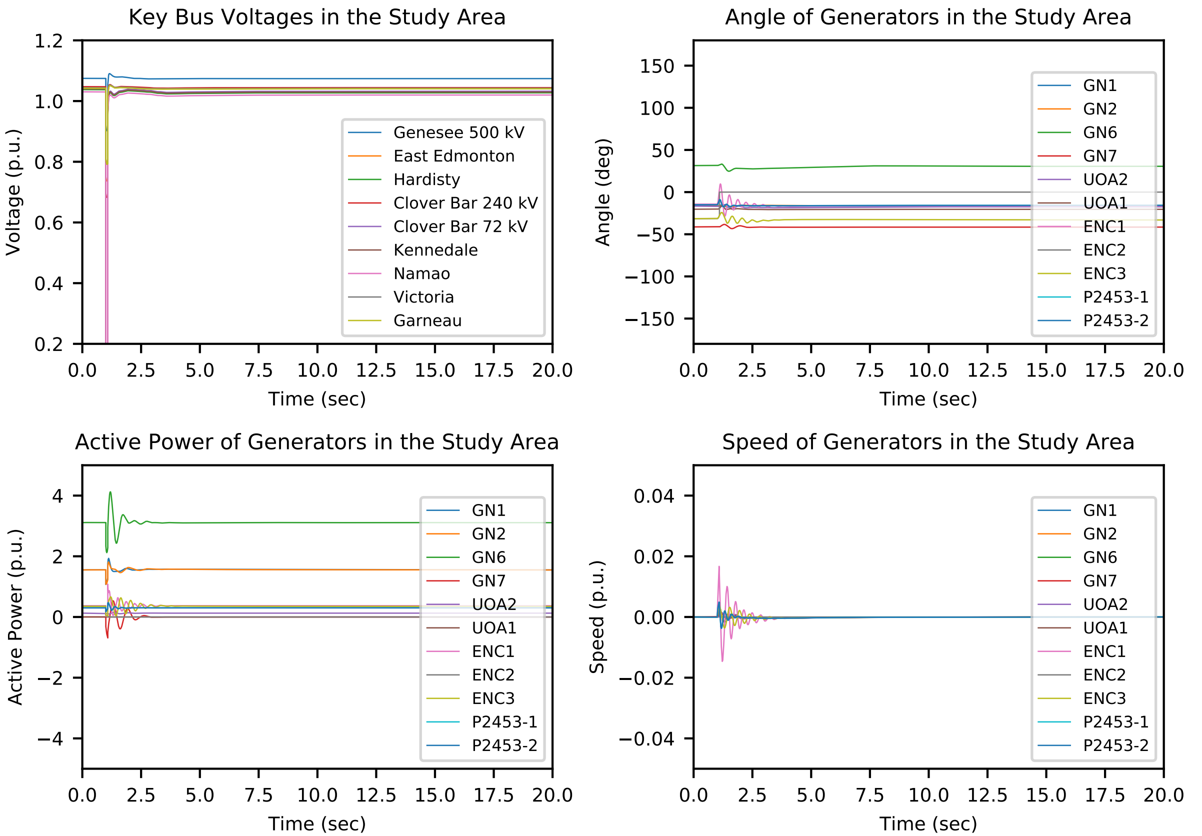
2026 Pre-CETR CloverBar_T2



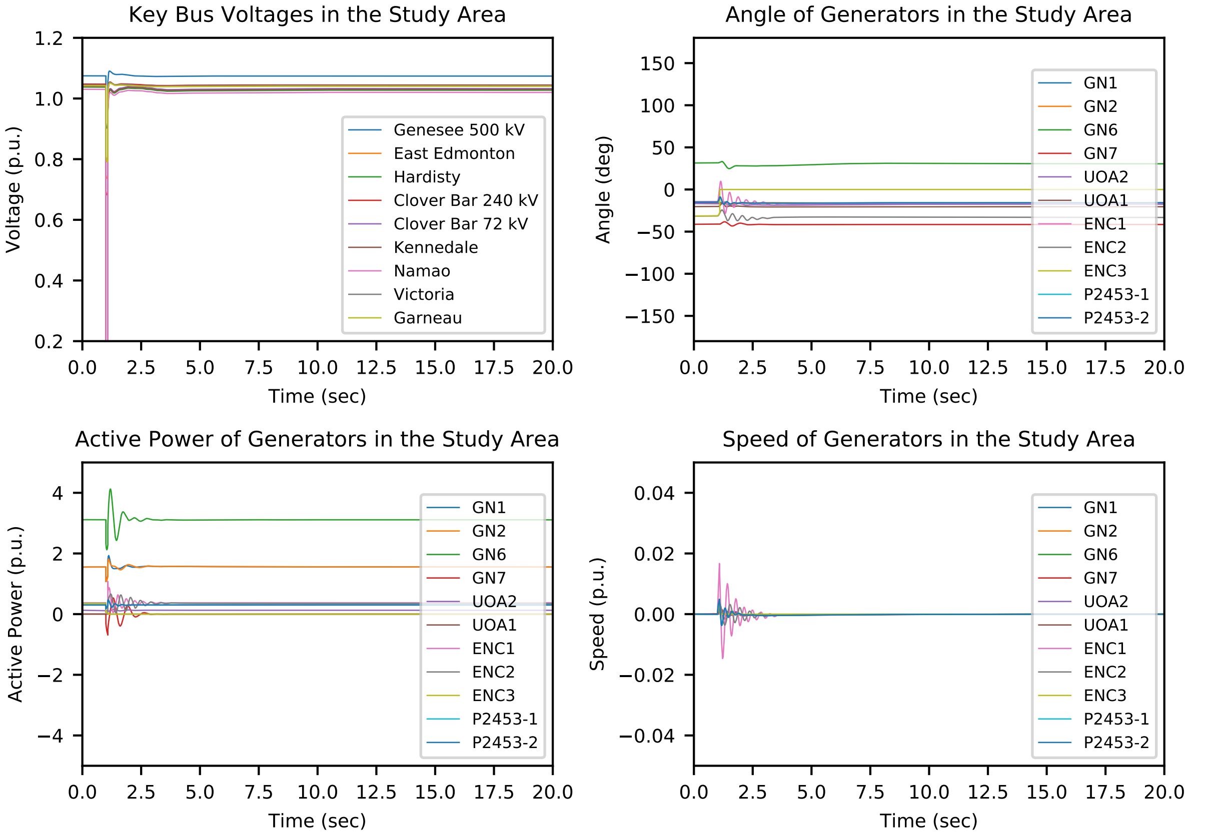


2026 Pre-CETR ENC1
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Kennedale
Namao
Victoria
Garneau
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)

2026 Pre-CETR ENC2



2026 Pre-CETR ENC3

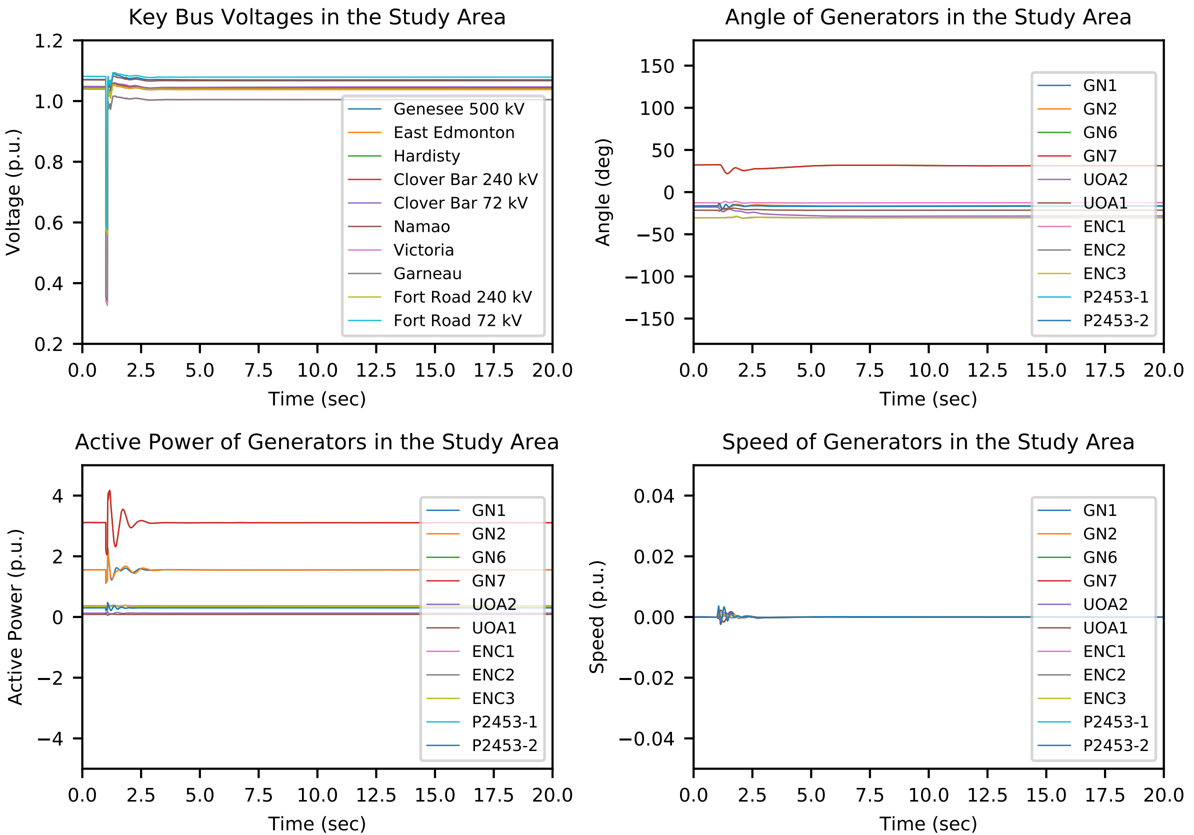


Attachment E

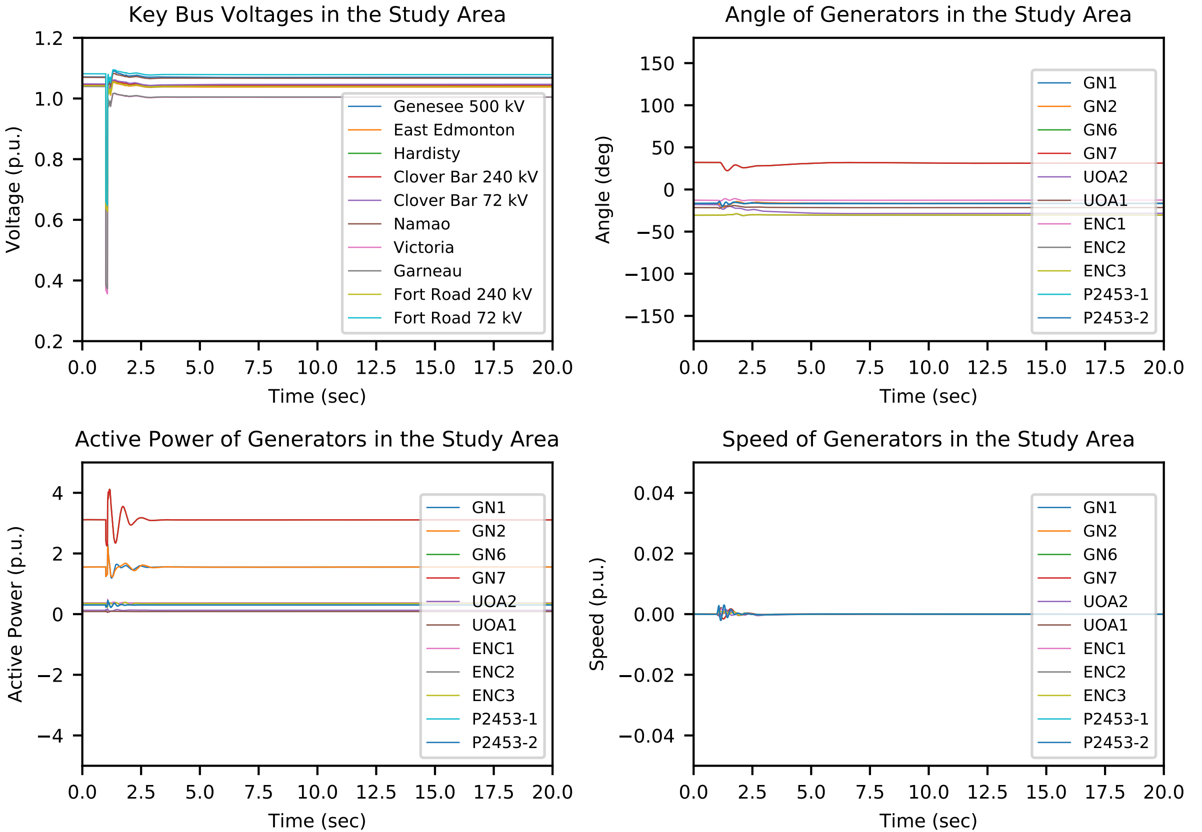
Transient Simulation Results

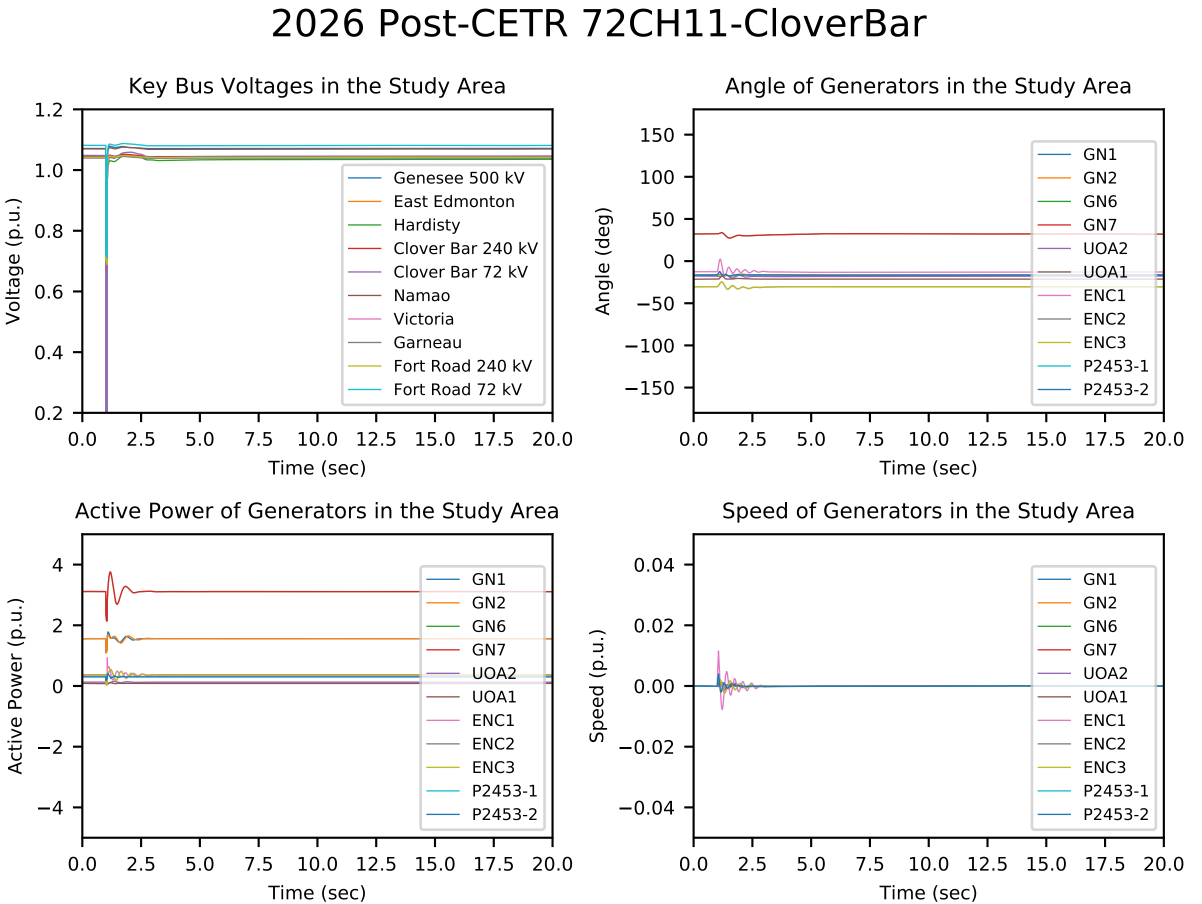
Section: E-2

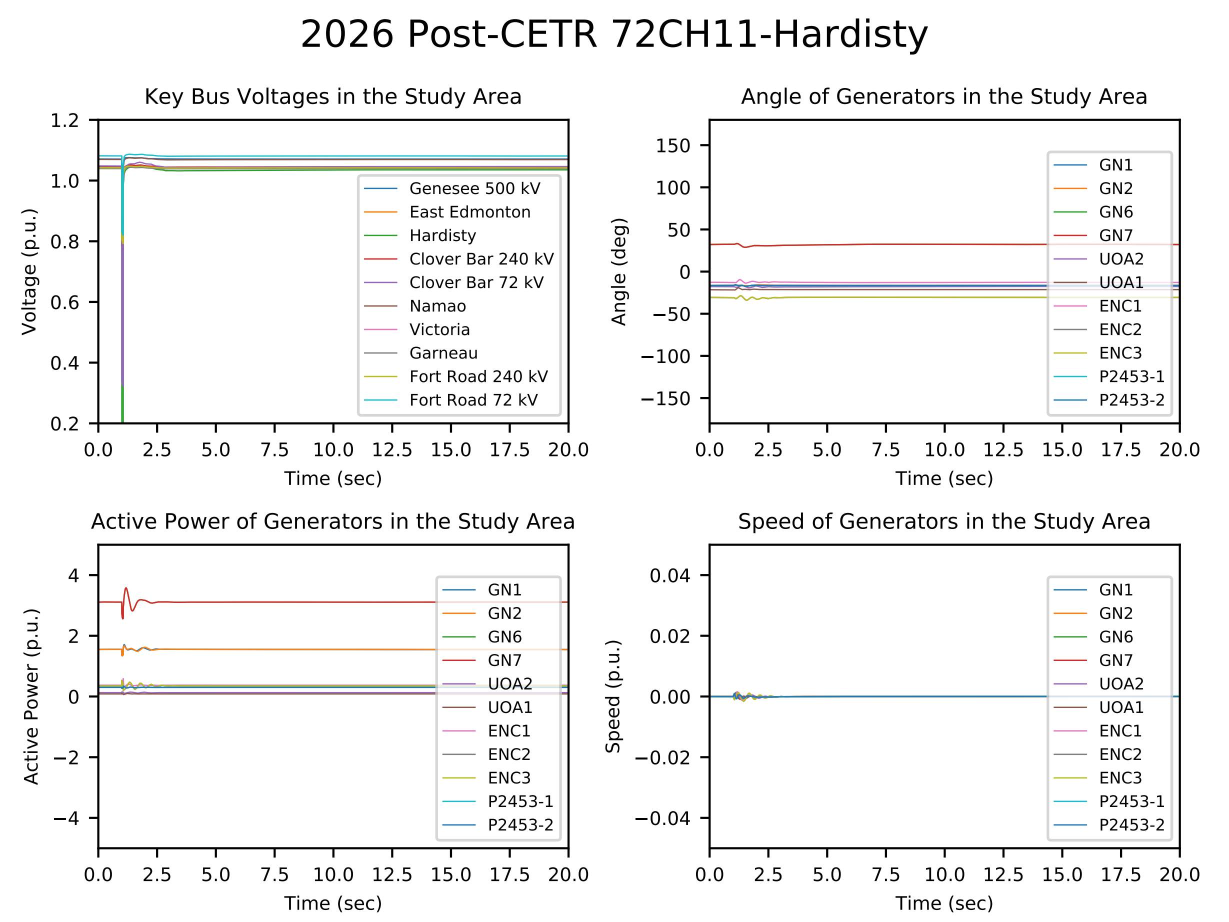
2026 Post-CETR 240CV5-CastleDowns

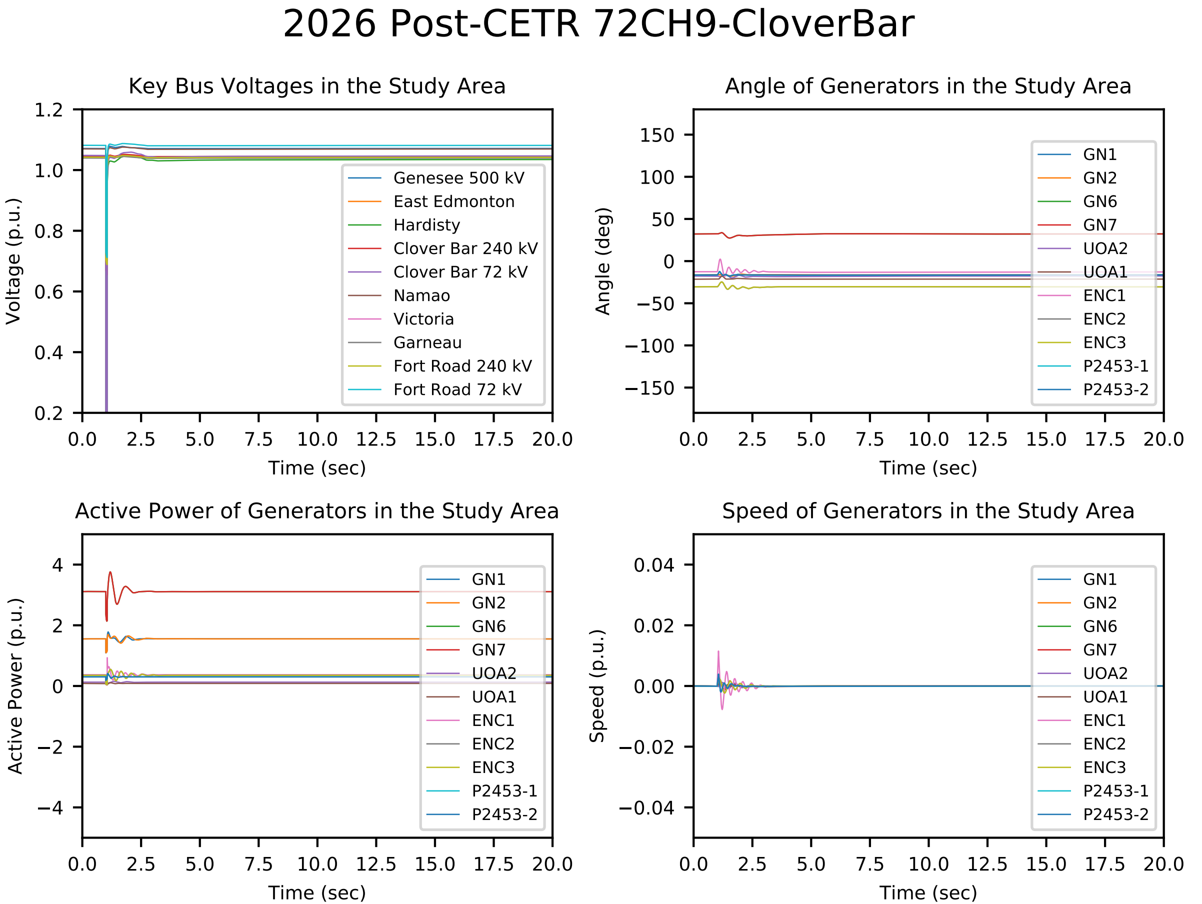


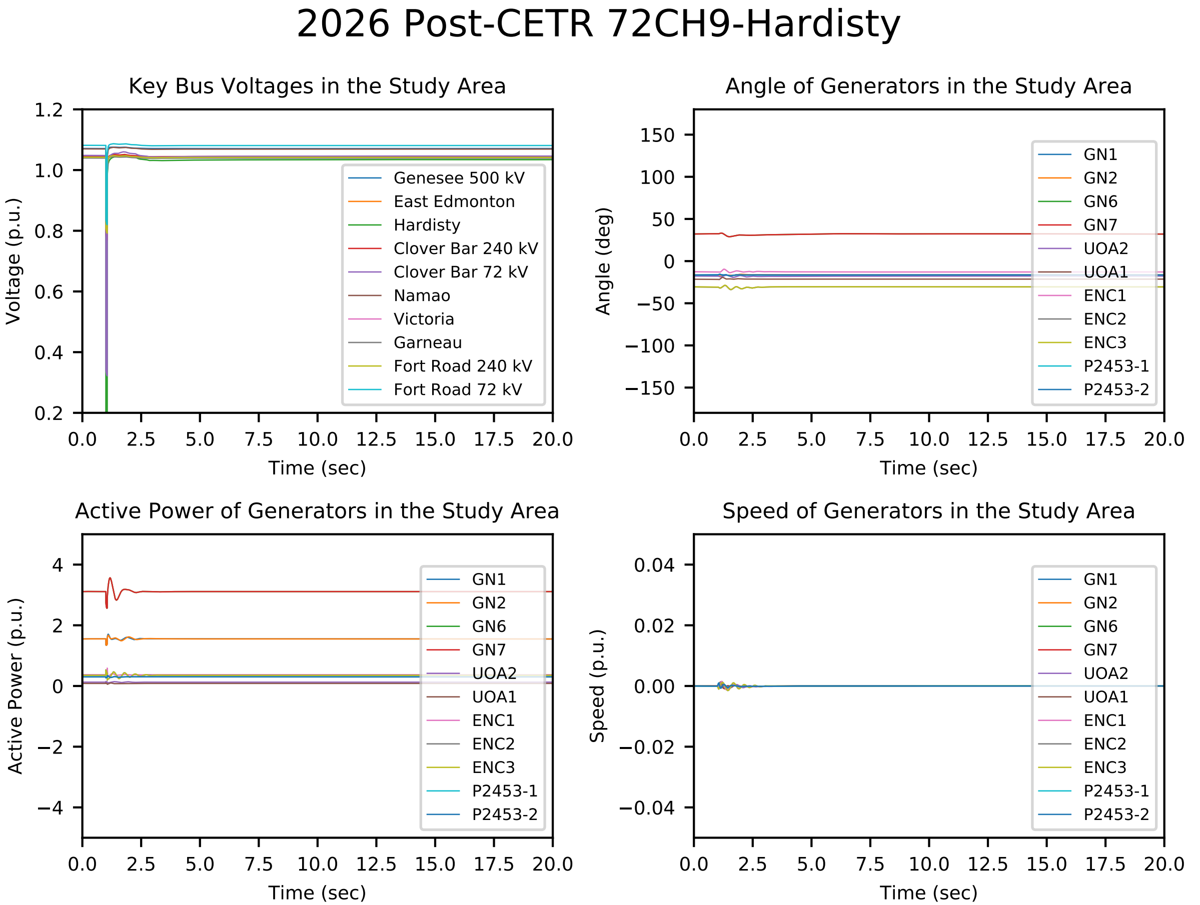
2026 Post-CETR 240CV5-Victoria

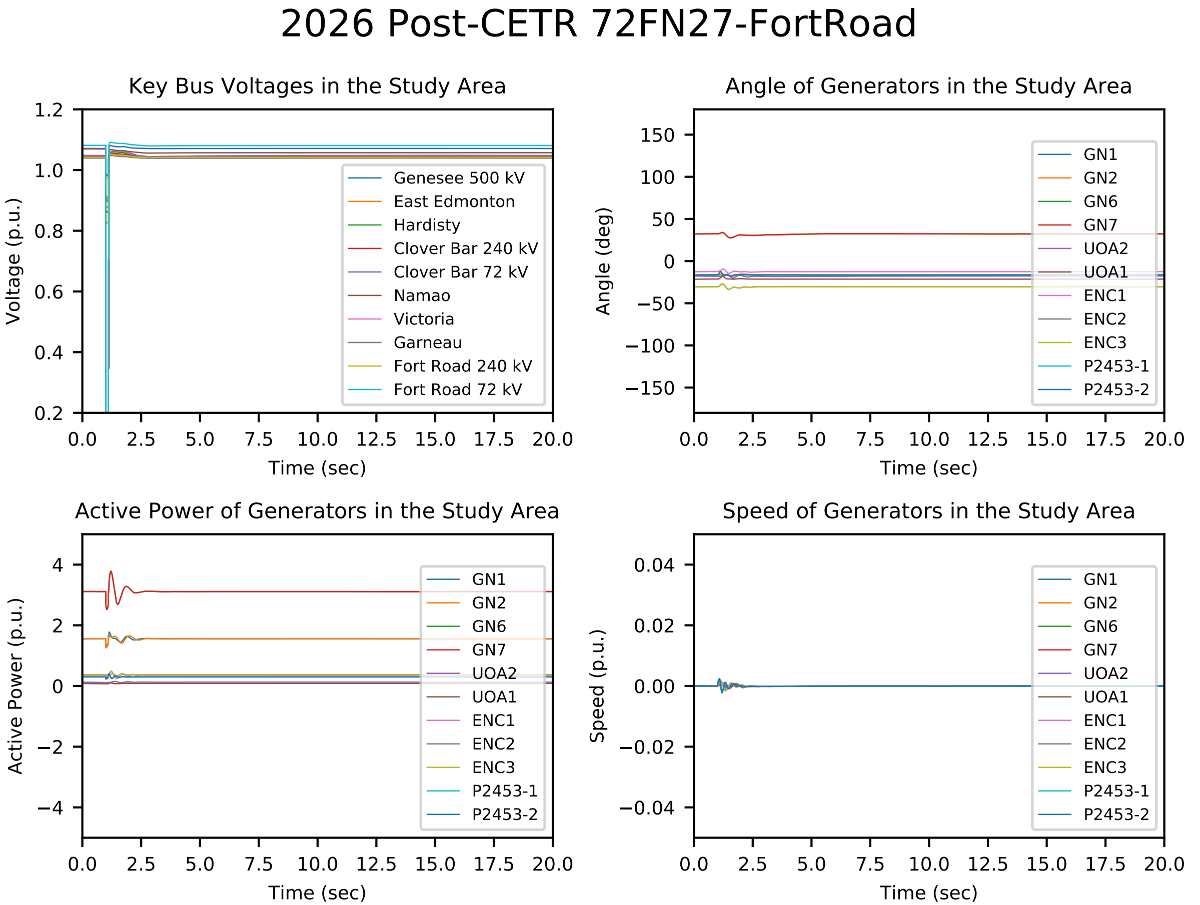



2026 Post-CETR 72CH11-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

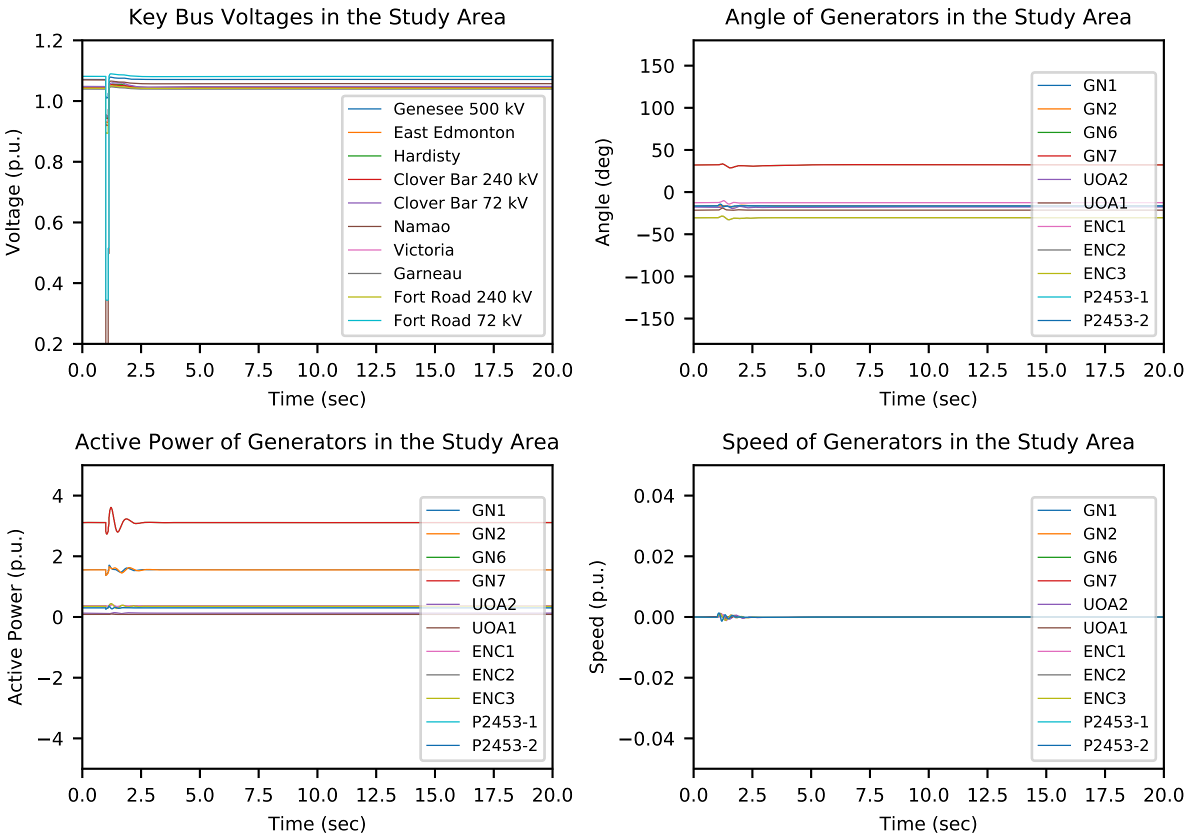

2026 Post-CETR 72CH11-Hardisty
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2


2026 Post-CETR 72CH9-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

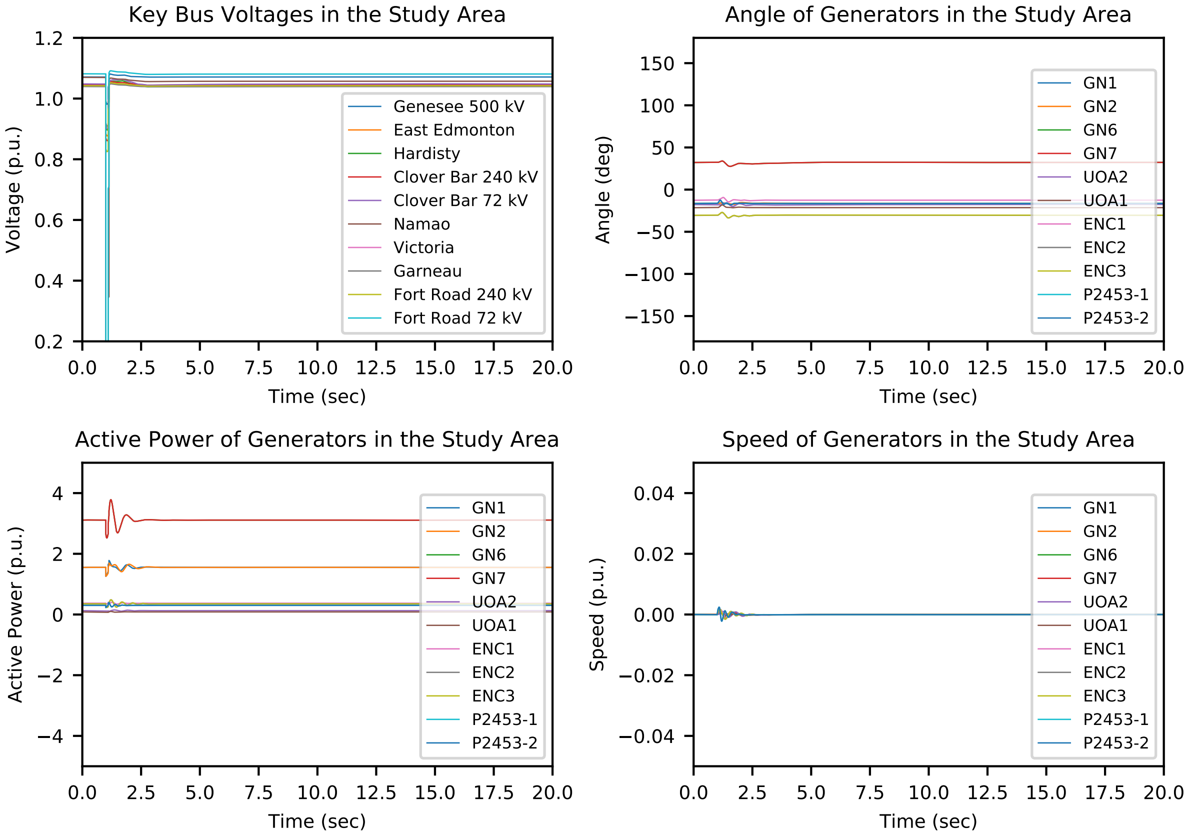

2026 Post-CETR 72CH9-Hardisty
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)


2026 Post-CETR 72FN27-FortRoad
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

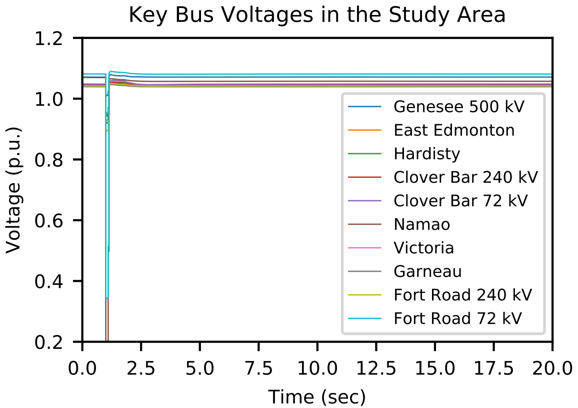
2026 Post-CETR 72FN27-Namao

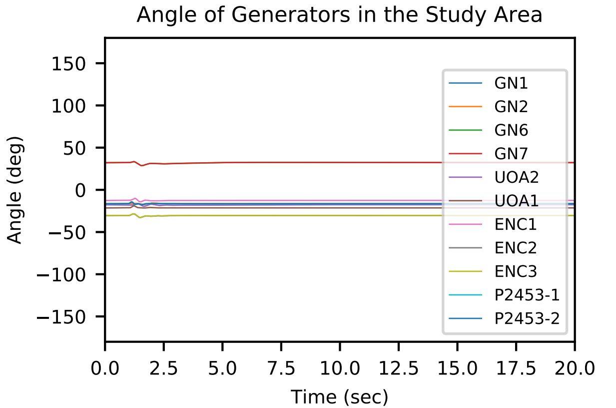


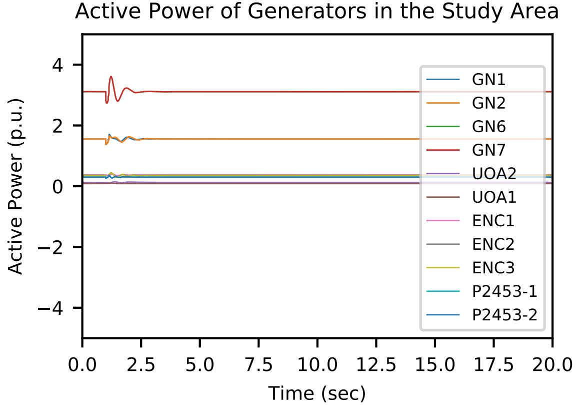
2026 Post-CETR 72FN28-FortRoad

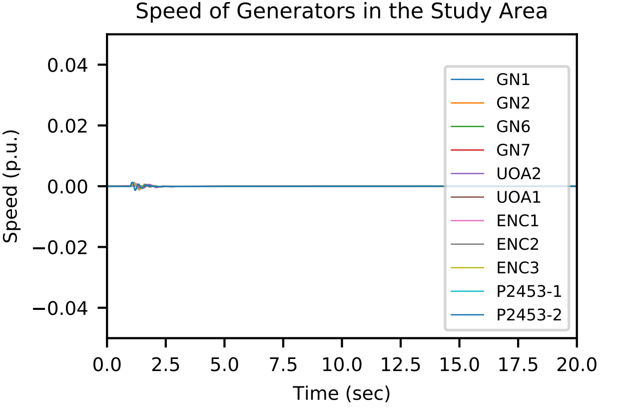


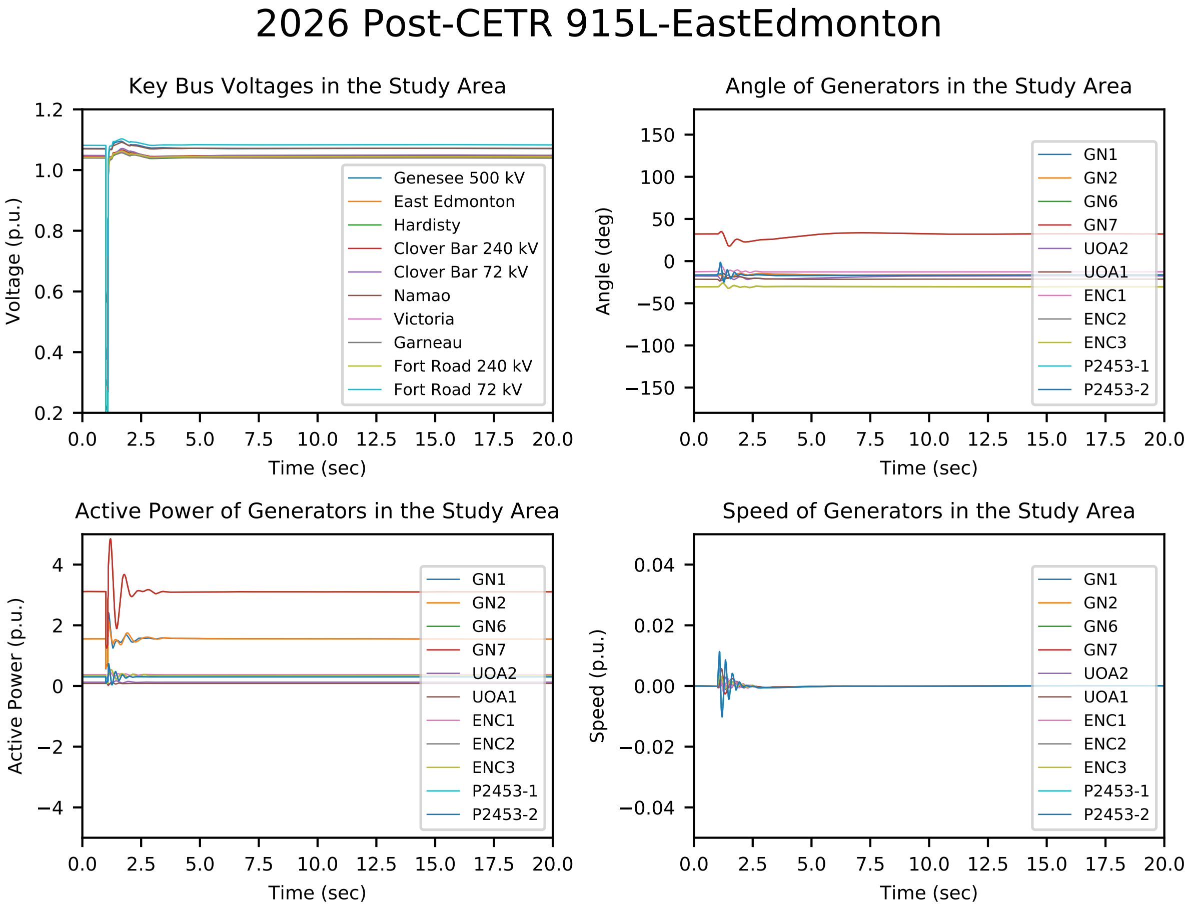
2026 Post-CETR 72FN28-Namao



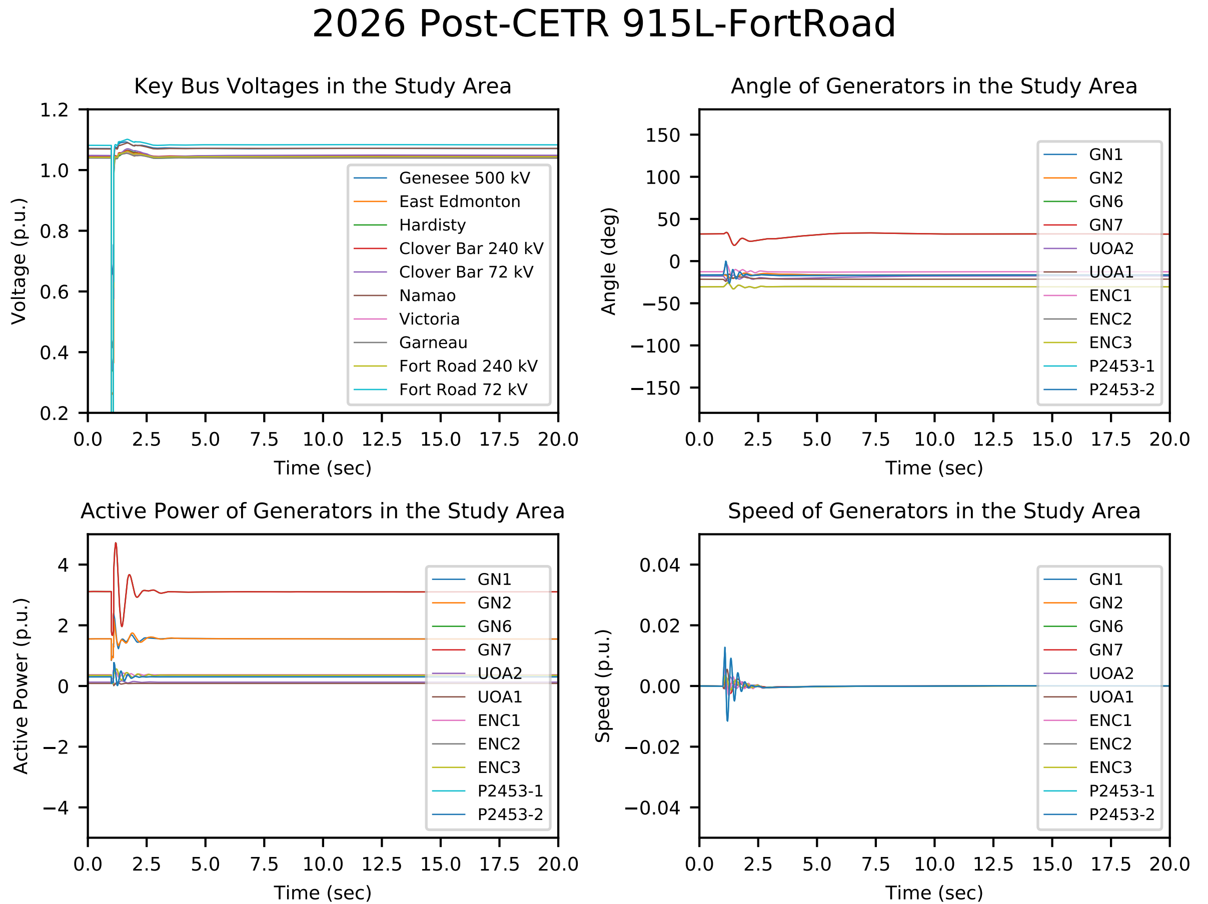




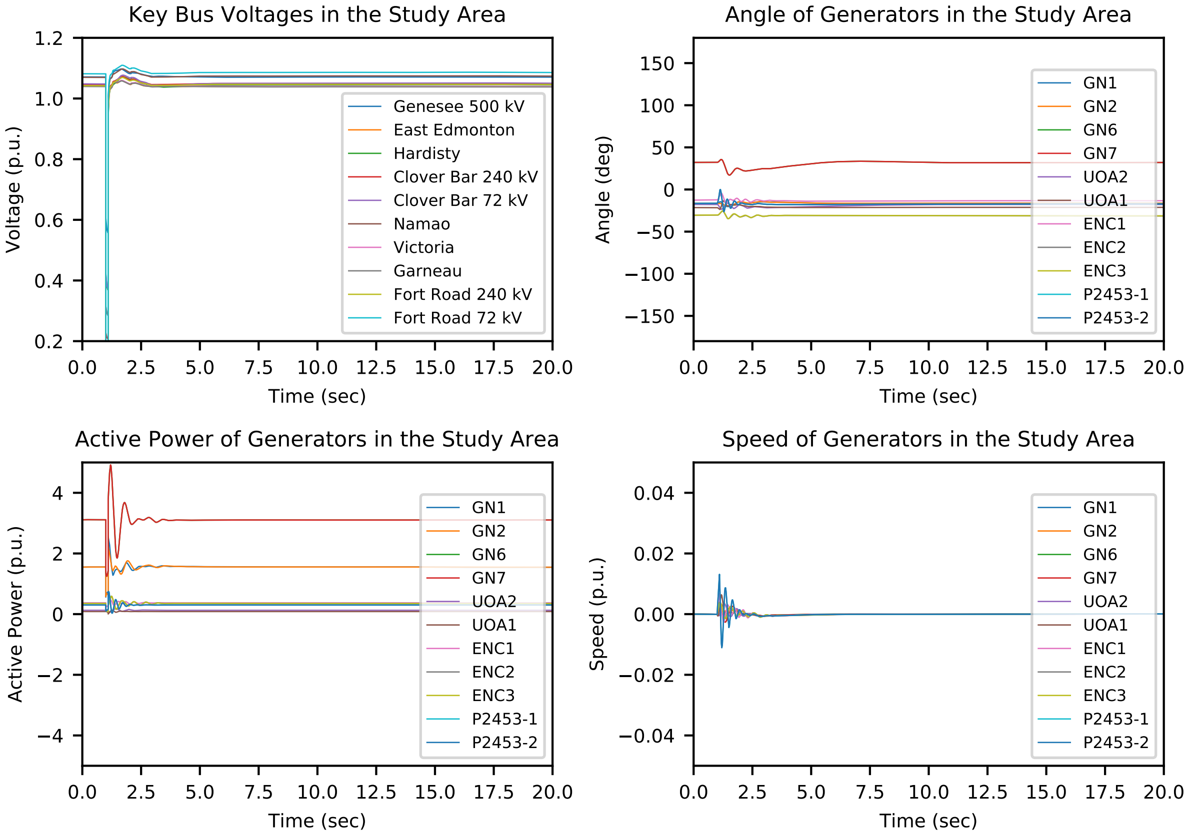




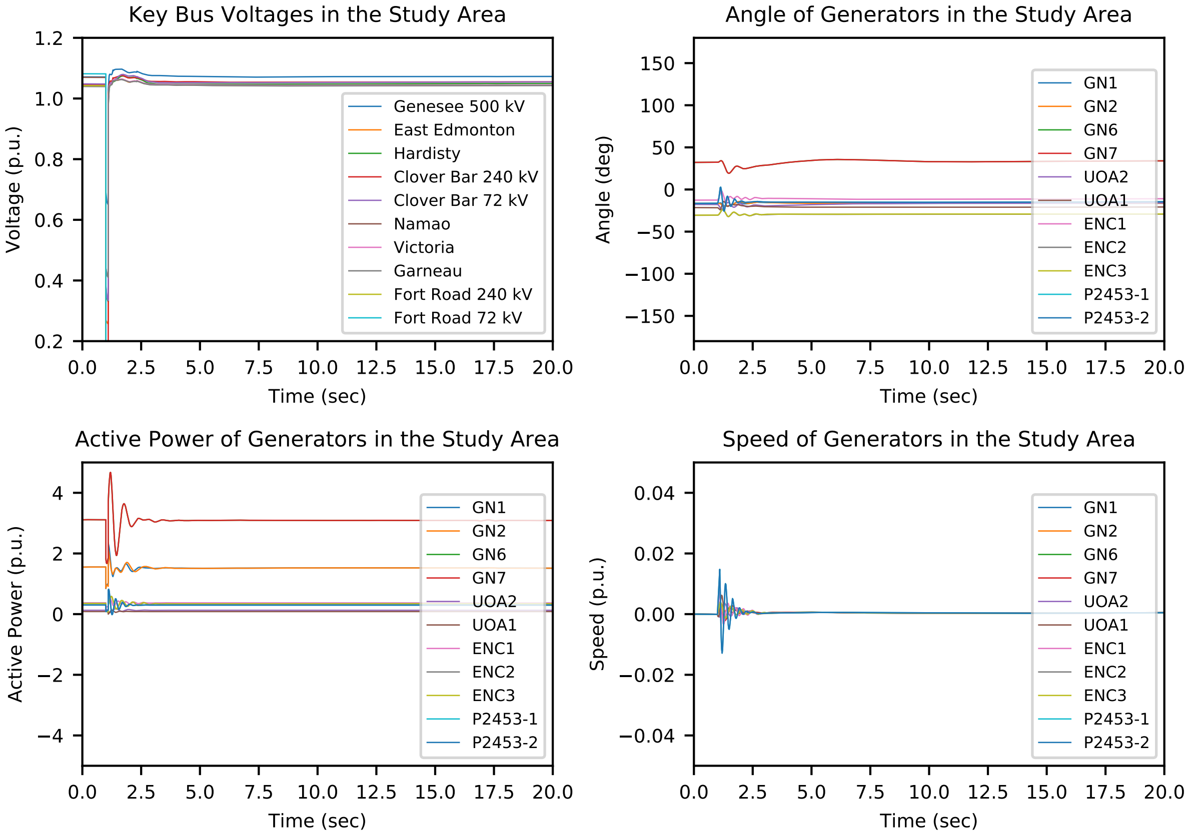
2026 Post-CETR 915L-EastEdmonton
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2


2026 Post-CETR 915L-FortRoad
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

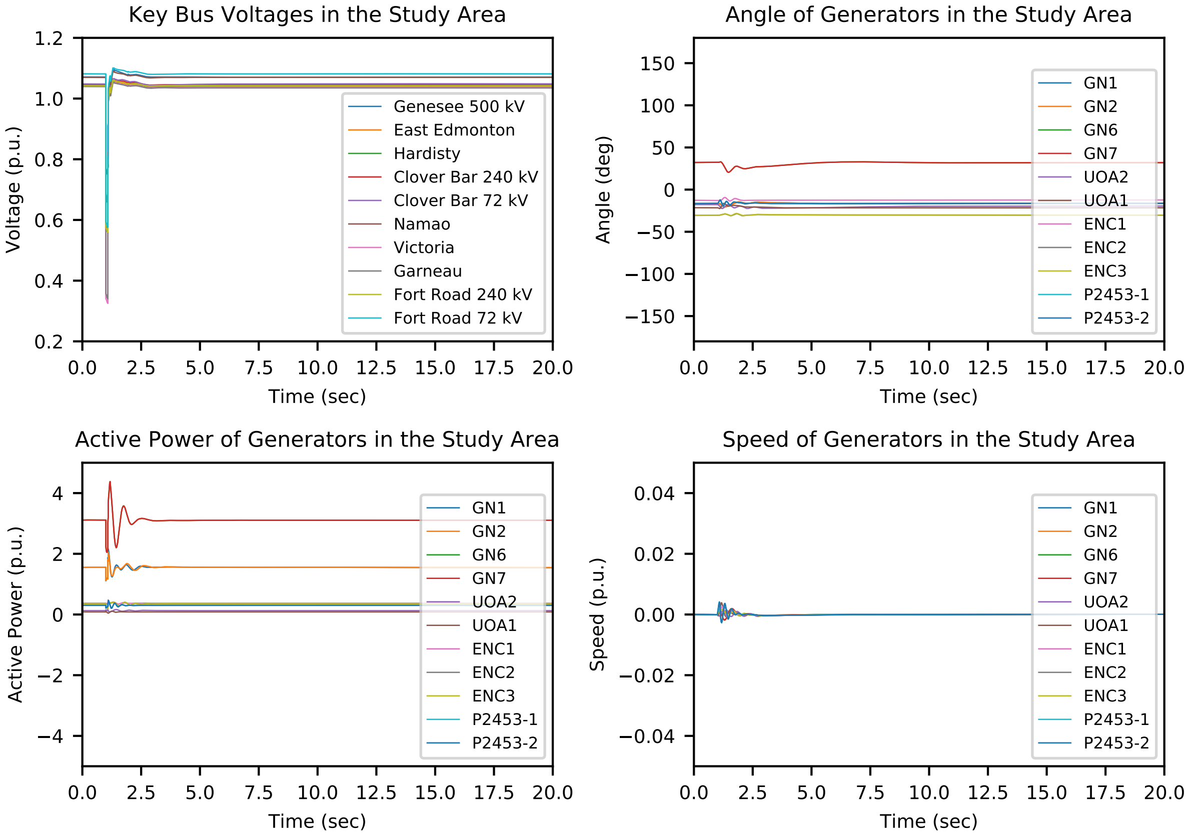
2026 Post-CETR 915L_947L-EastEdmonton



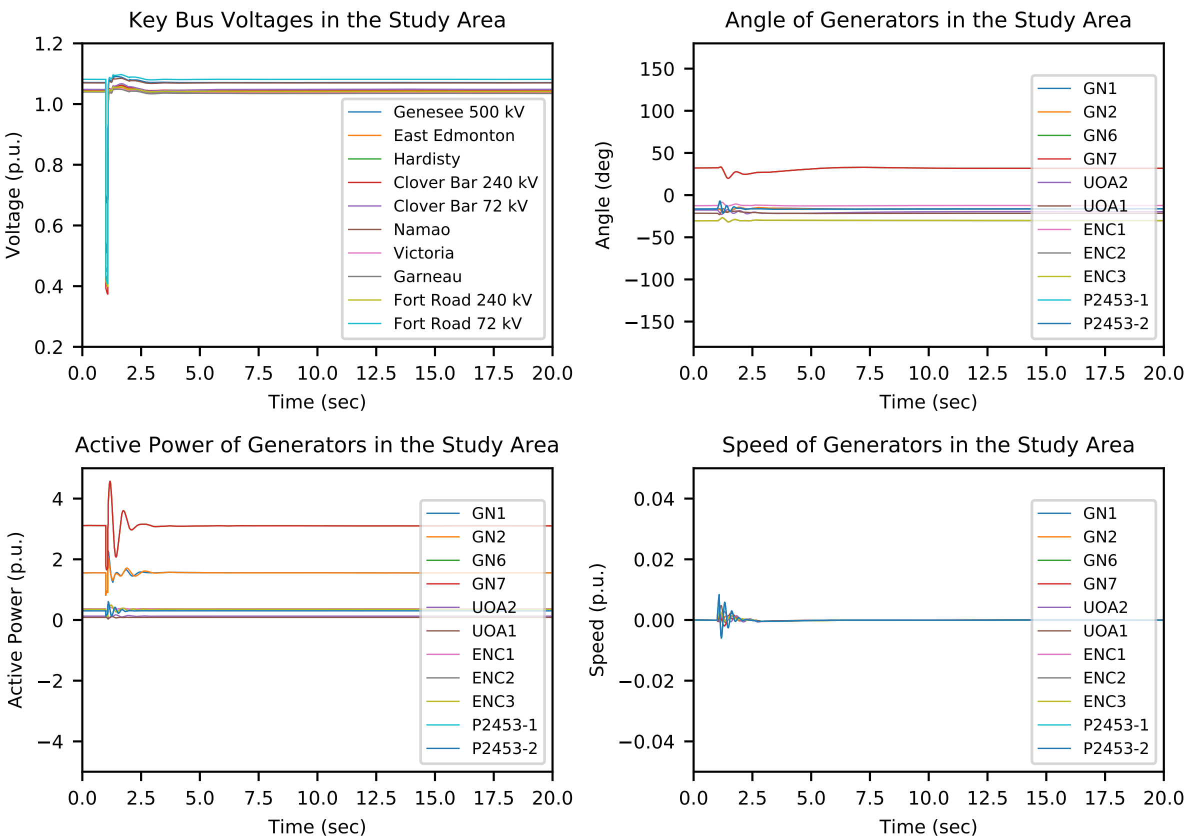
2026 Post-CETR 915L_993L-FortRoad



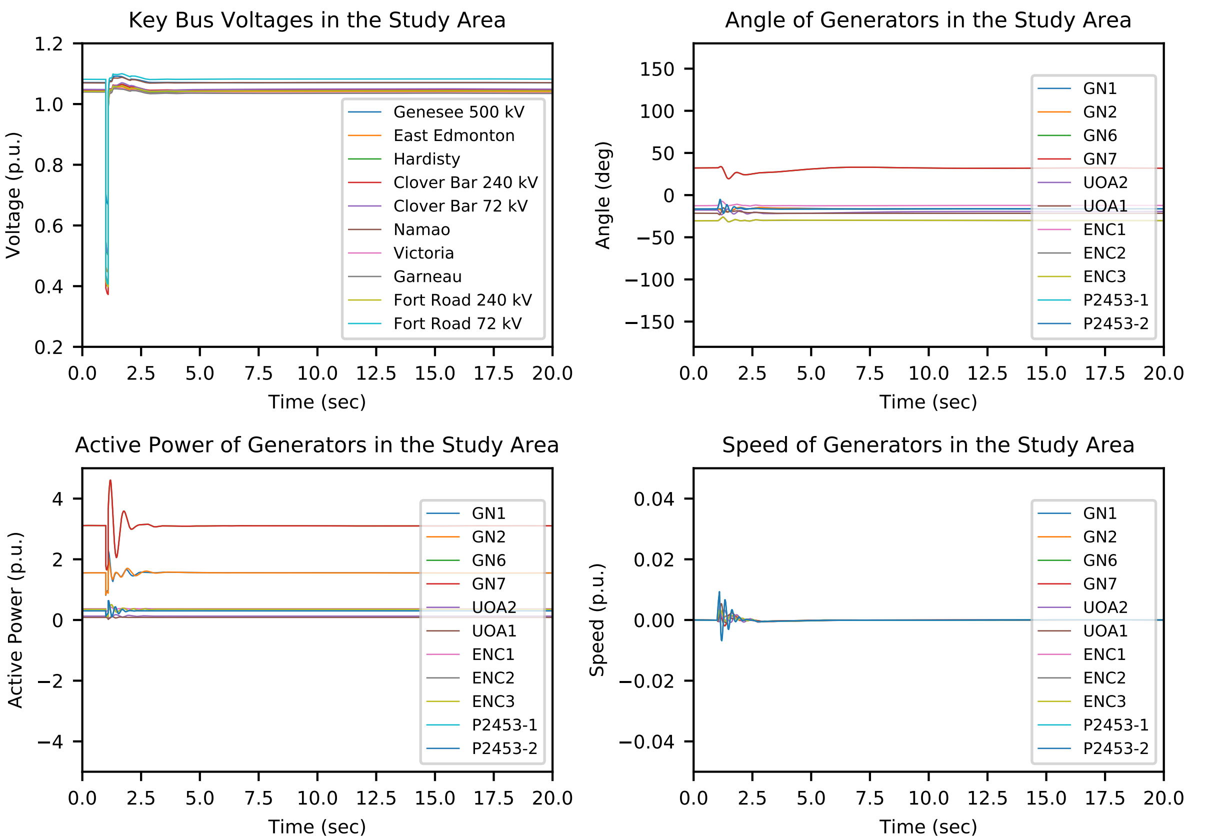
2026 Post-CETR 920L-CastleDowns



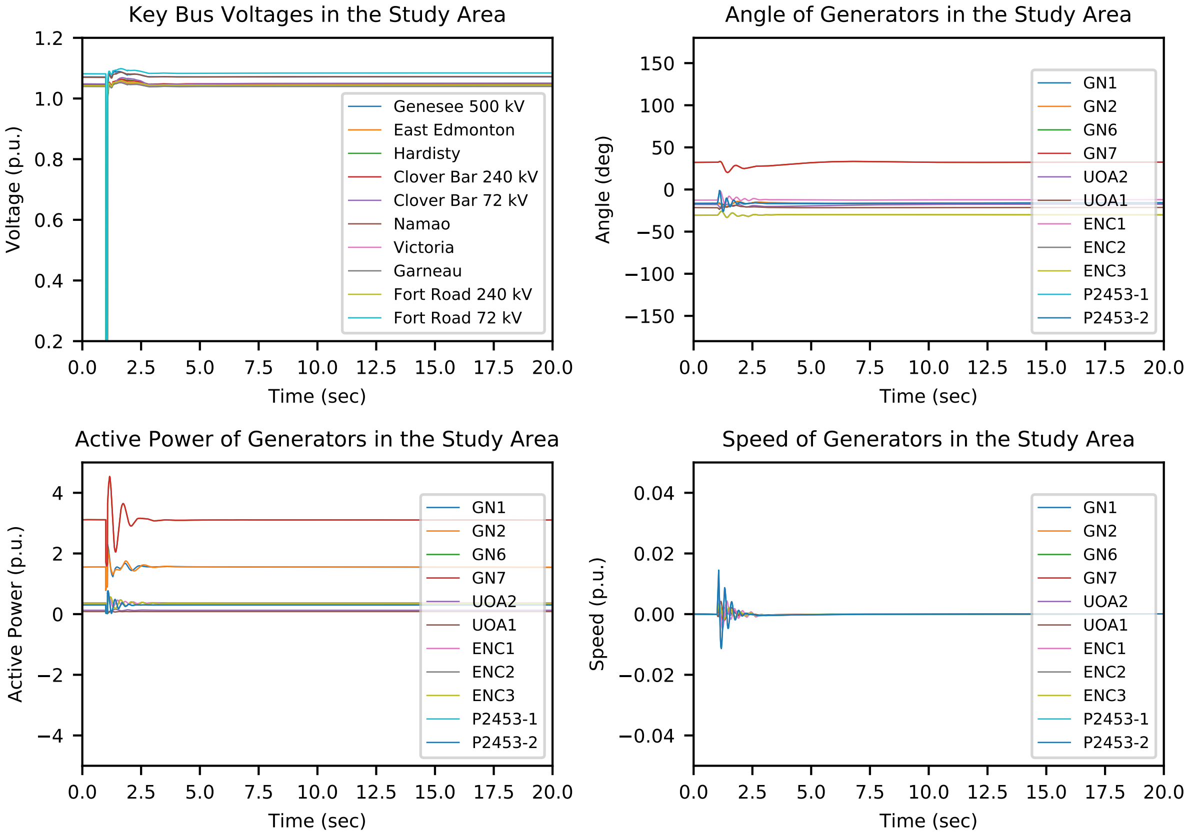
2026 Post-CETR 920L-Lamoureux



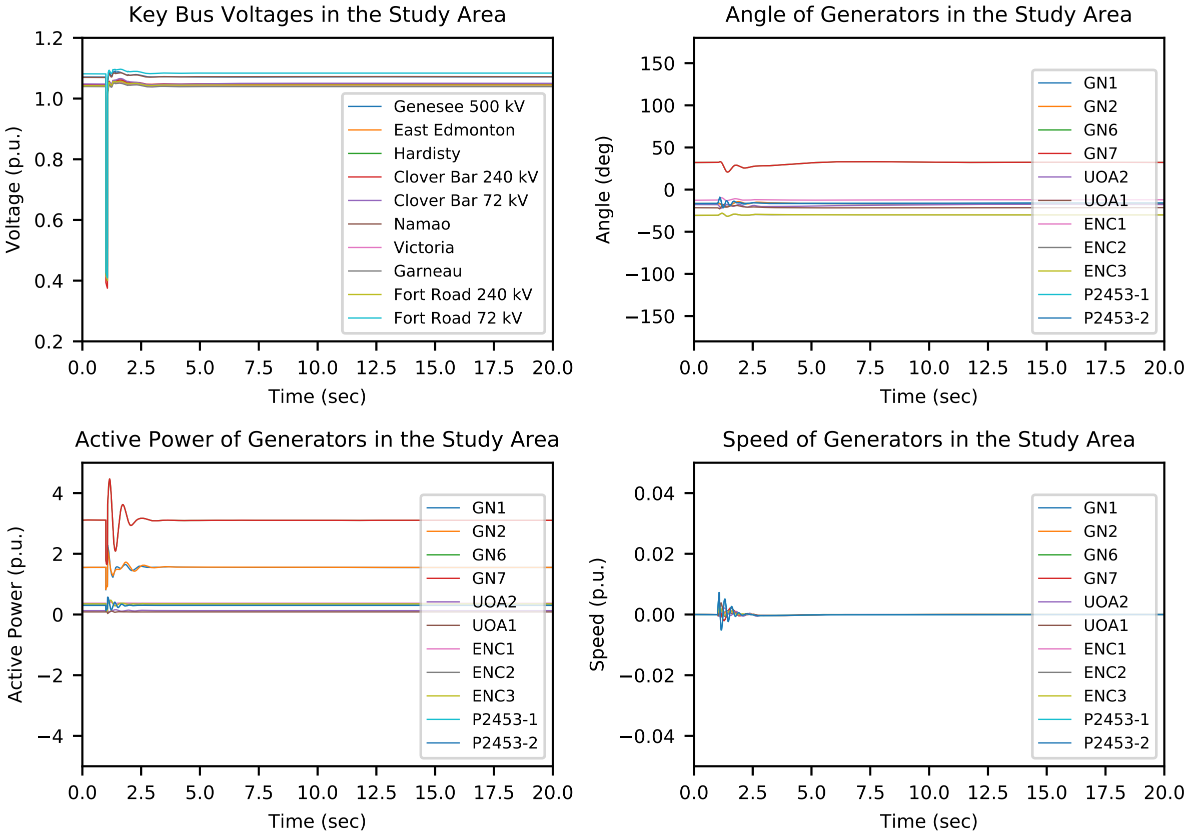
2026 Post-CETR 920L_921L-Lamoureux

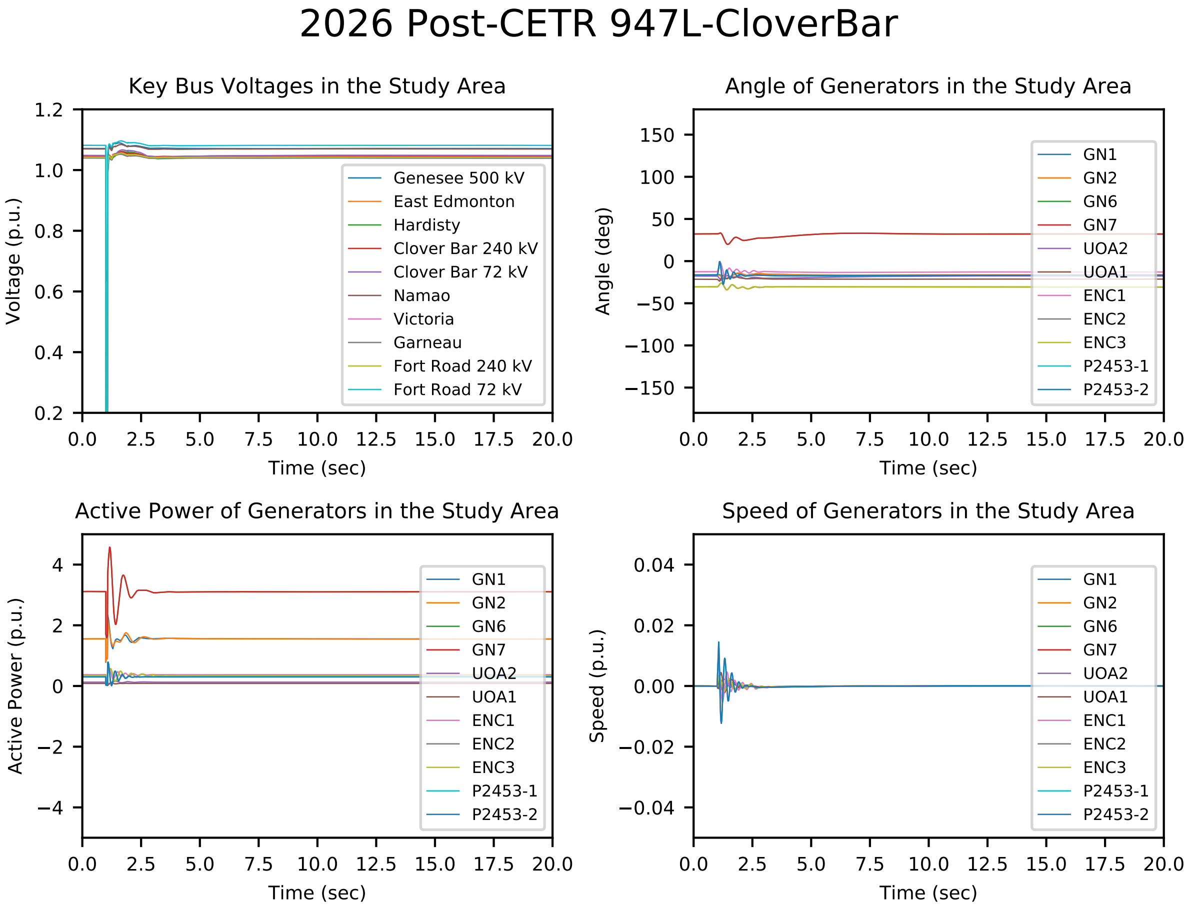


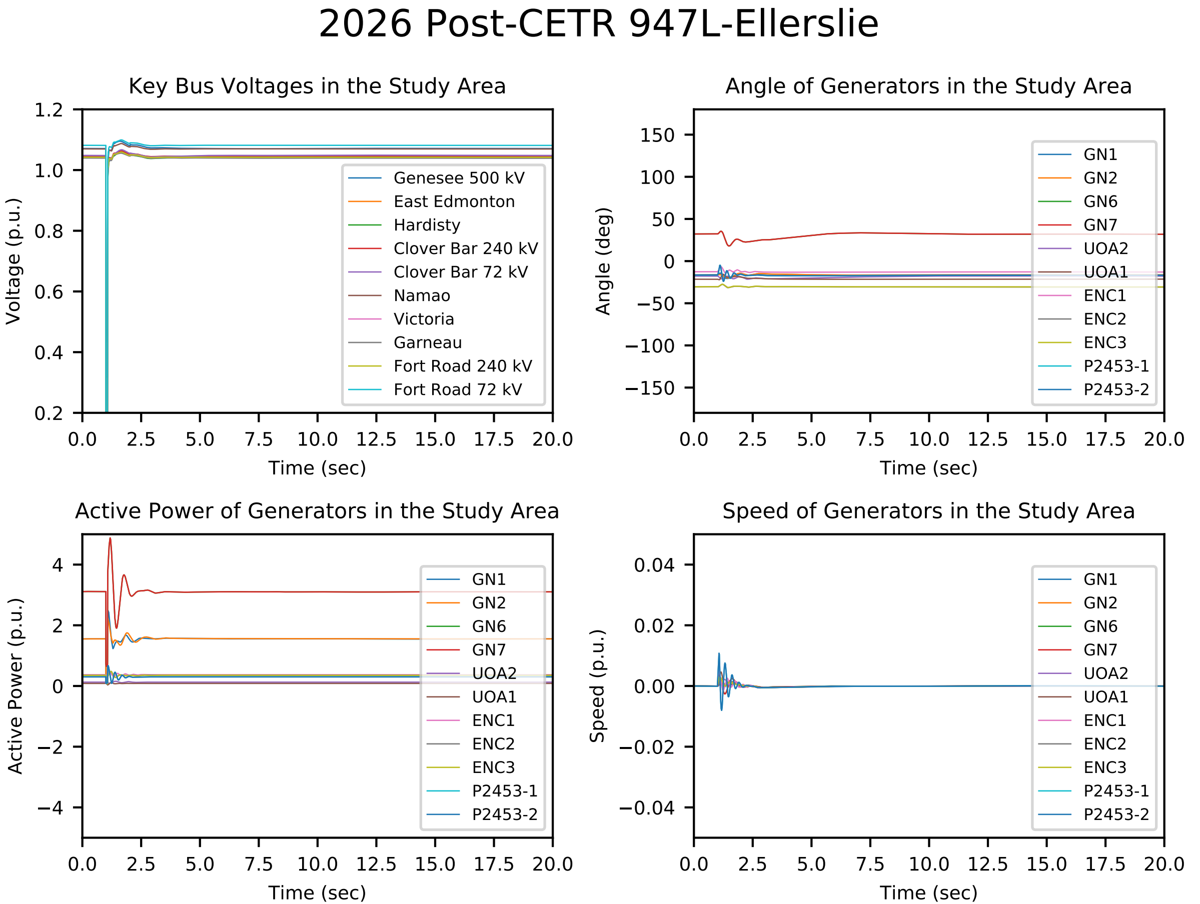
2026 Post-CETR 921L-CloverBar



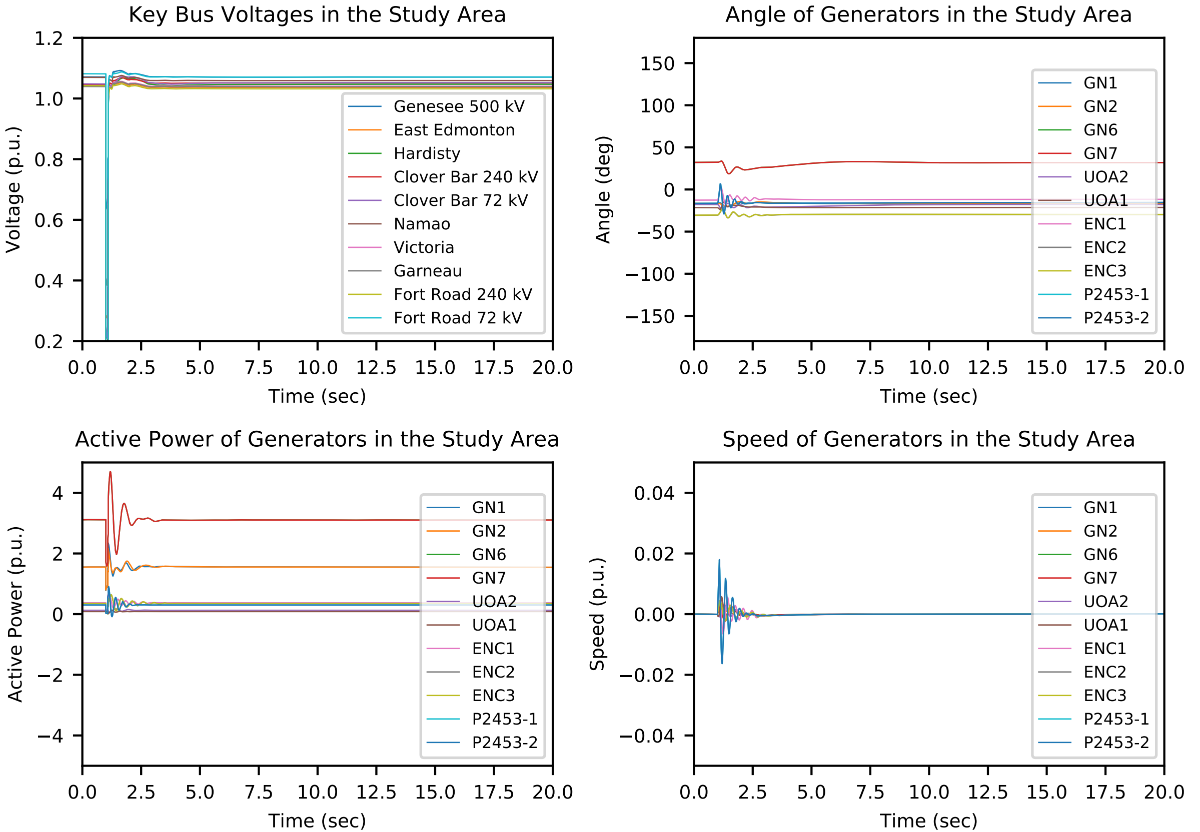
2026 Post-CETR 921L-Lamoureux



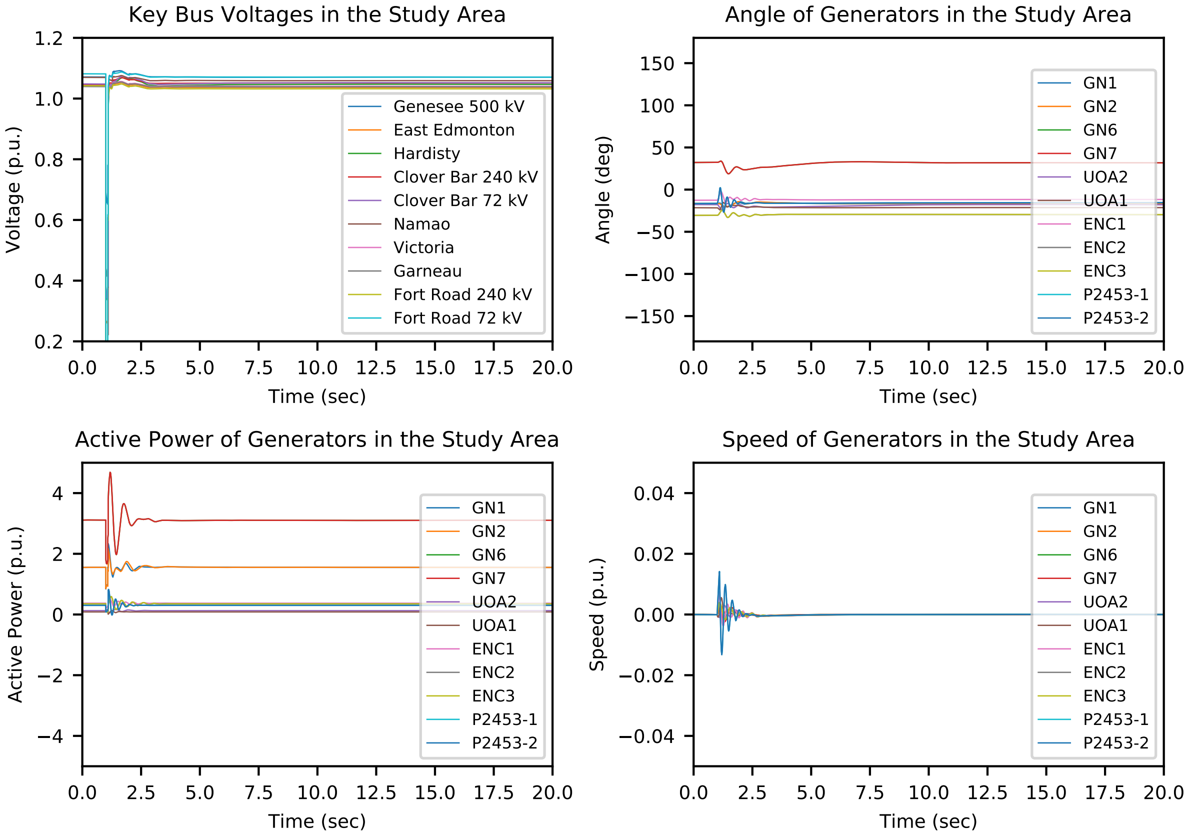

2026 Post-CETR 947L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)


2026 Post-CETR 947L-Ellerslie
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
GN1
GN2
GN6
GN7
UOA2
UOA1
ENC1
ENC2
ENC3
P2453-1
P2453-2

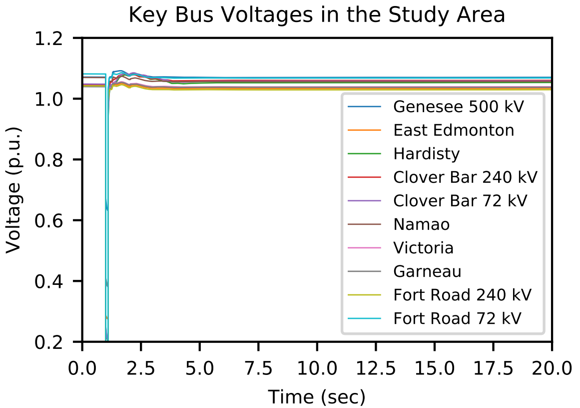
2026 Post-CETR 993L-CloverBar

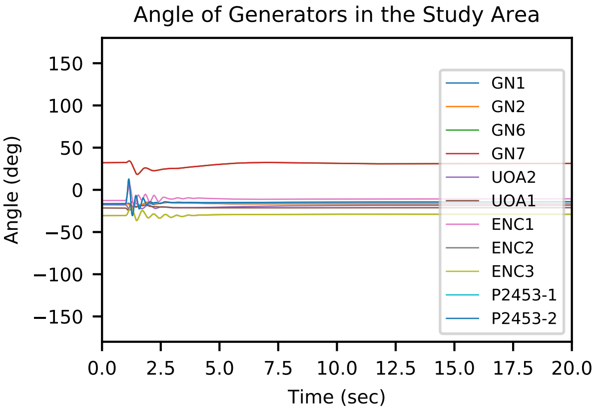


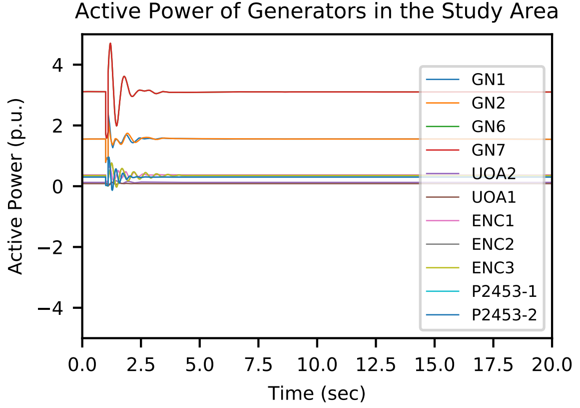
2026 Post-CETR 993L-FortRoad

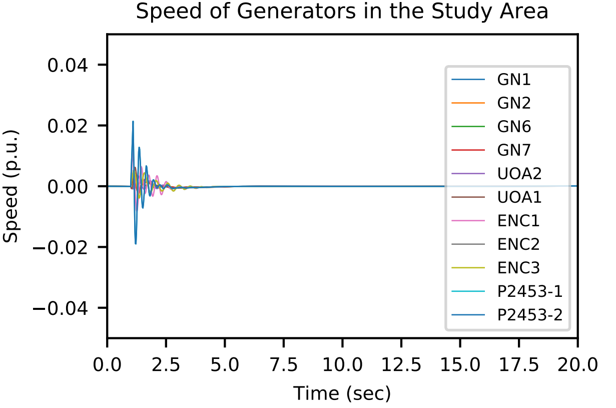


2026 Post-CETR 993L_947L-CloverBar

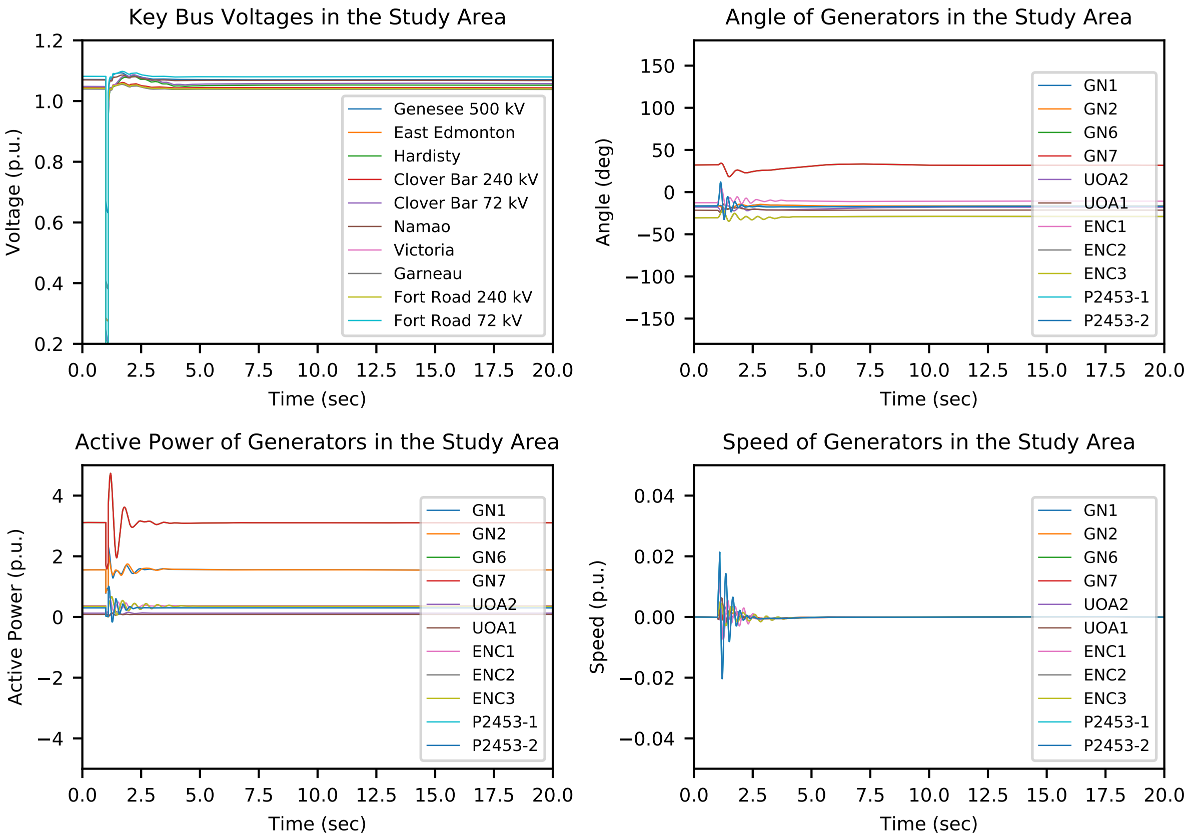




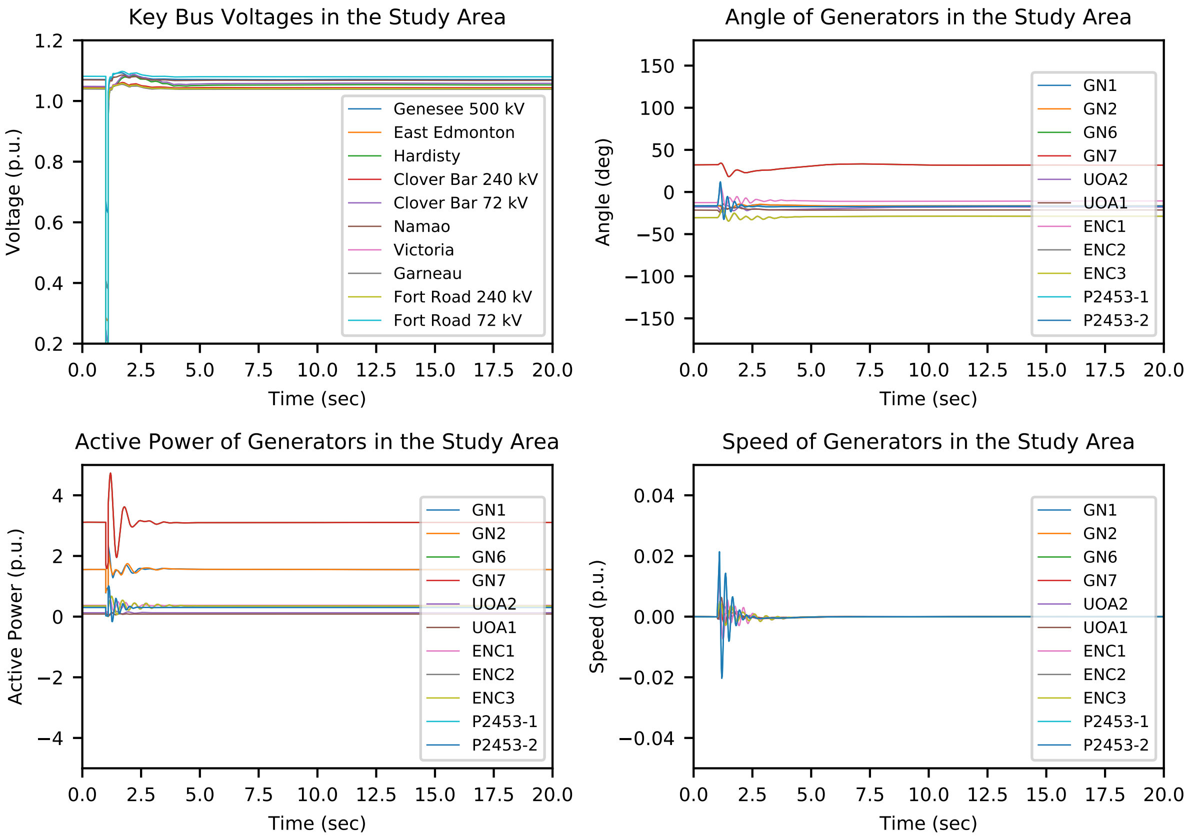




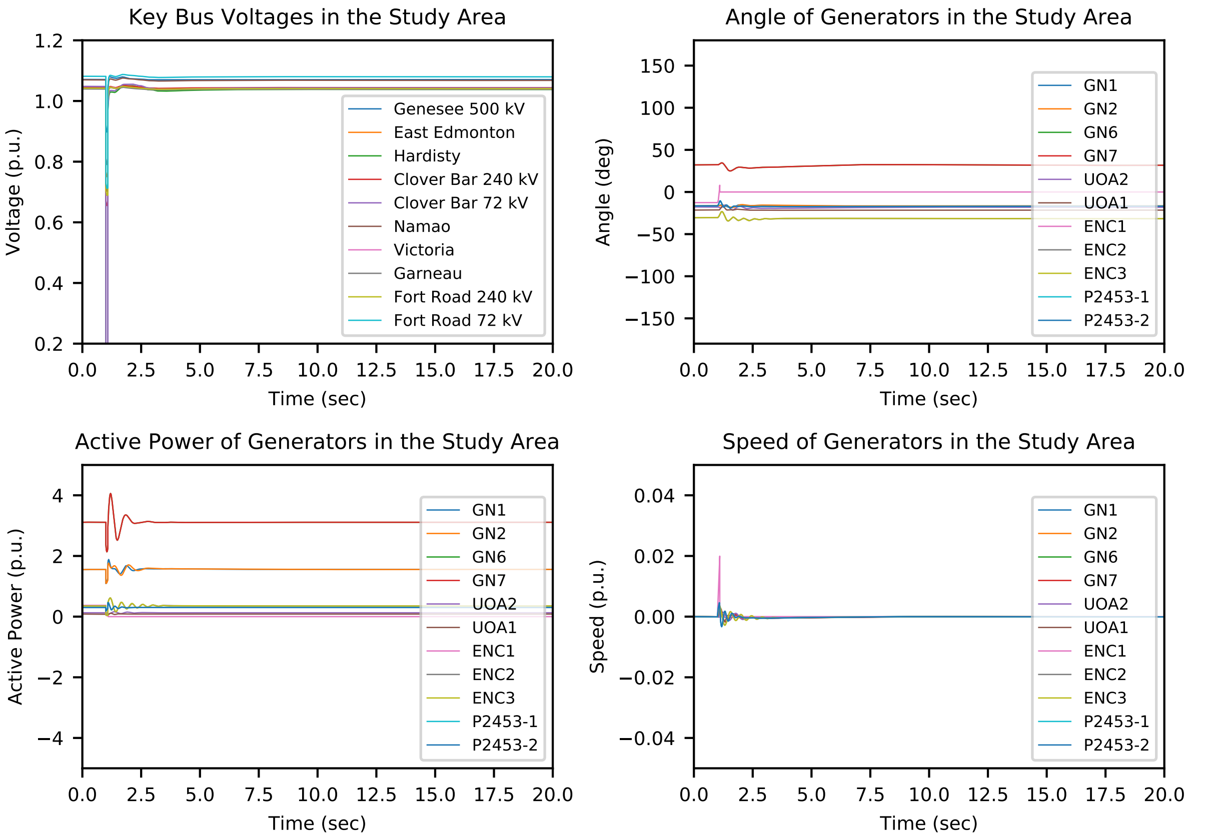
2026 Post-CETR CloverBar_T1



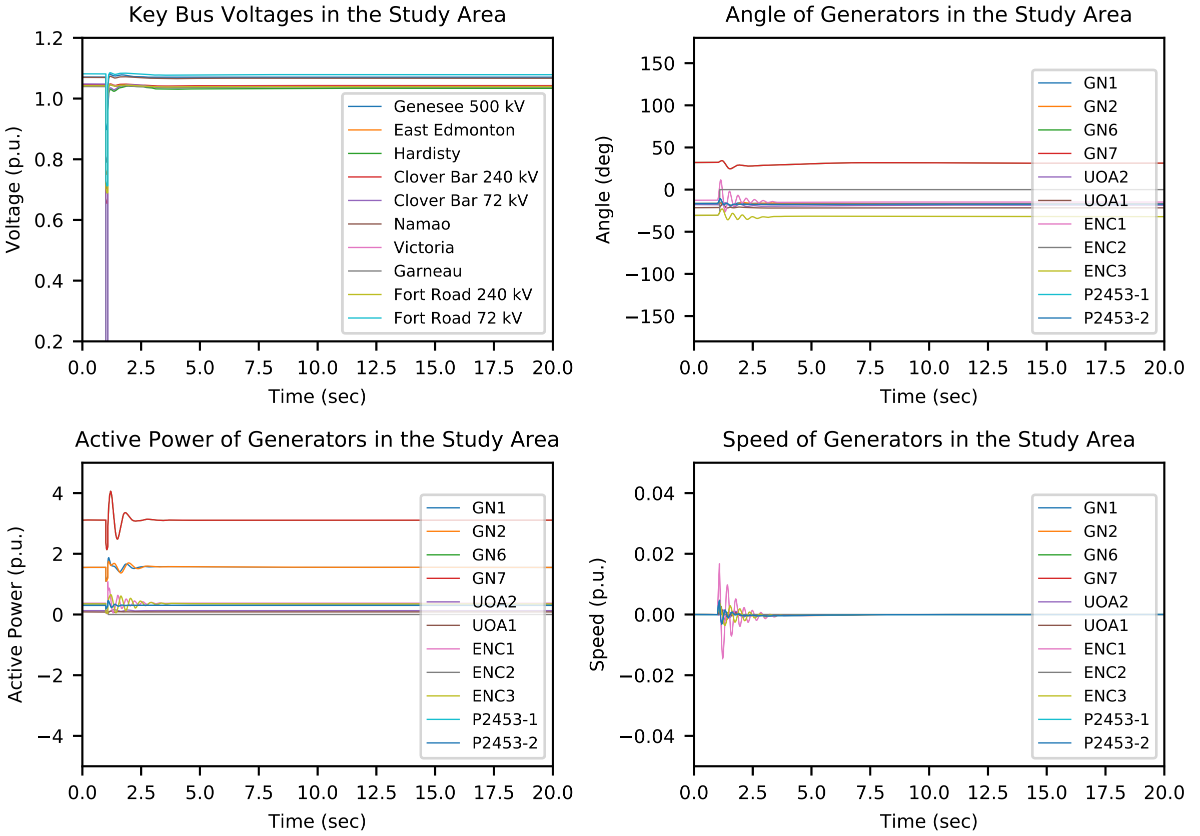
2026 Post-CETR CloverBar_T2



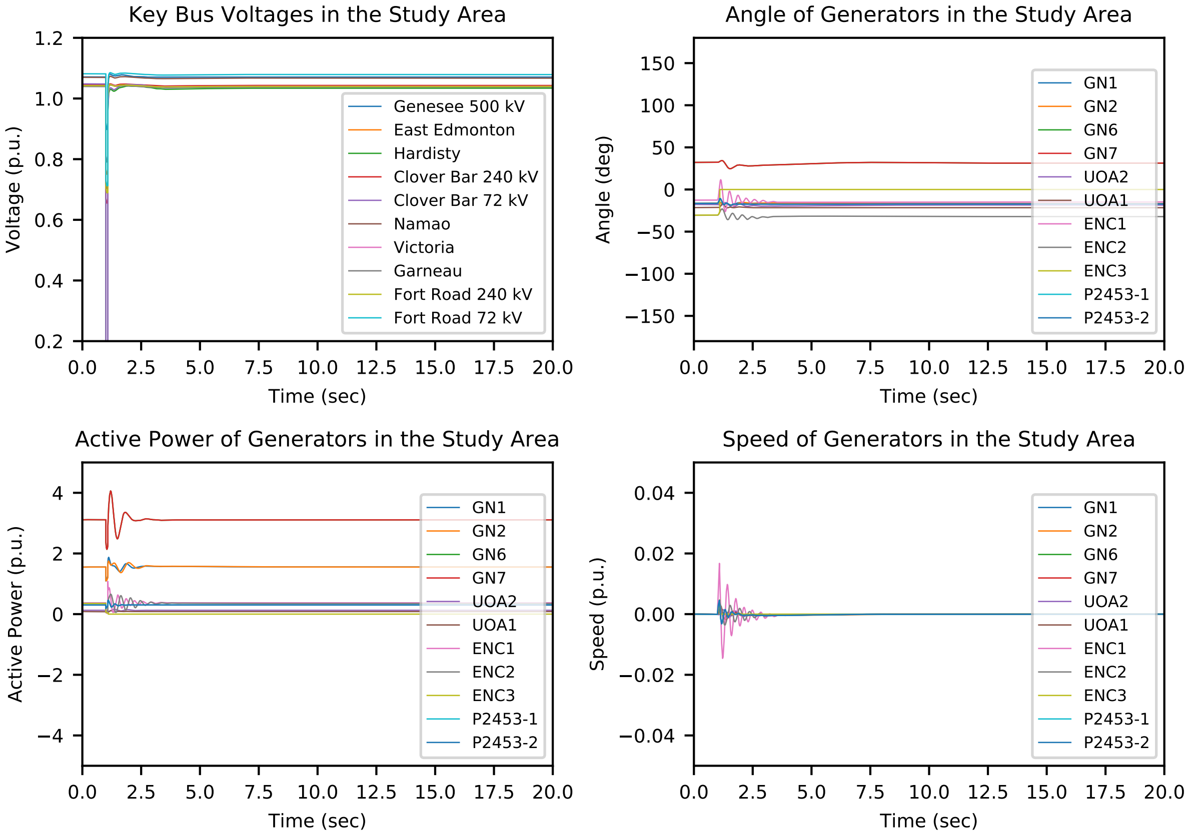
2026 Post-CETR ENC1



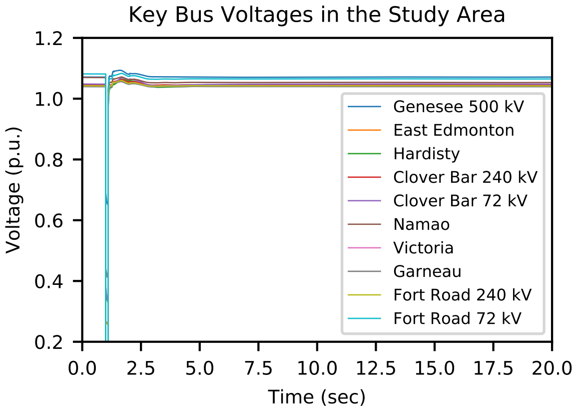
2026 Post-CETR ENC2

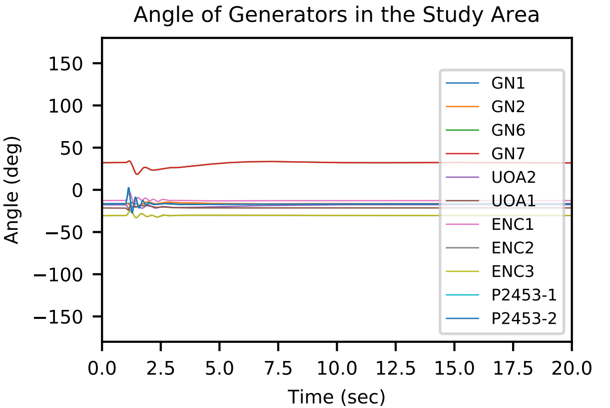


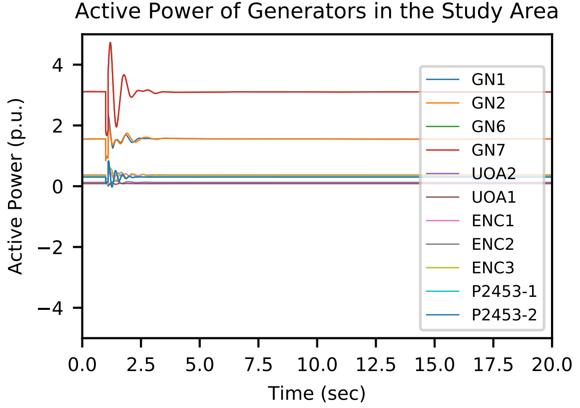
2026 Post-CETR ENC3

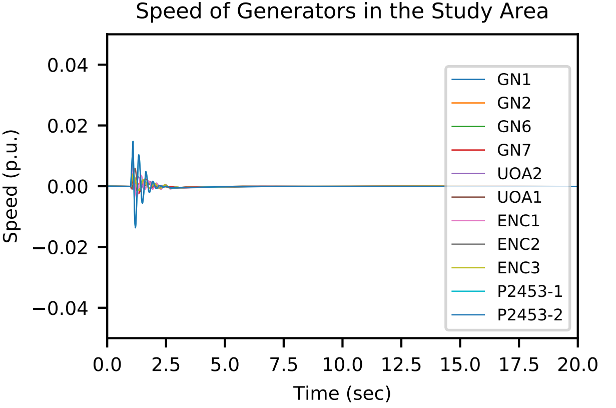


2026 Post-CETR FortRoad_T1

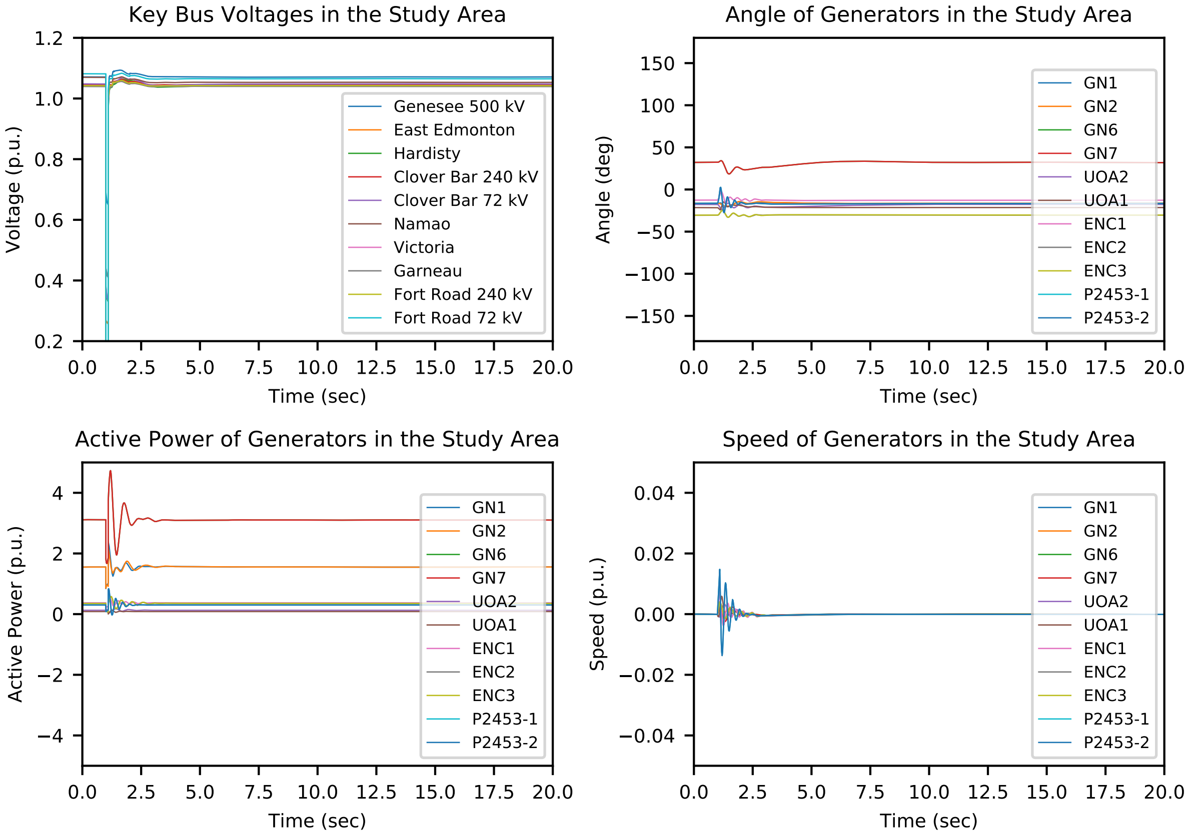








2026 Post-CETR FortRoad_T2

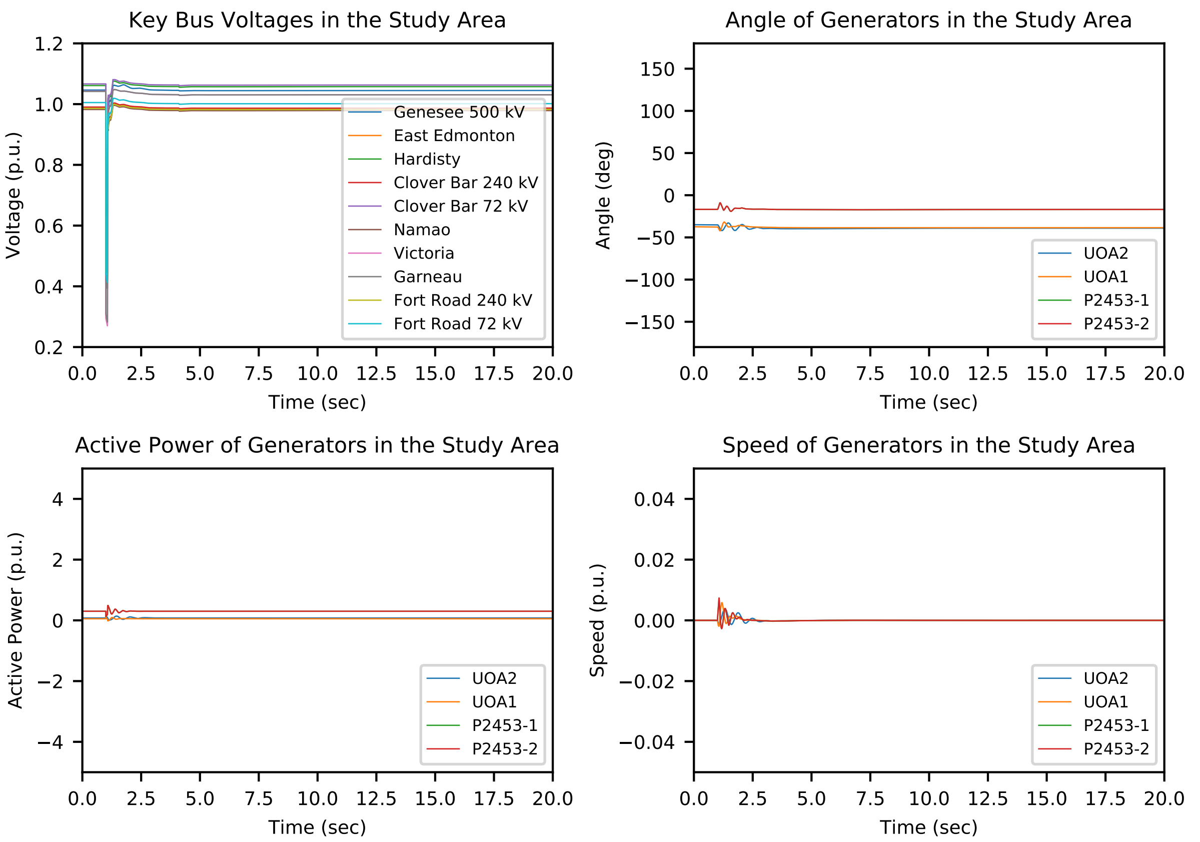


Attachment E

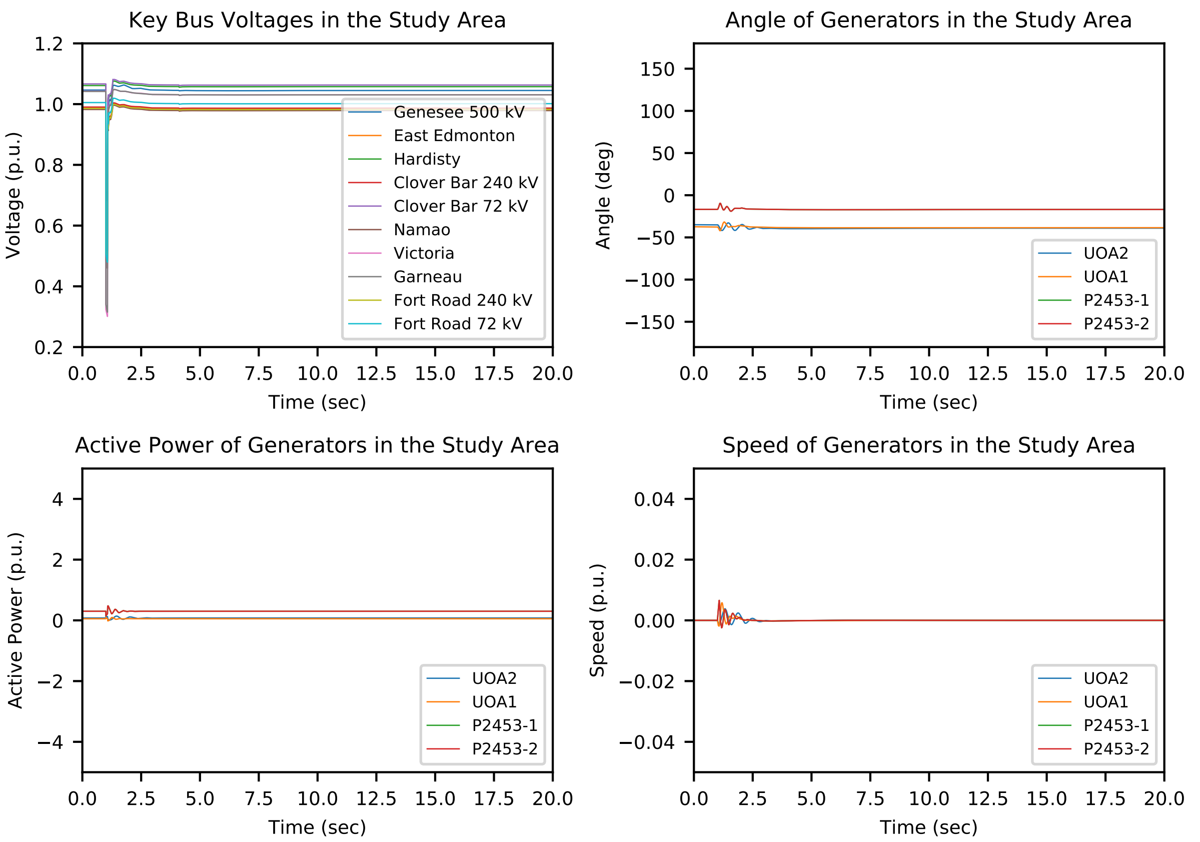
Transient Simulation Results

Section: E-3

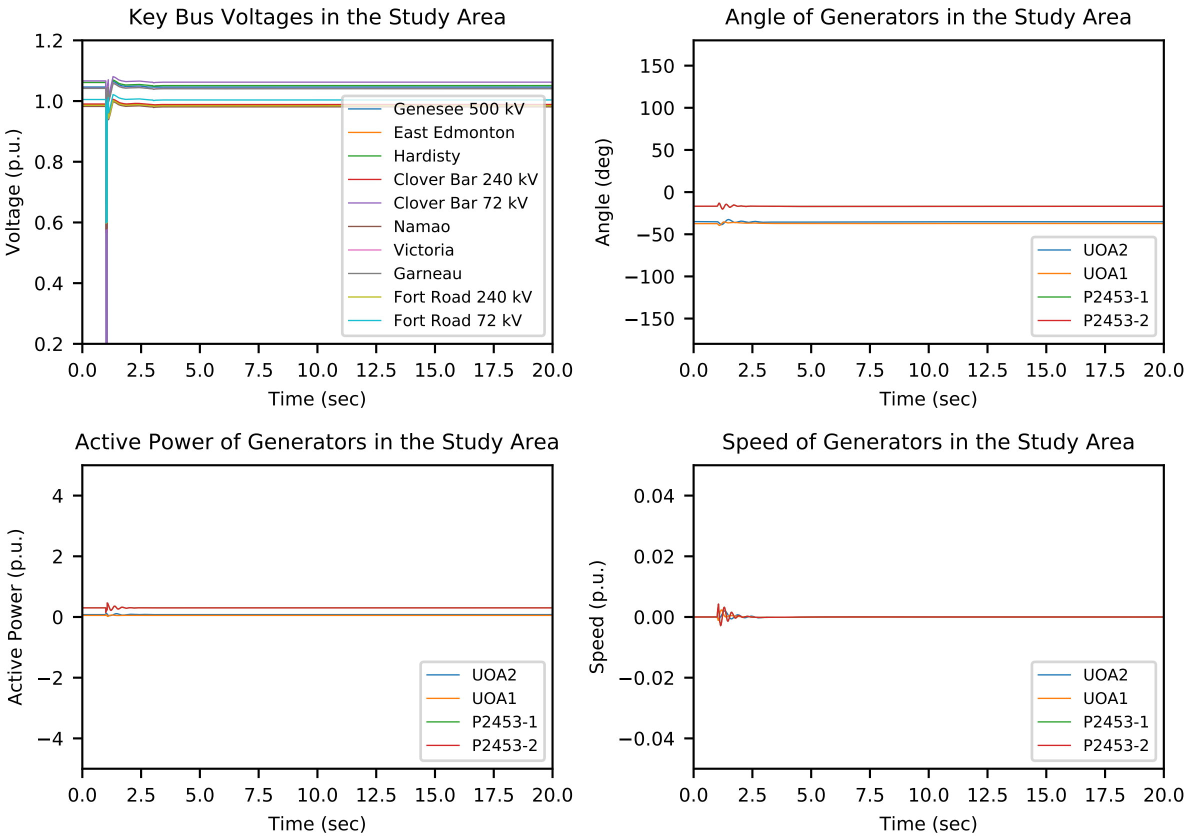
2043 Post-CETR 240CV5-CastleDowns

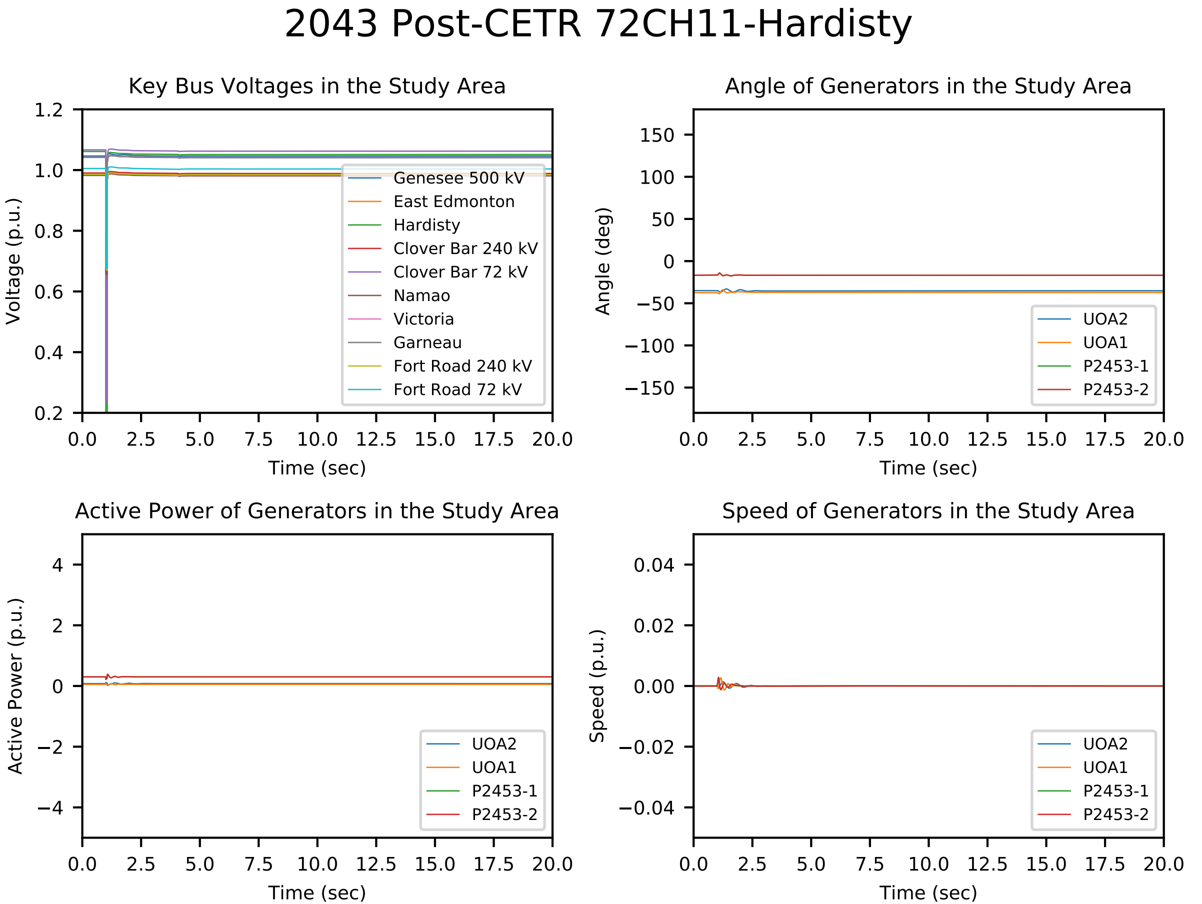


2043 Post-CETR 240CV5-Victoria

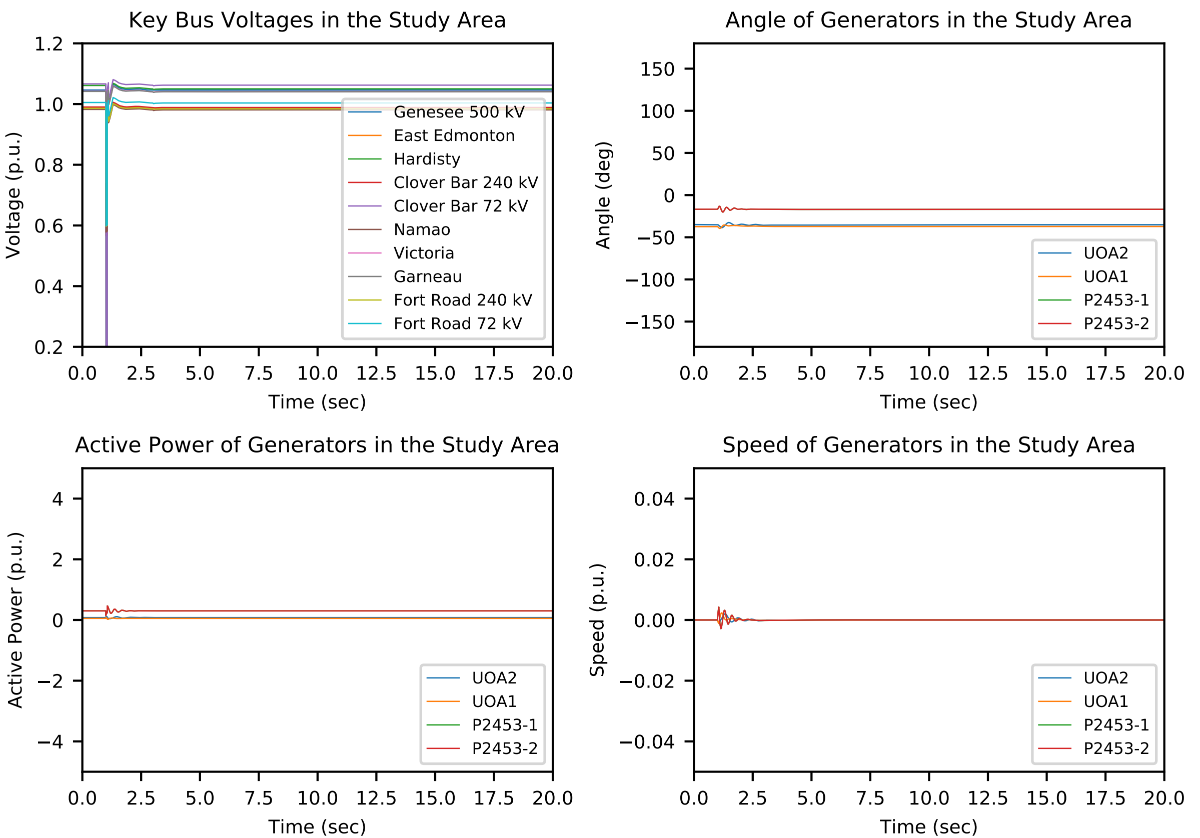


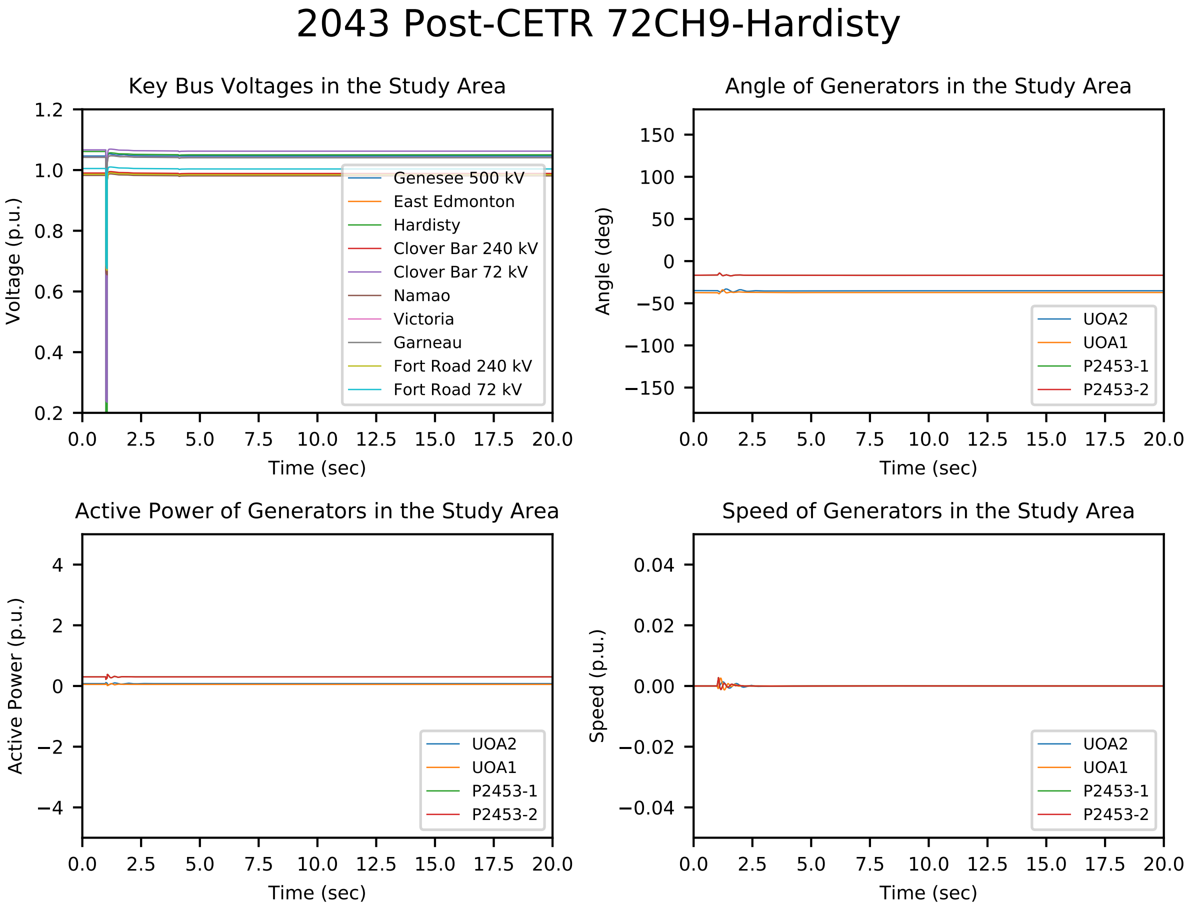
2043 Post-CETR 72CH11-CloverBar



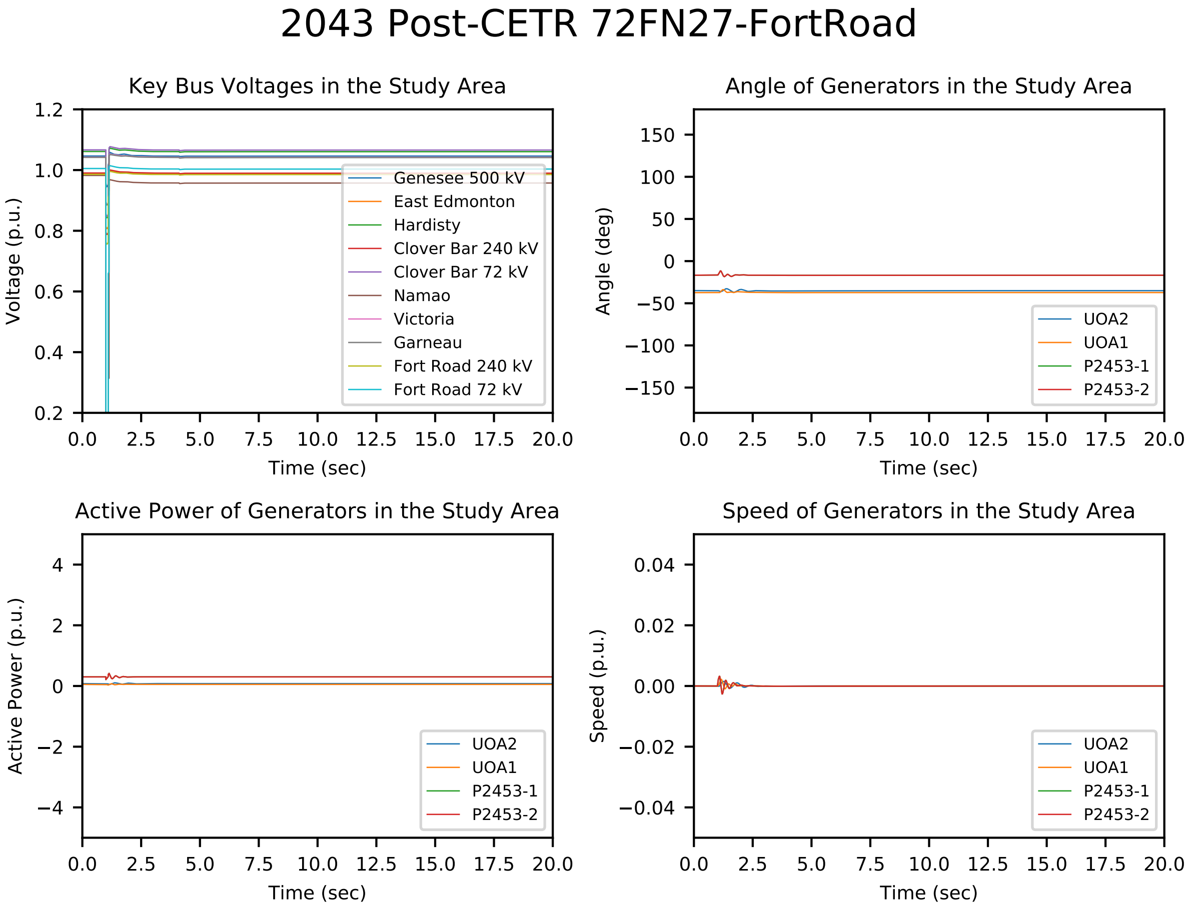

2043 Post-CETR 72CH11-Hardisty
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2

2043 Post-CETR 72CH9-CloverBar

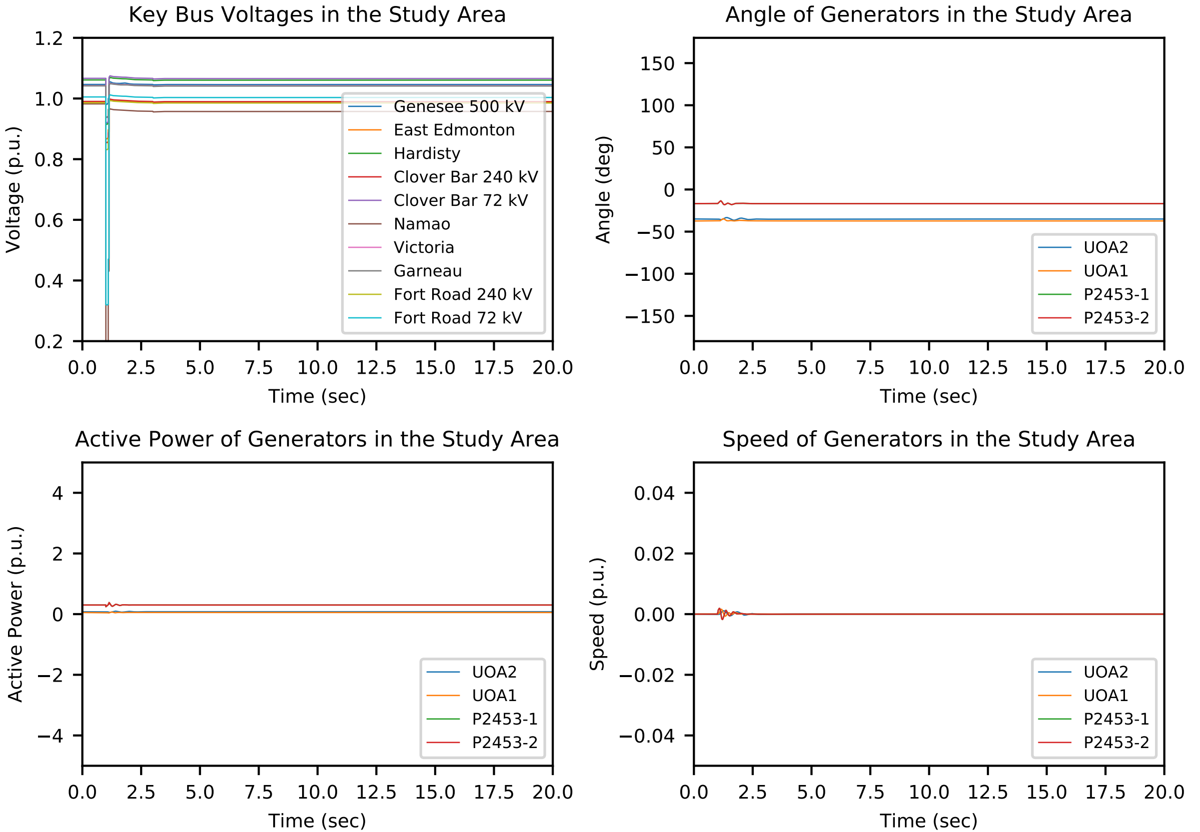


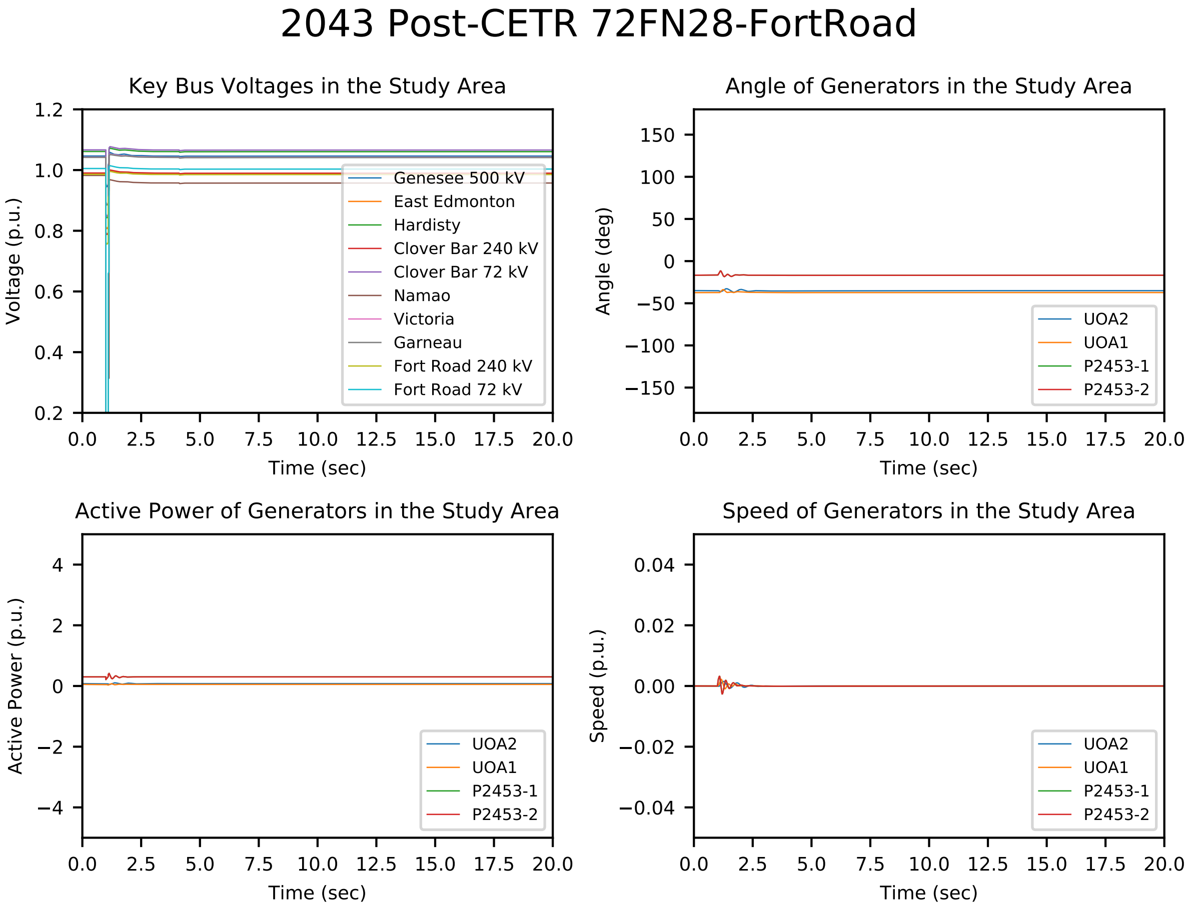


2043 Post-CETR 72CH9-Hardisty
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2

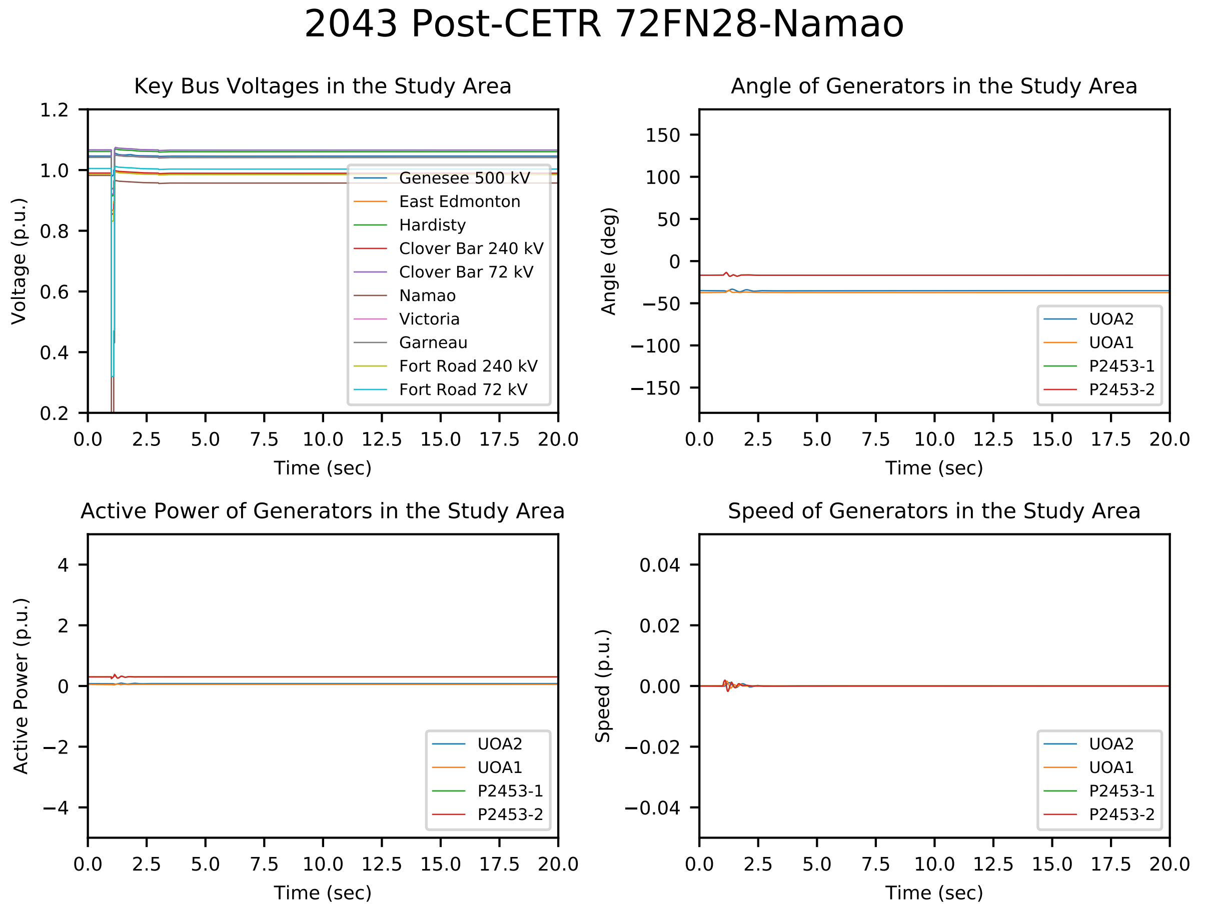

2043 Post-CETR 72FN27-FortRoad
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)

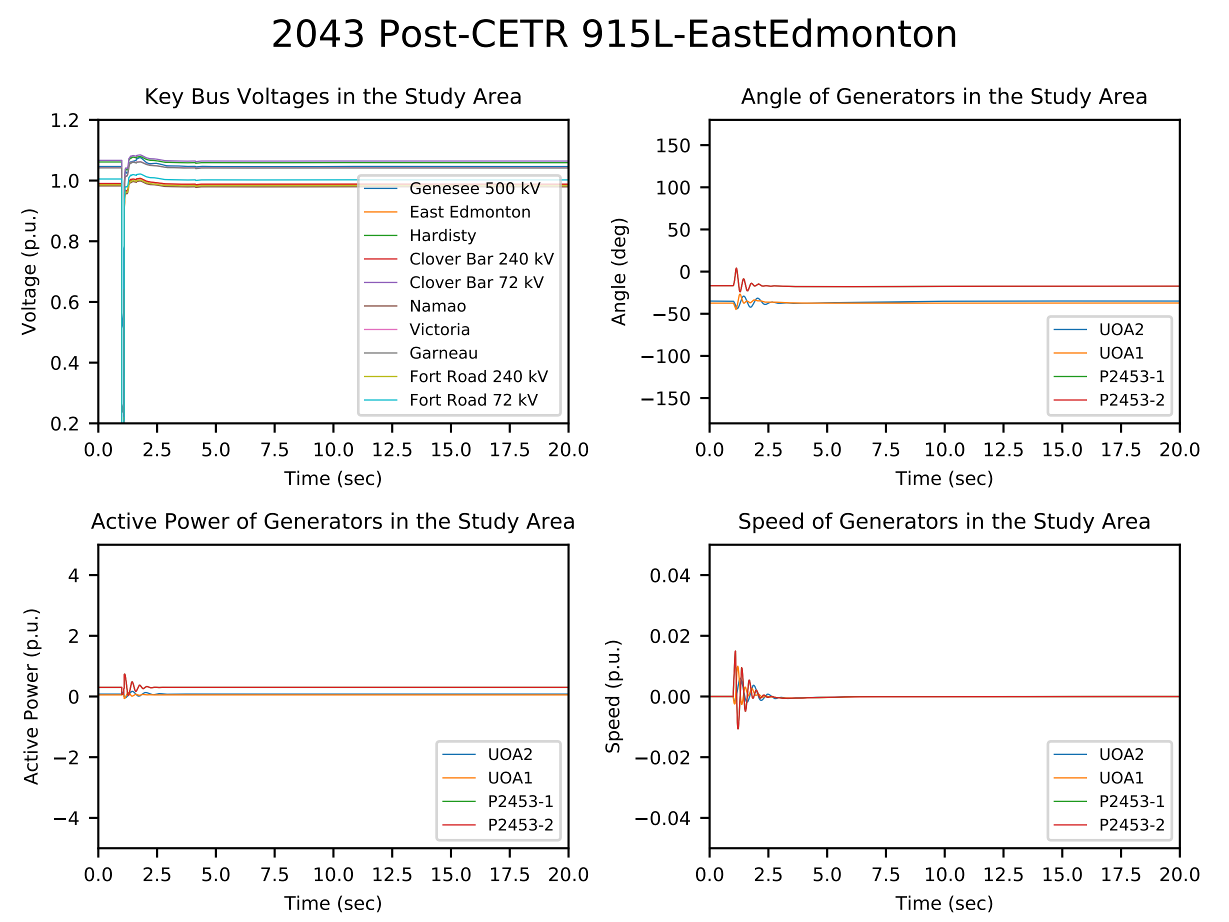
2043 Post-CETR 72FN27-Namao

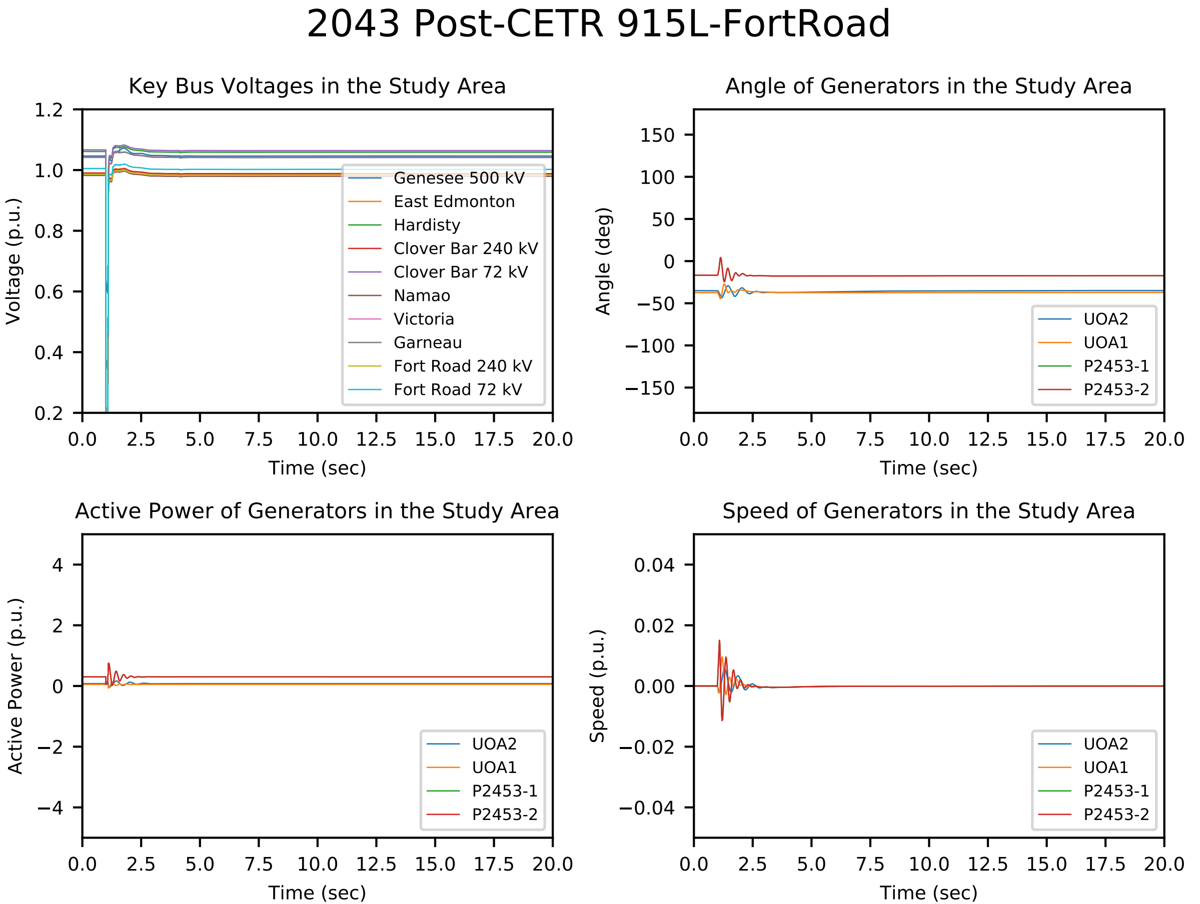




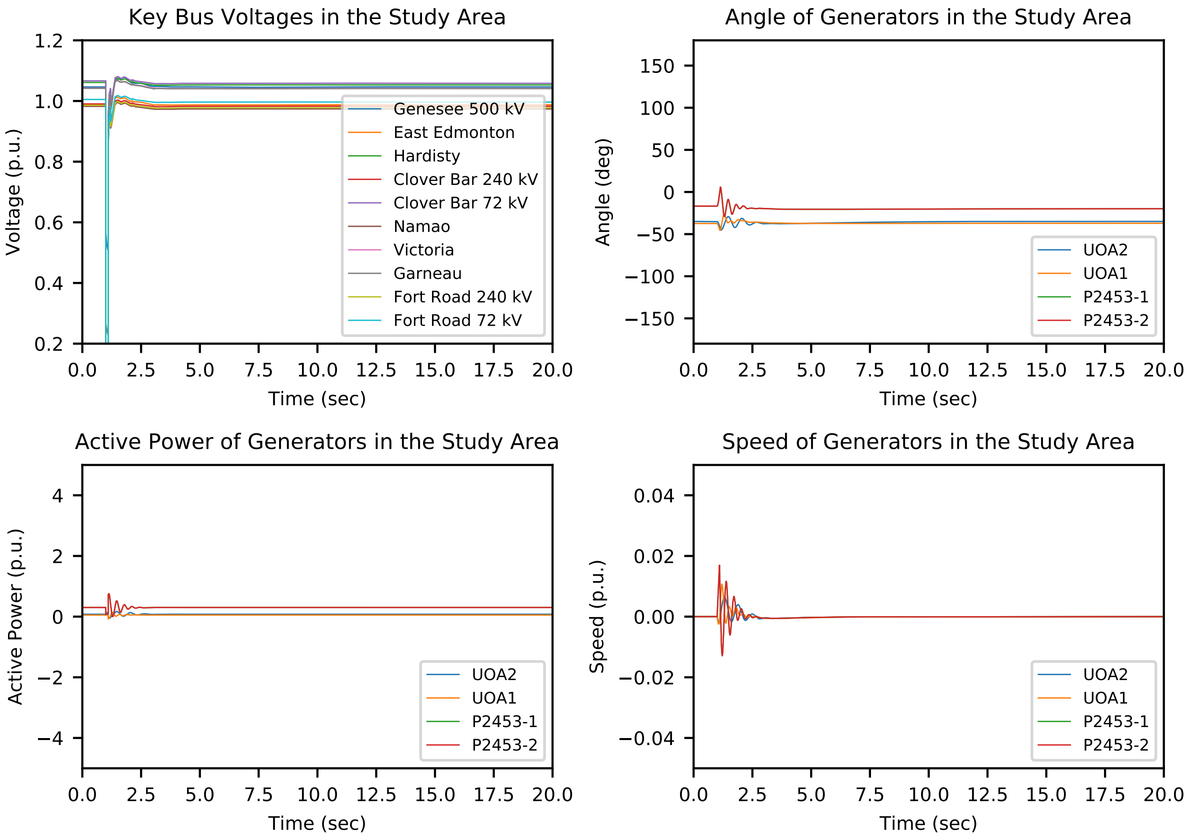
2043 Post-CETR 72FN28-FortRoad
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2


2043 Post-CETR 72FN28-Namao
Key Bus Voltages in the Study Area
Voltage (p.u.)
1.2
1.0
0.8
0.6
0.4
0.2
Time (sec)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
150
100
50
0
−50
−100
−150
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
4
2
0
−2
−4
Speed of Generators in the Study Area
Speed (p.u.)
0.04
0.02
0.00
−0.02
−0.04

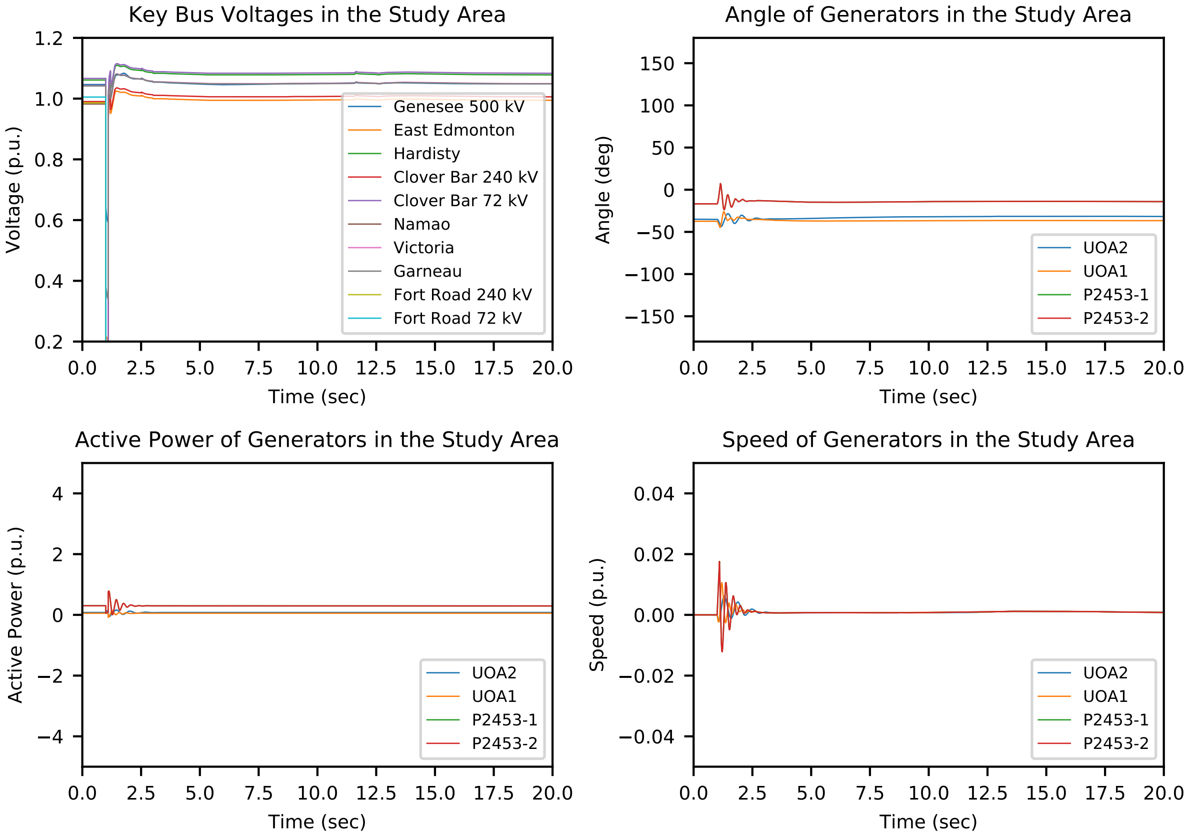

2043 Post-CETR 915L-EastEdmonton
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)


2043 Post-CETR 915L-FortRoad
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)

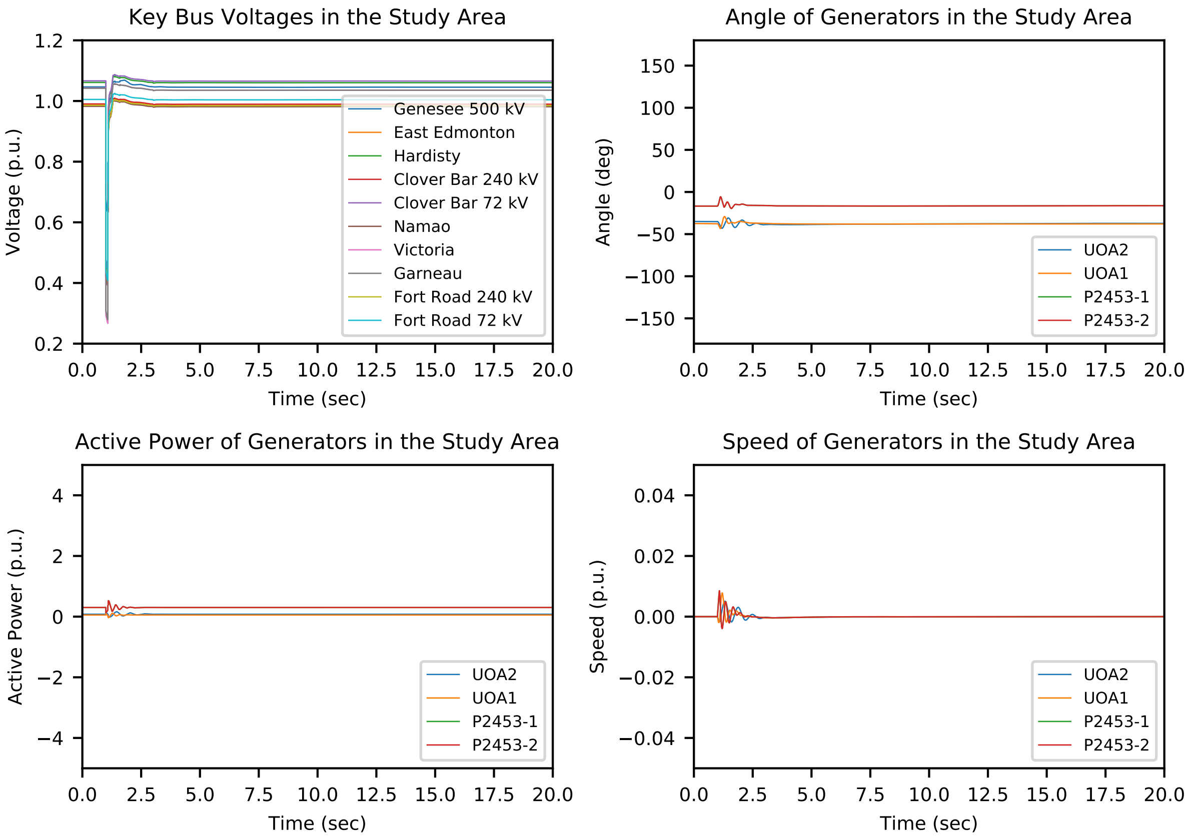
2043 Post-CETR 915L_947L-EastEdmonton

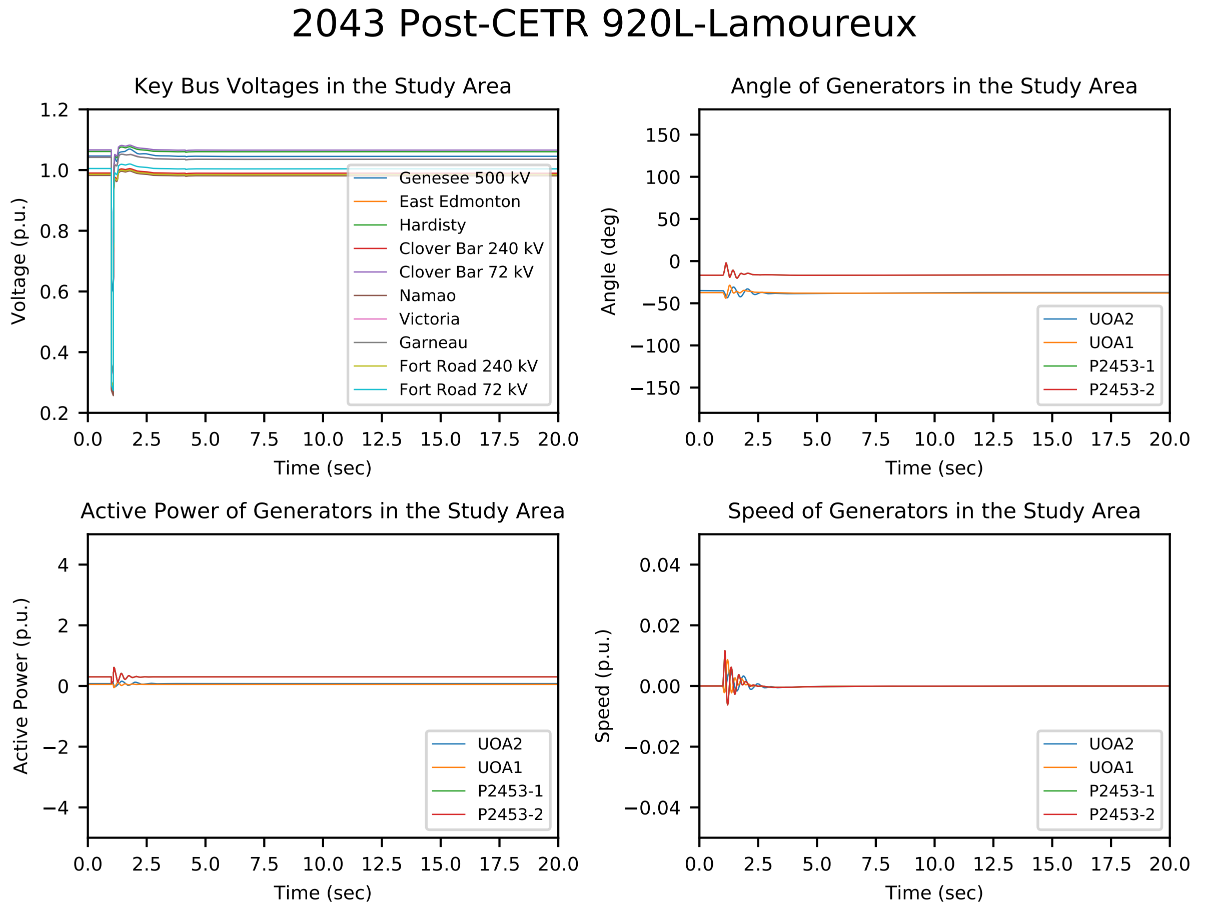


2043 Post-CETR 915L_993L-FortRoad

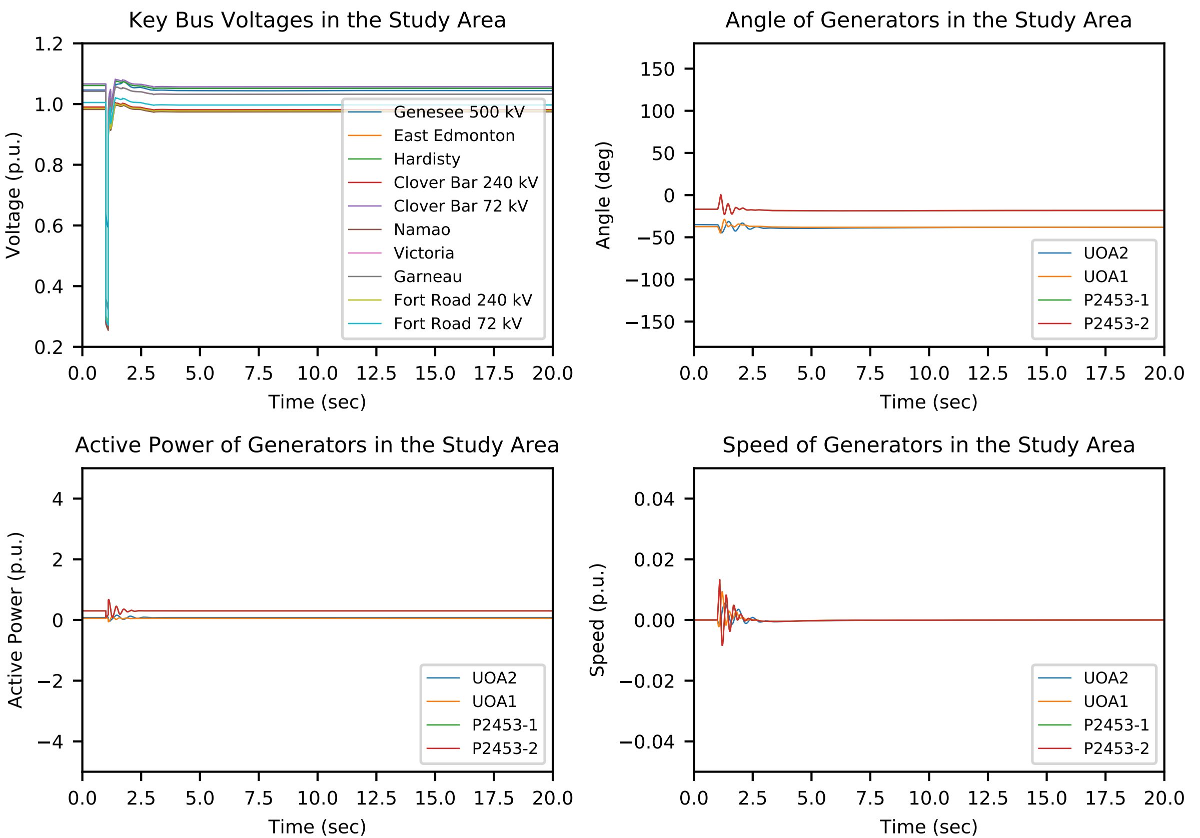


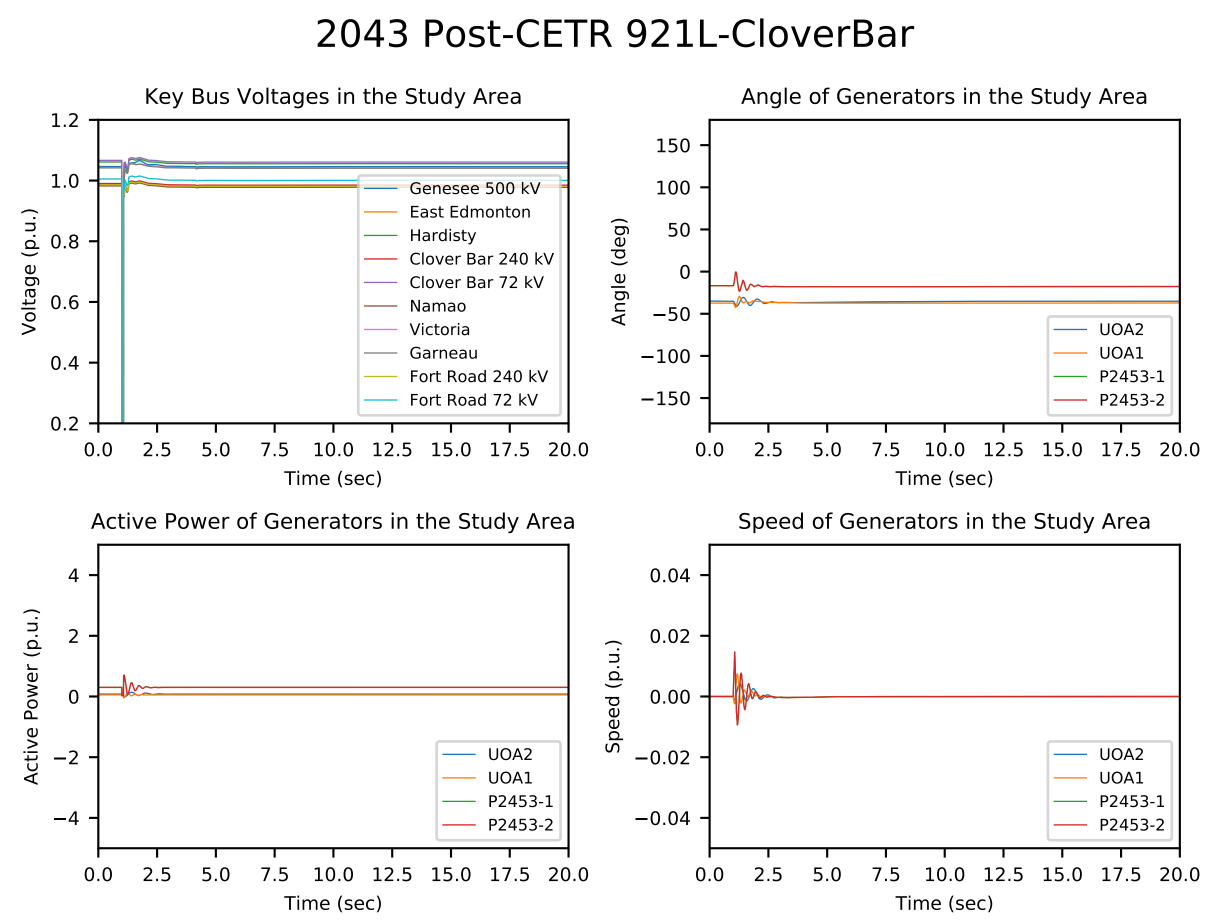
2043 Post-CETR 920L-CastleDowns

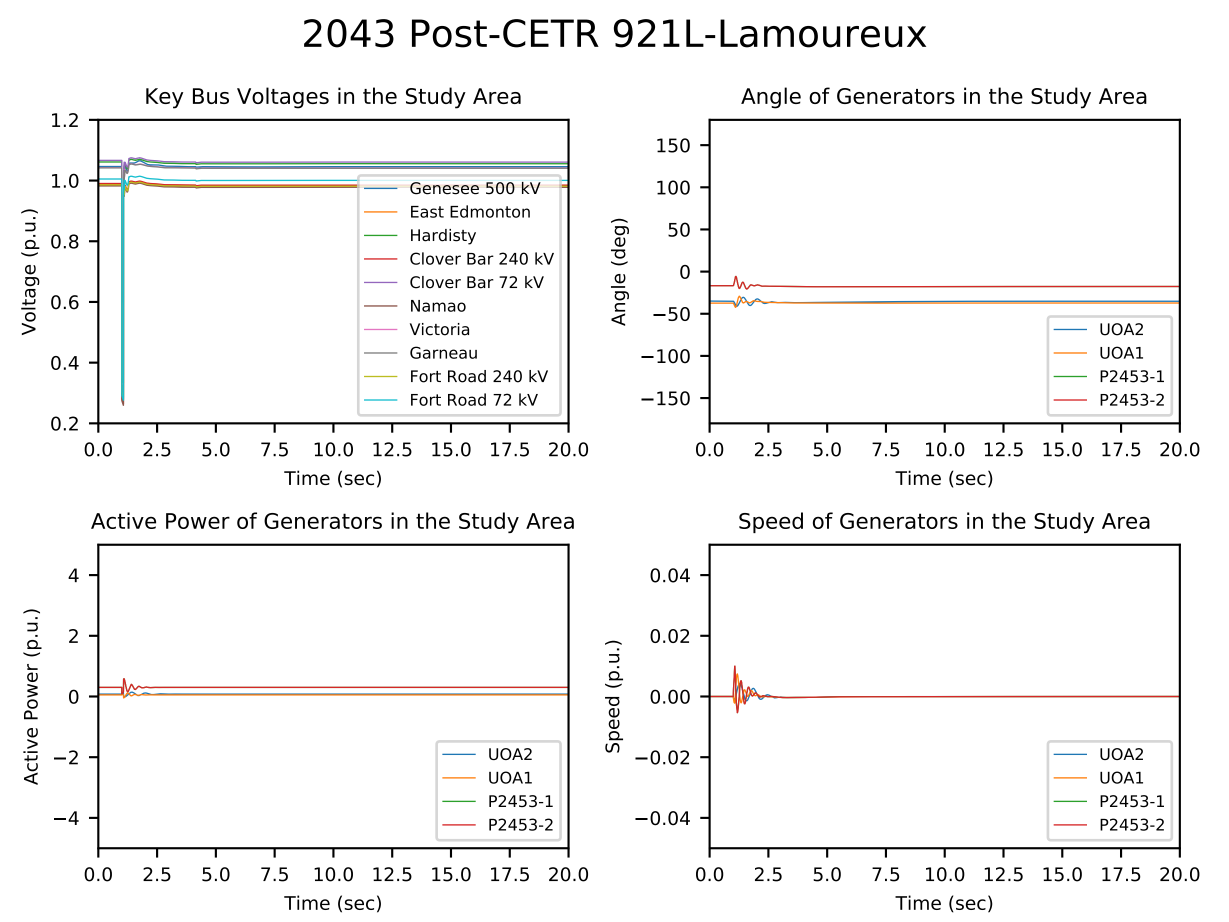



2043 Post-CETR 920L-Lamoureux
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)

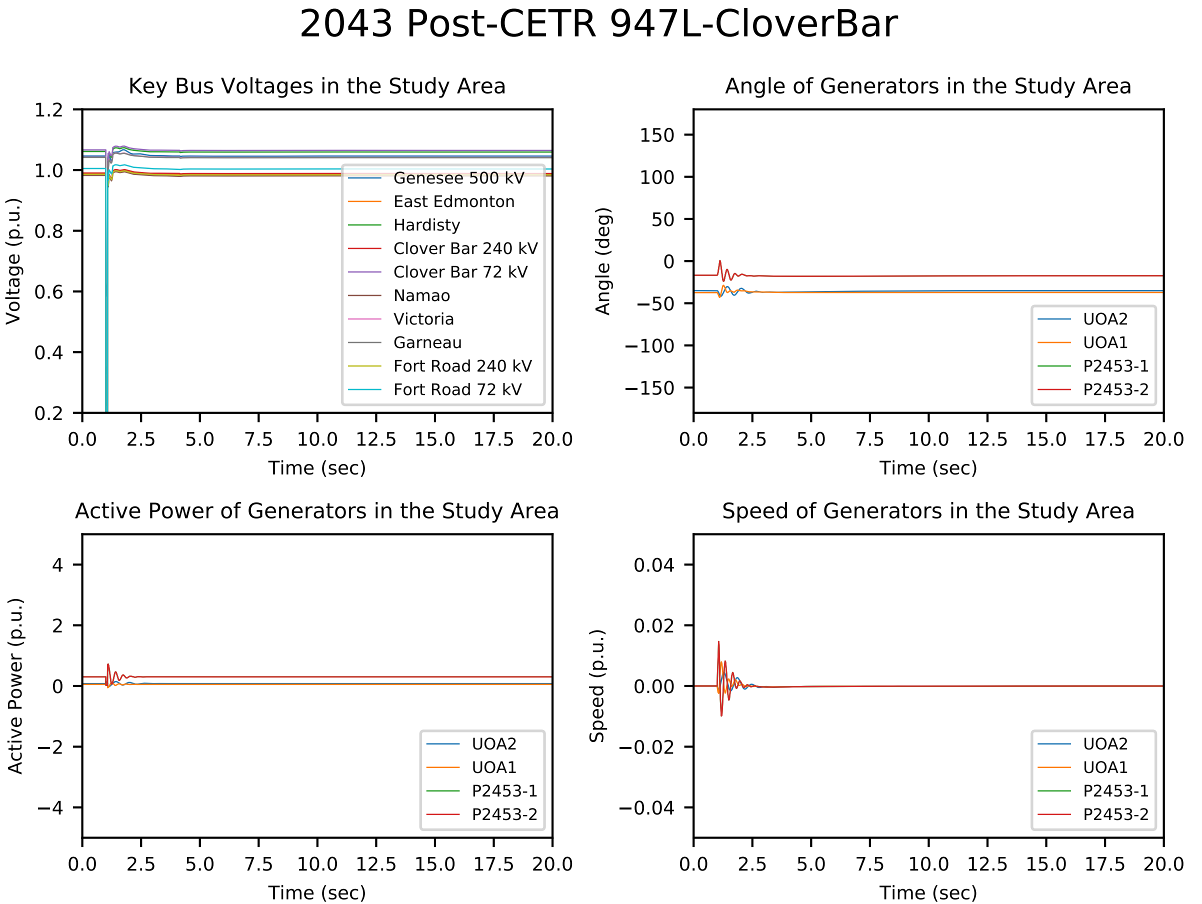
2043 Post-CETR 920L_921L-Lamoureux



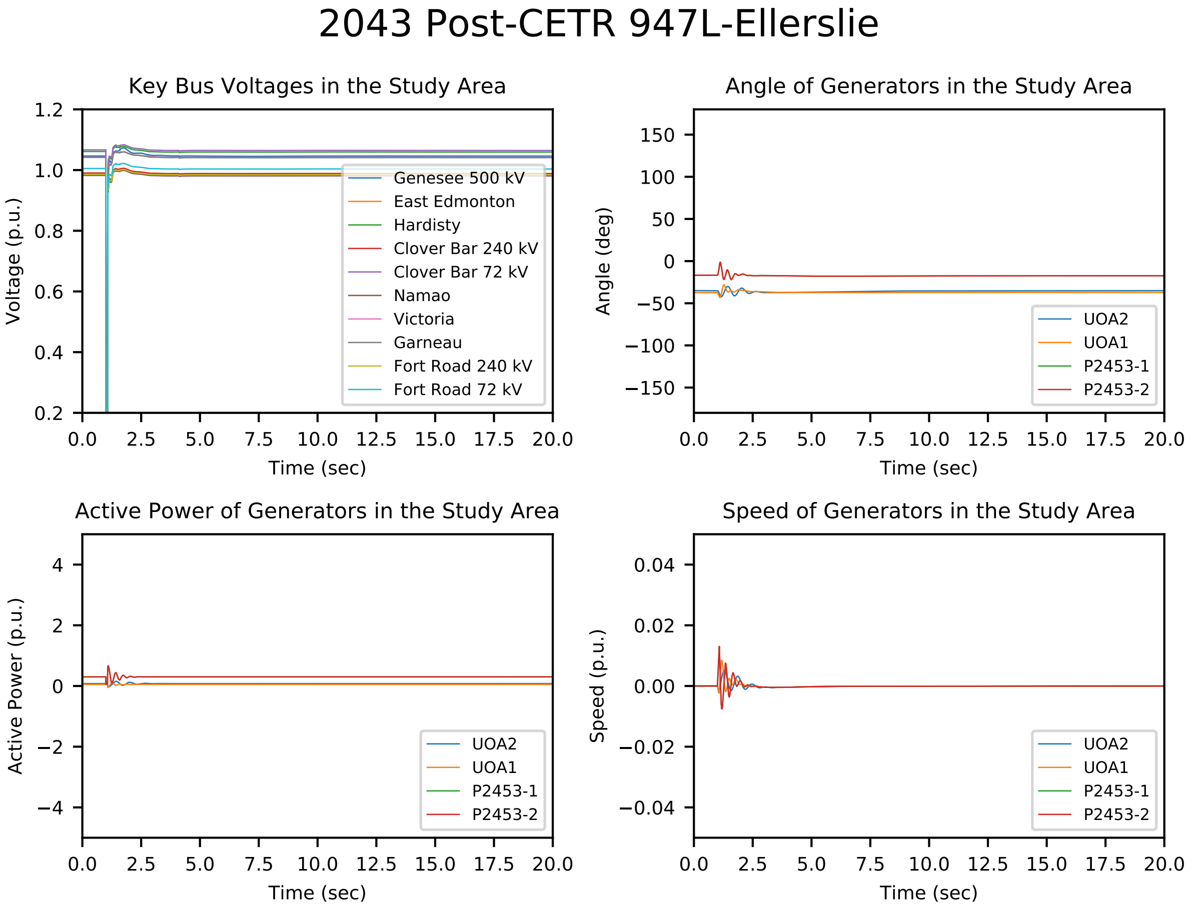

2043 Post-CETR 921L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2



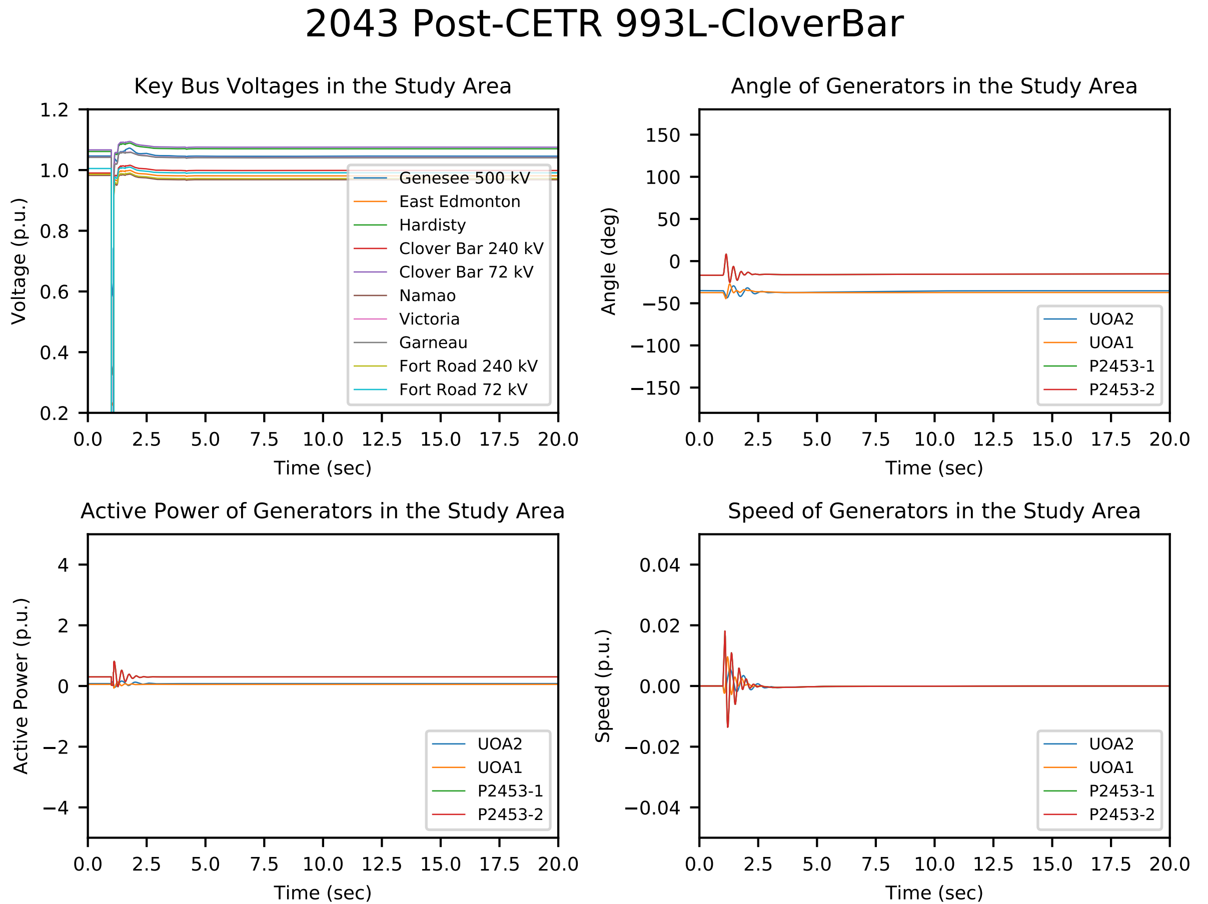
2043 Post-CETR 921L-Lamoureux
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2



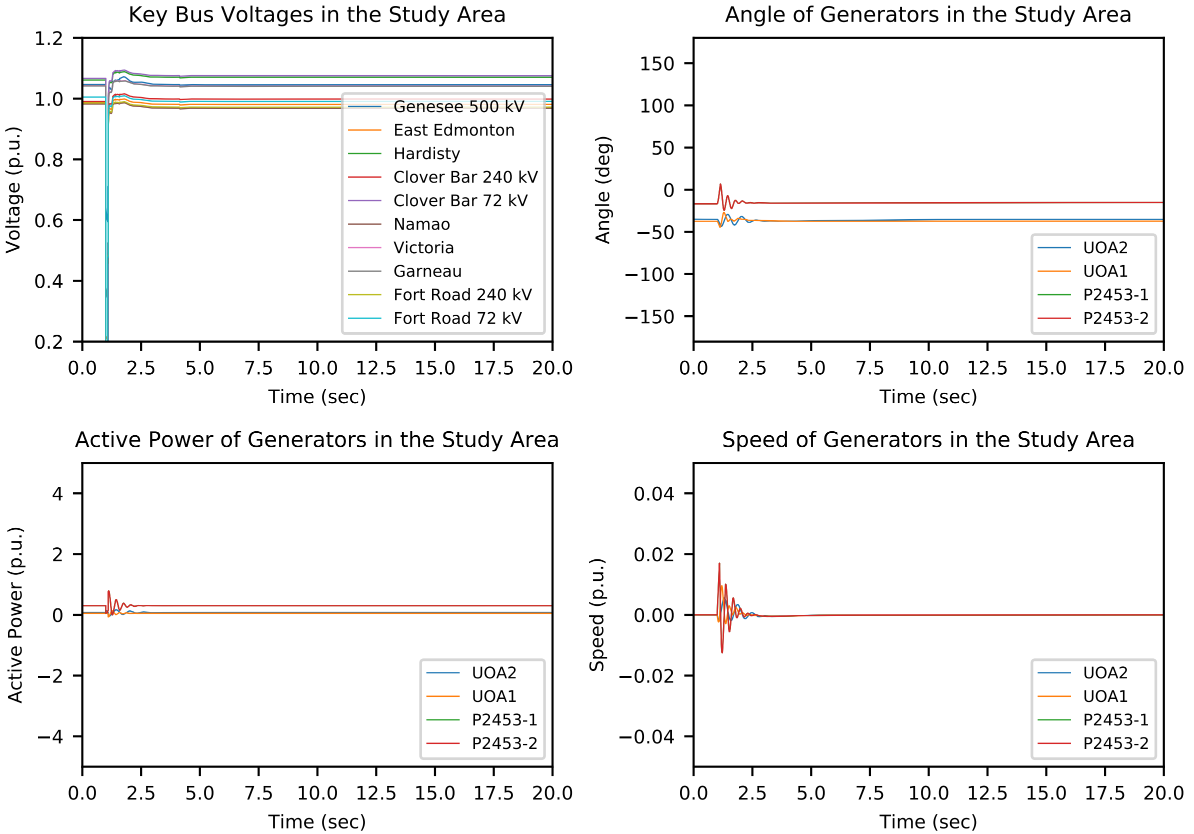
2043 Post-CETR 947L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2

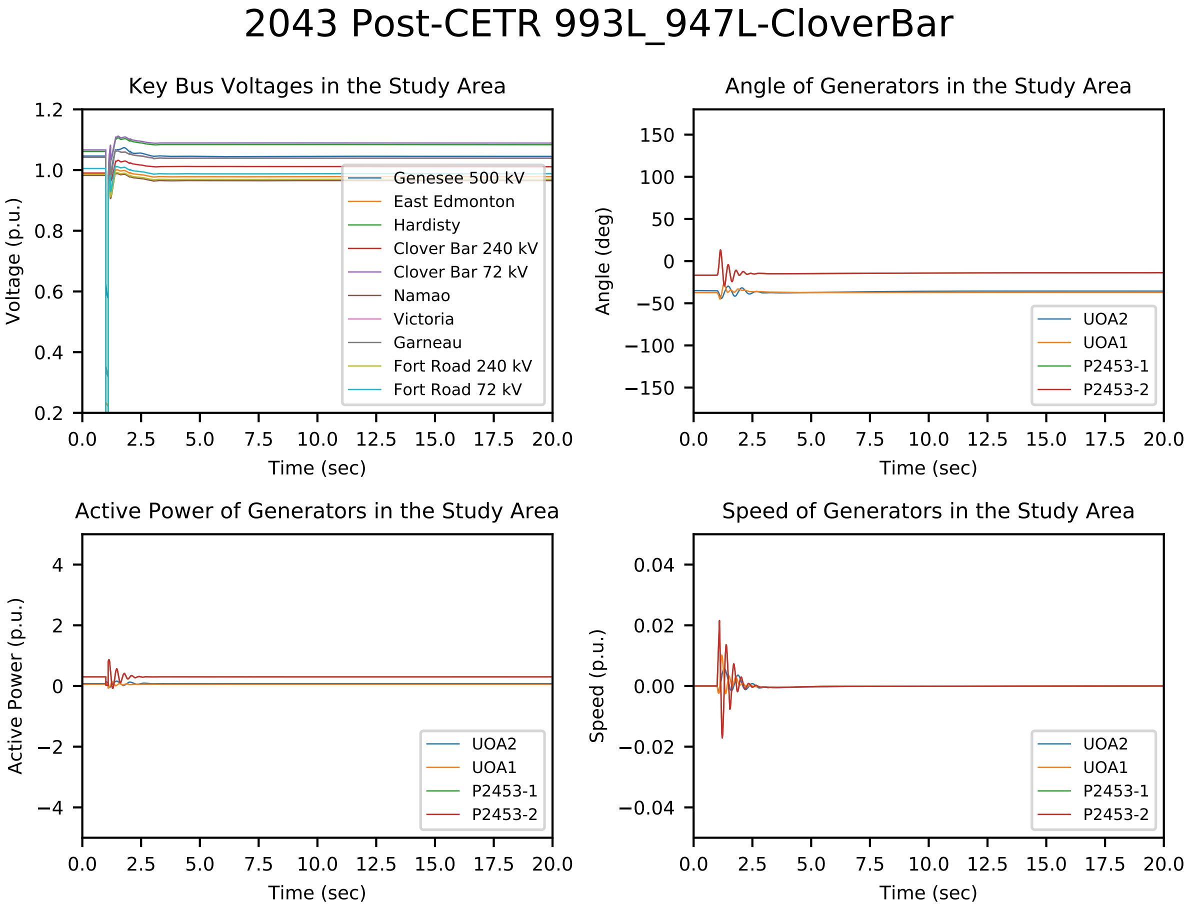


2043 Post-CETR 947L-Ellerslie
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2


2043 Post-CETR 993L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2

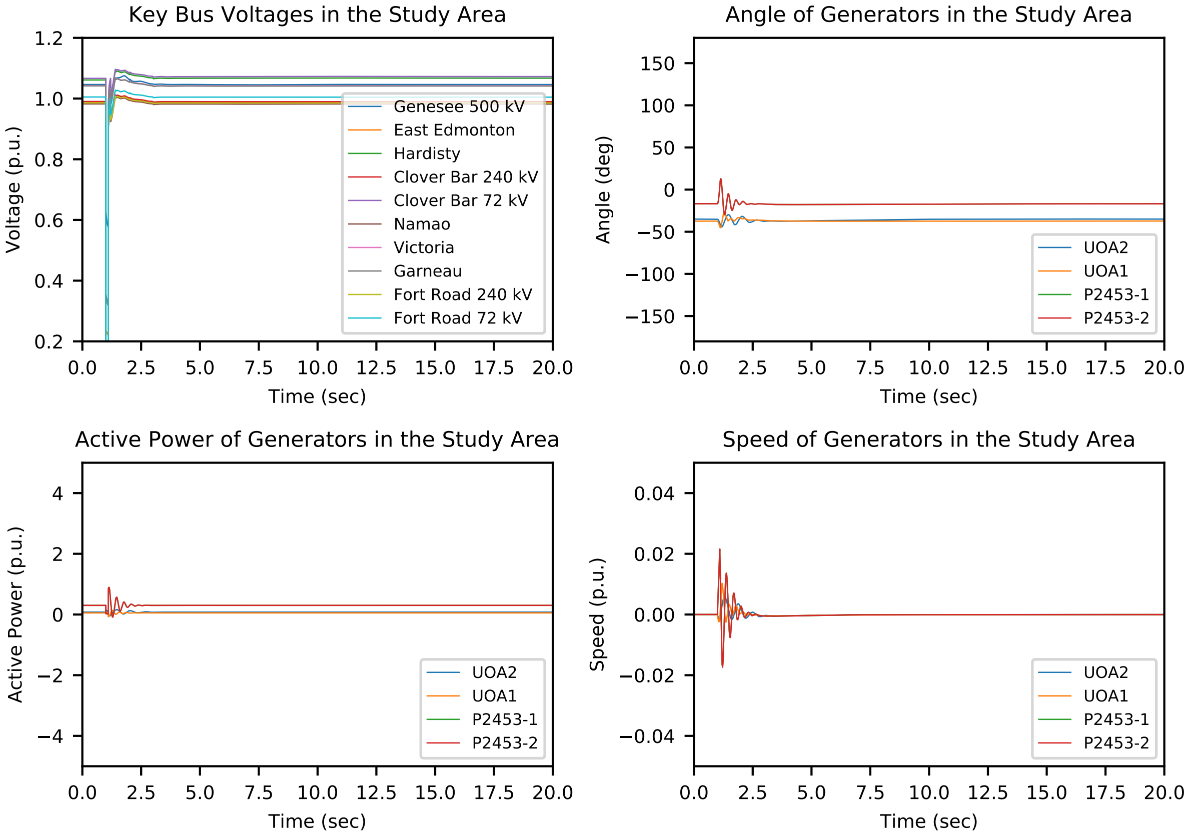
2043 Post-CETR 993L-FortRoad



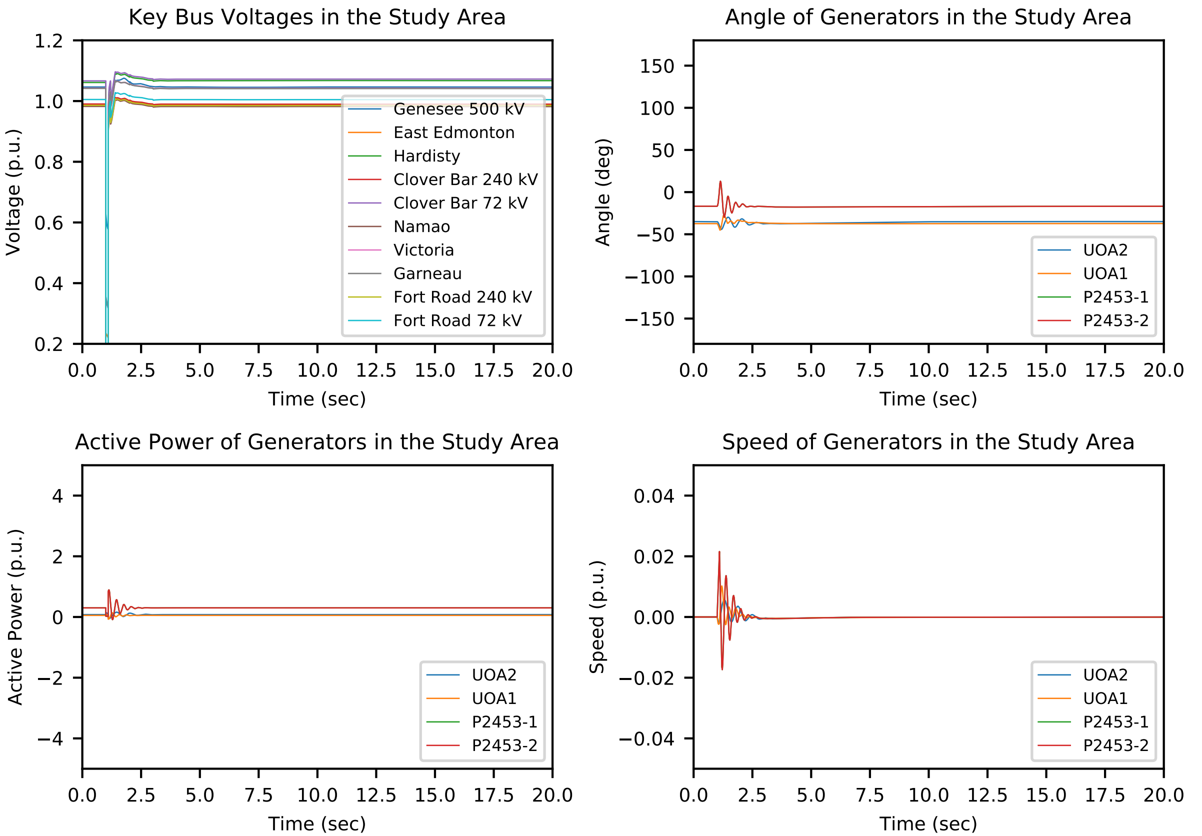


2043 Post-CETR 993L_947L-CloverBar
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)

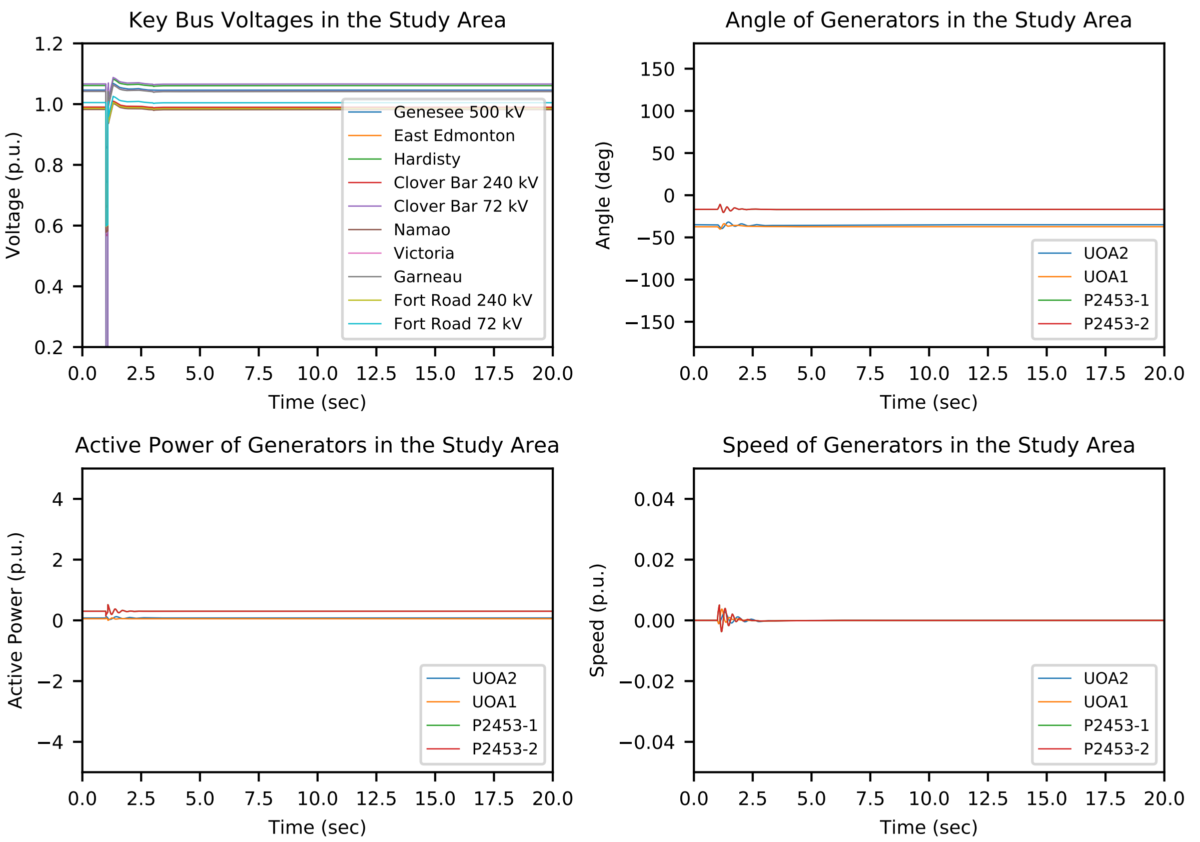
2043 Post-CETR CloverBar_T1

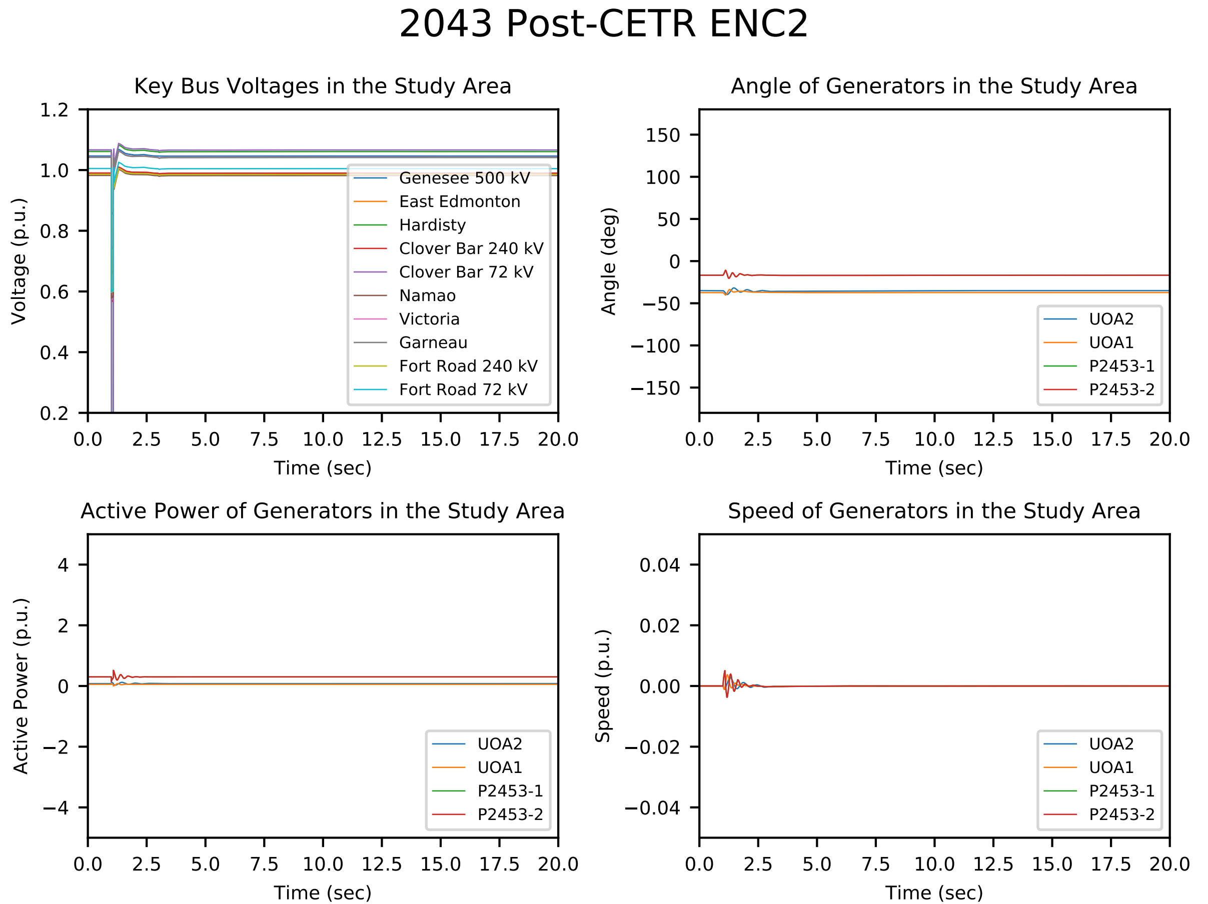


2043 Post-CETR CloverBar_T2

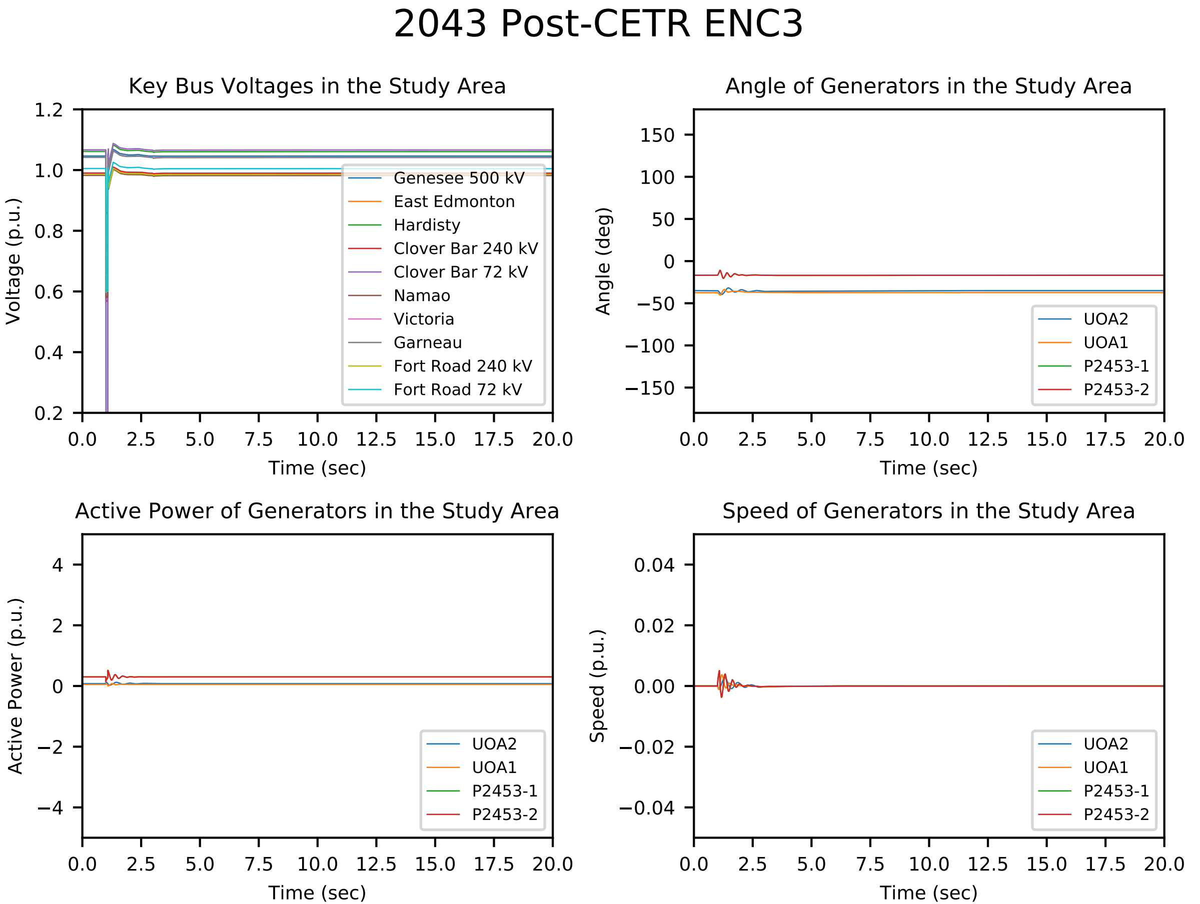


2043 Post-CETR ENC1

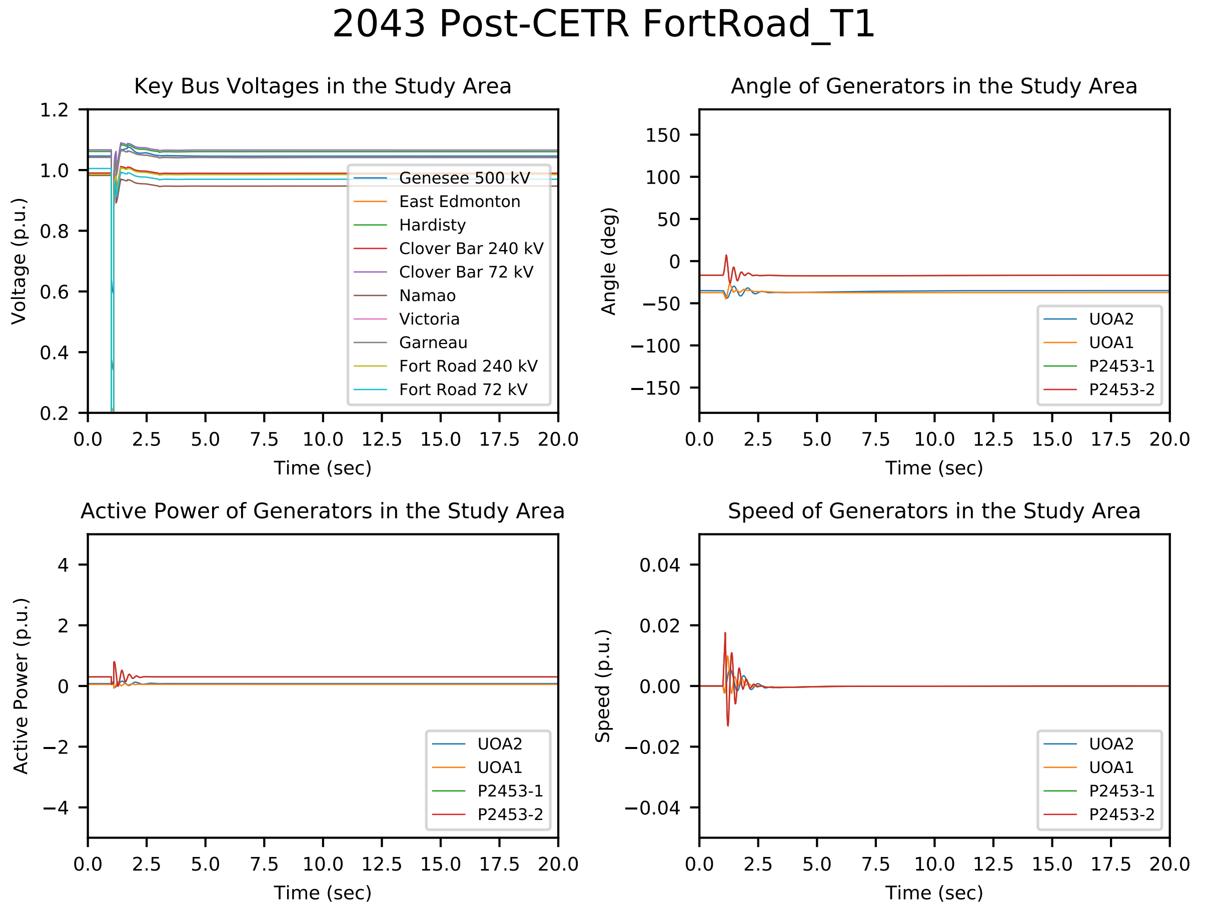


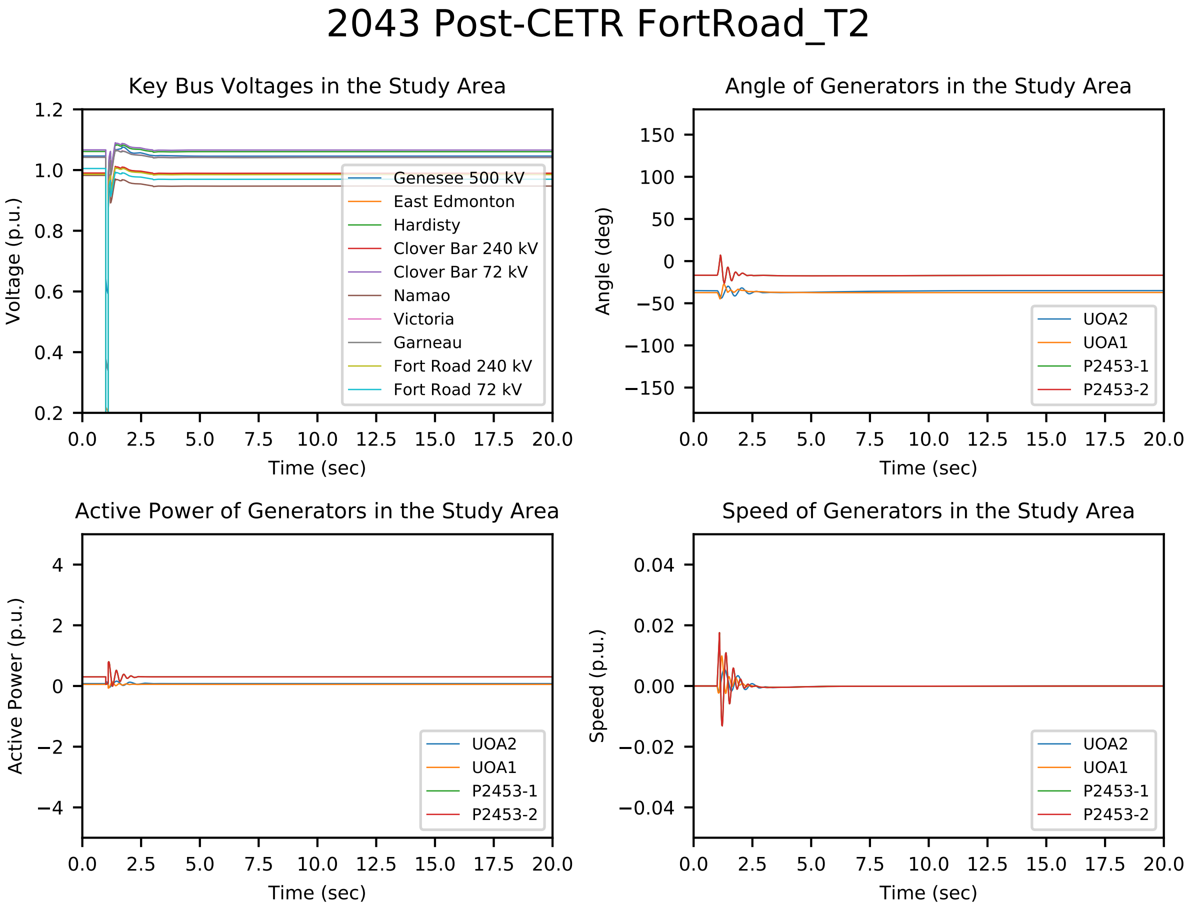


2043 Post-CETR ENC2
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2



2043 Post-CETR ENC3
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2


2043 Post-CETR FortRoad_T1
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Active Power of Generators in the Study Area
Active Power (p.u.)
Speed of Generators in the Study Area
Speed (p.u.)
UOA2
UOA1
P2453-1
P2453-2


2043 Post-CETR FortRoad_T2
Key Bus Voltages in the Study Area
Voltage (p.u.)
Time (sec)
Genesee 500 kV
East Edmonton
Hardisty
Clover Bar 240 kV
Clover Bar 72 kV
Namao
Victoria
Garneau
Fort Road 240 kV
Fort Road 72 kV
Angle of Generators in the Study Area
Angle (deg)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Active Power of Generators in the Study Area
Active Power (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2
Speed of Generators in the Study Area
Speed (p.u.)
Time (sec)
UOA2
UOA1
P2453-1
P2453-2

Attachment F: Short Circuit Analysis

2026 WP Pre – Development

Substation Name	Substation number	Base Voltage (kV)	Pre- Fault Voltage(p.u.)	3-Φ Fault (kA)	Positive Sequence Impedance (R1 +jX1) (p.u.)	1-Φ Fault (kA)	Zero Sequence Impedance (R0 +jX0) (p.u.)
Lamoureux	71S	240	1.1	26.1	0.001+0.010j	22.1	0.002+0.016j
Lamoureux	71S	138	1.1	34.2	0.002+0.013j	31.1	0.002+0.017j
East Edmonton	38S	138	1.1	26	0.003+0.017j	22.1	0.004+0.027j
East Edmonton	38S	240	1.1	30.3	0.001+0.009j	23.2	0.003+0.016j
Castle Down	--	240	1.1	18.5	0.002+0.014j	16.1	0.003+0.021j
Victoria	511S	240	1.1	15.4	0.002+0.017j	14.2	0.004+0.021j
Victoria	511S	69	1.1	32.2	0.003+0.028j	39.6	0.003+0.012j
Woodcroft_2	--	69	1.1	12.2	0.017+0.073j	9.8	0.102+0.101j
Woodcroft_1	--	69	1.1	17.5	0.019+0.049j	14.4	0.070+0.060j
Clover Bar	987S	240	1.1	28.2	0.001+0.009j	23.1	0.002+0.015j
Clover Bar	987S	69	1.1	33.9	0.002+0.027j	35.6	0.001+0.023j
Namao	--	69	1.1	16.4	0.016+0.054j	9.7	0.117+0.136j
Kennedale	--	69	1.1	27.8	0.005+0.033j	24	0.028+0.043j

2026 WP Post Development

Substation Name	Substation number	Base Voltage (kV)	Pre- Fault Voltage(p.u.)	3-Φ Fault (kA)	Positive Sequence Impedance (R1 +jX1) (p.u.)	1-Φ Fault (kA)	Zero Sequence Impedance (R0 +jX0) (p.u.)
Lamoureux	71S	240	1.1	25.9	0.001+0.010j	22.1	0.002+0.015j
Lamoureux	71S	138	1.1	34.2	0.002+0.013j	31.1	0.002+0.017j
East Edmonton	38S	138	1.1	25.8	0.003+0.018j	21.7	0.004+0.028j
East Edmonton	38S	240	1.1	28.8	0.002+0.009j	21.9	0.004+0.018j
Castle Down	--	240	1.1	18.5	0.002+0.014j	16.1	0.003+0.020j
Victoria	511S	240	1.1	15.4	0.002+0.017j	14.3	0.004+0.021j
Victoria	511S	69	1.1	32.2	0.003+0.028j	39.6	0.003+0.012j
Woodcroft_2	--	69	1.1	12.2	0.017+0.073j	9.8	0.102+0.101j
Woodcroft_1	--	69	1.1	17.5	0.019+0.049j	14.4	0.070+0.060j
Clover Bar	987S	240	1.1	25.5	0.001+0.010j	22.2	0.002+0.015j
Clover Bar	987S	69	1.1	33	0.002+0.028j	35.1	0.001+0.023j
Namao	--	69	1.1	8.3	0.015+0.110j	6.6	0.026+0.194j
Fort Road	240	240	1.1	23.3	0.002+0.011j	19.4	0.003+0.018j
Fort Road	69	69	1.1	12.1	0.005+0.076j	11.6	0.004+0.085j

2043 WP Pre – Development

Substation Name	Substation number	Base Voltage (kV)	Pre- Fault Voltage(p.u.)	3-Φ Fault (kA)	Positive Sequence Impedance (R1 +jX1) (p.u.)	1-Φ Fault (kA)	Zero Sequence Impedance (R0 +jX0) (p.u.)
Lamoureux	71S	240	1.1	26.5	0.002+0.010j	22.2	0.002+0.016j
Lamoureux	71S	138	1.1	34.2	0.002+0.013j	30.8	0.002+0.018j
East Edmonton	38S	138	1.1	26	0.003+0.017j	22	0.004+0.027j
East Edmonton	38S	240	1.1	31.4	0.002+0.008j	23.9	0.003+0.016j
Castle Down	--	240	1.1	18.6	0.003+0.014j	15.9	0.003+0.021j
Victoria	511S	240	1.1	15.4	0.003+0.017j	14	0.004+0.022j
Victoria	511S	69	1.1	32.6	0.004+0.028j	40.1	0.003+0.012j
Woodcroft_2	--	69	1.1	12.5	0.019+0.071j	9.8	0.102+0.101j
Woodcroft_1	--	69	1.1	17.7	0.020+0.048j	14.5	0.070+0.060j
Clover Bar	987S	240	1.1	29.3	0.002+0.009j	24.1	0.002+0.015j
Clover Bar	987S	69	1.1	32.6	0.003+0.028j	34	0.002+0.025j
Namao	--	69	1.1	16.3	0.018+0.054j	9.6	0.117+0.138j
Kennedale	--	69	1.1	26.9	0.006+0.034j	23.2	0.028+0.045j

2043 WP Post Development

Substation Name	Substation number	Base Voltage (kV)	Pre- Fault Voltage(p.u.)	3-Φ Fault (kA)	Positive Sequence Impedance (R1 +jX1) (p.u.)	1-Φ Fault (kA)	Zero Sequence Impedance (R0 +jX0) (p.u.)
Lamoureux	71S	240	1.1	26.4	0.002+0.010j	22.2	0.002+0.016j
Lamoureux	71S	138	1.1	34.2	0.002+0.013j	30.9	0.002+0.018j
East Edmonton	38S	138	1.1	25.8	0.003+0.018j	21.5	0.004+0.028j
East Edmonton	38S	240	1.1	29.7	0.002+0.009j	22.4	0.004+0.017j
Castle Down	--	240	1.1	18.6	0.003+0.014j	15.9	0.003+0.021j
Victoria	511S	240	1.1	15.4	0.003+0.017j	14	0.004+0.022j
Victoria	511S	69	1.1	32.6	0.004+0.028j	40.1	0.003+0.012j
Woodcroft_2	--	69	1.1	12.5	0.019+0.071j	9.8	0.102+0.101j
Woodcroft_1	--	69	1.1	17.7	0.020+0.048j	14.5	0.070+0.060j
Clover Bar	987S	240	1.1	26.5	0.002+0.010j	23.1	0.002+0.014j
Clover Bar	987S	69	1.1	31.3	0.002+0.029j	33.1	0.001+0.024j
Namao	--	69	1.1	8.5	0.018+0.107j	6.7	0.026+0.194j
Fort Road	240	240	1.1	24.1	0.002+0.011j	19.9	0.003+0.018j
Fort Road	69	69	1.1	12.3	0.007+0.074j	11.8	0.004+0.085j

Attachment G: TFO Underground Transmission Line Rating Practice

Request:

EPCOR to provide a write up around the rating practices of underground cables and how the condition of cable impacts the rating.

Response:

EDTI's general cable ampacity methodology uses detailed cable studies as the initial basis for EDTI's ratings. EDTI periodically employs third party consultants to perform these studies, which are based on loading, routing, cable and soil thermal properties. EDTI then utilizes internal Subject Matter Experts (SMEs) to incorporate these studies and adjust the ratings of each cable based on:

a. Asset health condition – based on multiple indicators such as dissolved gas analysis, insulating paper test results, fault and loading history, visual inspections and supporting infrastructure; and,
b. Risk profile – including environmental risks (ie. river crossings), impact of unplanned outages to the system, routing concerns (mature neighbourhoods, nearby utilities).

These activities are meant to maximize the value and lifecycle of the cable. A list of drivers and considerations for cable replacements and ratings are described further in EDTI's 2023-2025 TFO Tariff Application (Exhibit 27675-X0006.02, paragraph 386) and is provided below for reference:

> 386. Through its maintenance practices, EDTI has been able to keep its OFPT circuits in operation near, or beyond, their expected service lives. However, EDTI notes a number of technical, economic and environmental drivers that support its continued effort on a program to replace this specific technology over the course of the next 5-20 years, as determined to be necessary based on asset and system drivers. These drivers include, but are not limited to:
>
> - Asset Condition; which includes:
>   - Paper Insulation condition
>   - Dissolved Gas Analysis ("DGA")
>   - Load History

- Ratings and Thermal Considerations
    - Design load vs modified load vs actual load
    - Recorded hot spots or thermal trending during high load periods
- Increasing repair and maintenance costs
- Technological Obsolescence
    - One vendor in all of North America
    - Limited industry penetration (lack of spares/agreements with neighbouring TFOs)
- Supporting Infrastructure and Systems including:
    - Pump Plants and Oil System
    - Cathodic Protection
- Age
    - the age of an underground cable and its supporting ancillary systems, provides an indication of the accumulation of factors that degrade such assets over their service life, such as heat and physical stress or degradation
- Consequence of Failure
    - Potential for the release of insulating fluid into the environment and the loss of supply to large sectors of Edmonton's power system
    - System operating limitations during failure recovery – other planned capitaland operating work delayed or deferred due to limited system capacity
    - Environmental Risks and River Crossings
- Fault and Maintenance History
    - A number of these cables have experienced thermal faults and other maintenance failures in their past
- Route Characteristics including:
    - Utility crossings
    - Proximity to other circuits
    - Encroaching neighbourhoods

Attachment H: Kennedale Lifecycle Replacement

EDTI-AESO-2020MAY27-028 (Revised)

Reference: **NID Cost Estimate & NID 7(9) Report; PDF 148**

Request:

When compared to the configuration for Alternative 2a, is the approach of de-commissioning Kennedale proposed under Alternative 4 more cost-effective? Are the costs associated with replacing Kennedale once it reaches end of life already considered in EDTI's cost estimates? Please provide the cost breakdown comparison.

Response:

Yes, the approach of decommissioning Kennedale substation as proposed under Alternative 4 is more cost-effective compared to the configuration for Alternative 2A (build a new 240/72 kV Fort Road substation to supply at 72 kV the existing Kennedale and Namao substations).

As described in EDTI's NID Cost Estimate & NID 7(9) Report under Alternative 4, EDTI proposes to decommission the high voltage and medium voltage equipment at its Kennedale substation, as well as the existing 72 kV transmission circuits supplying the Kennedale substation. As such, EDTI does not plan to replace Kennedale once it reaches end of life. The total cost estimate for Alternative 4 includes approximately $2.0 million related to decommissioning EDTI's Kennedale substation and approximately $36.0 million related to distribution feeder relocations[1].

Revised Table EDTI-AESO-2020MAY27-028-1 below provides a cost comparison between Alternatives 2A and 4, including the estimated Kennedale substation life cycle replacement / decommissioning costs.

[1] See NID Cost Estimate and & NID 7(9) Report, Appendix E Attachment 7 (Revised).

Revised Table EDTI-AESO-2020MAY27-028-1
Comparison of Total Project Costs - Alternatives 2A and 4
Including Kennedale Life Cycle Replacement Costs (Alternative 2A)
And Kennedale Decommissioning Costs (Alternative 4)
($ millions)

		A Alternative 2A	B Alternative 4
1	Project Costs	$265.0	$270.7
2	Kennedale substation Life Cycle Replacements	$46.8	-
3	**Total Costs**	**$311.8**	**$270.7**

In addition to having a lower estimated total cost compared to Alternative 2A (as shown in row 3 in the above table), Alternative 4, will also result in EDTI having one less substation within the City of Edmonton to operate, maintain and repair (resulting in lower annual operating expenditures).

Revised Table EDTI-AESO-2020MAY27-028-2 below provides a further breakdown of the Kennedale substation life cycle replacement costs associated with Alternative 2A over the 2026-2040 time period, and include an escalation factor consistent with the AESO's cost estimating methodology and cost estimates for alternatives 2A and 4.

Revised Table EDTI-AESO-2020MAY27-028-2
Estimated Life Cycle Replacement Costs Associated With Alternative 2A
Kennedale Substation – 2026-2033
($ millions)

	Equipment	A Approximate Time Period	B Estimated LCR Cost ($2023)	C Escalation Years	D Escalation Rate	E Escalation	F Total
1	72 kV Transformers (2)	2027, 2028	$14.8	5	1.30%	$1.0	$15.8
2	15 kV Switchgear (4 busses)	2033-2036	$24.0	13	1.30%	$4.4	$28.4
3	72 kV Breakers (4)	2040+	$2.1	17	1.30%	$0.5	$2.6
4	**Total Life Cycle Replacement Costs**		**$40.9**			$5.9	$46.8

With respect to the land use considerations and transmission line routing impacts associated with Alternatives 2A and 4, the key differences between Alternatives 2A and 4 are summarized below.

Alternative 2A Land and Transmission Line Routing Impacts

- Implementing Alternative 2A will require the construction of a new Fort Road substation and upgrades to be made to Kennedale substation;
- Existing land use and development constraints at Kennedale substation will make any substation boundary expansion challenging (i.e., site footprint surrounded by existing businesses) and will likely result in greater impacts to surrounding land parcels;
- Increased volume of residential developments between the Fort Road and Kennedale substation sites may constrain transmission line routing options;
- Implementing Alternative 2A will result in the end-of-life decommissioning of 72 kV underground oil-filled pipe type ("OFPT") transmission circuits 72CK12 and 72CK13 (running between EDTI's existing Clover Bar and Kennedale substations, including an underwater crossing of the North Saskatchewan River) as well as 72CN10 (running between EDTI's existing Clover Bar and Namao substations, including an underwater crossing of the North Saskatchewan River). This decommissioning will result in the removal of a potential source of an environmental spill into the river; and,
- Implementing Alternative 2A will result in the near-term decommissioning of the 72 kV underground OFPT transmission circuit 72KN23 (running between EDTI's existing Kennedale and Namao substations). This decommissioning will result in the removal of a potential source for the release of cable insulating oil into the environment.

Alternative 4 Land and Transmission Line Routing Impacts

- The decommissioning of the existing Kennedale substation will result in the reduction of EDTI's overall substation footprint within the City (compared to Alternative 2A);
- The decommissioning of Kennedale will remove a substation site from a commercial land use area. The addition of the new Fort Road substation in an industrial land use area will better facilitate transmission line interconnection and provide for greater compatibility with the surrounding land uses;
- Implementing Alternative 4 will result in the near-term decommissioning of the 72 kV underground OFPT transmission circuits 72CK12 and 72CK13 (running between EDTI's existing Clover Bar and Kennedale substations, including an underwater crossing of the north Saskatchewan River. This decommissioning will result in the removal of a potential source of an environmental spill into the river);
- Implementing Alternative 4 will result in the near-term decommissioning of the 72 kV underground OFPT transmission circuit 72KN23 (running between EDTI's existing Kennedale and Namao substations) and 72CN10 (running between EDTI's existing Clover Bar and Namao substations, including an underwater crossing of the North Saskatchewan River). This decommissioning will result in the removal of a potential source for the release of cable insulating oil into the environment;
- The transmission line routing alignments near the Fort Road substation are expected to have less residential impacts compared to the potential impacts at EDTI's Kennedale substation; and,
- Implementing Alternative 4 will require reconfigurations of the distribution feeders currently emanating from the (to be decommissioned) Kennedale substation. These reconfigurations will primarily be constructed in existing public roadway allowances and utility rights of way.

Attachment I: AESO Transmission Planning Criteria

Transmission Planning Criteria - Basis and Assumptions

Version 1.0

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1. Introduction

This document presents the reliability standards, criteria, and assumptions to be used as the basis for planning the Alberta Transmission System. The criteria, standards and assumptions identified in this document supersede those previously established.

2. Transmission Reliability Standards and Criteria[1]

The AESO applies the following Alberta Reliability Standards to ensure that the transmission system is planned to meet applicable performance requirements under a defined set of system conditions and contingencies. A brief description of each of these standards is given below:

1. **TPL-001-AB-0: System Performance Under Normal Conditions**
   Category A represents a normal system condition with all elements in service (N-0). All equipment must be within its applicable rating, voltages must be within their applicable ratings and the system must be stable with no cascading outages. Under Category A, electric supply to load cannot be interrupted and generating units cannot be removed from service.

2. **TPL-002-AB-0: System Performance Following Loss of a Single BES Element**
   Category B events result in the loss of any single element (N-1) under specified fault conditions with normal clearing. The specified elements are a generating unit, a transmission circuit, a transformer or a single pole of a direct current transmission line. The acceptable impact on the system is the same as Category A with the exception that radial customers or some local network customers, including loads or generating units, are allowed to be disconnected from the system if they are connected through the faulted element. The loss of opportunity load or opportunity interchanges is allowed. No cascading can occur.

3. **TPL-003-AB-0: System Performance Following Loss of Two or More BES Elements**
   Category C events result in the loss of two or more bulk electric system elements (sequential, N-1-1 or concurrent, N-2) under specified fault conditions and include both normal and delayed fault clearing. All of the system limits for Category A and B events apply with the exception that planned and controlled loss of firm load, firm transfers and/or generation is acceptable provided there is no cascading.

4. **TPL-004-AB-0: System Performance Following Extreme BES Events**
   Category D represents a wide variety of extreme, rare and unpredictable events, which may result in the loss of load and generation in widespread areas. The system may not be able to reach a new stable steady state, which means a blackout is a possible outcome. The AESO needs to evaluate these events, at its discretion, for risks and consequences prior to creating mitigation plans.

5. **FAC-014-AB-2: Establishing and Communicating System Operating Limits**
   The AESO is required to establish system operating limits where a contingency is not mitigated through construction of transmission facilities.

[1] A complete description of these standards are given in: AESO. *Alberta Reliability Standards*. Available from http://www.aeso.ca/rulesprocedures/17004.html

2.1 Thermal Loading Criteria

The AESO Thermal Loading Criteria require that the continuous thermal rating of any transmission element is not exceeded under normal and post-contingency operating conditions. Thermal limits are assumed to be 100% of the respective normal summer and winter ratings. Emergency limits are not considered in the planning evaluations.

2.2 Voltage Range and Voltage Stability Criteria

The normal minimum and maximum voltage limits as specified in the following table are used to identify Category A system voltage violations, while the extreme minimum and maximum limits are used to identify Category B and C system violations. Table 2-1 presents the acceptable steady state and contingency state voltage ranges for the AIES. Table 2-2 provides voltage stability criteria used to test the system performance.

Table 2-1: Acceptable Range of Steady State Voltage (kV)

Nominal Voltage	Extreme Minimum	Normal Minimum	Normal Maximum	Extreme Maximum
500	475	500	525	550
240	216	234	252	264
260 (Northeast & Northwest)*	234	247	266	275
144	130	137	151	155
138	124	135	145	152
72	65	68.5	75.5	79
69	62	65.5	72.5	76

Table 2-2: Voltage Stability Criteria

Performance Level	Disturbance (1)(2)(3)(4) Initiated by: Fault or No fault DC Disturbance	MW Margin (P-V method) (5)(6)(7)	MVAr Margin (V-Q method) (6)(7)
A	Any element such as: One Generator One Circuit One Transformer One Reactive Power Source One DC Monopole	$\geq$ 5%	Worst Case Scenario(8)
B	Bus Section	$\geq$ 5%	50% of Margin Requirement in Level A

Performance Level	Disturbance (1)(2)(3)(4) Initiated by: Fault or No fault DC Disturbance	MW Margin (P-V method) (5)(6)(7)	MVAr Margin (V-Q method) (6)(7)
C	Any combination of two elements such as: A Line and a Generator A Line and a Reactive Power Source Two Generators Two Circuits Two Transformers Two Reactive Power Sources DC Bipole	≥ 2.5%	50% of Margin Requirement in Level A
D	Any combination of three or more elements. i.e.: Three or More Circuits on ROW Entire Substation Entire Plant Including Switchyard	> 0	> 0

2.3 Transient Stability Analysis Assumptions

Standard fault clearing times as shown in Table 2-3 are used for the new facilities or when the actual clearing times are not available for the existing facilities. Double line-to-ground faults are applied for the Category C5 events with normal clearing times. Single line-to-ground faults are applied for Category C6 to C9 events with delayed clearing times as depicted in Table 2-4 and Table 2-5.

Table 2-3: Fault Clearing Times

Nominal	Near End	Far End
kV	**Cycles**	**Cycles**
500	4	5
240	5	6
144/138 with telecommunications	6	8
144/138 without telecommunications	6	30

Table 2-4: Stuck Breaker Clearing Times for Lines

Fault Clearing Time			Fault Clearing Time			Fault Clearing Time		
138/144 kV			240 kV			500 kV		
Near End	Far End	2nd Ckt (for C5 and C7 Only)	Near End	Far End	2nd Ckt (for C5 and C7 Only)	Near End	Far End	2nd Ckt (for C5 and C7 Only)
15	24	24	12	6	14	9	5	11

Table 2-5: Stuck Breaker Clearing Times for Transformers

Fault Clearing Time (Cycles)						Fault Clearing Time (Cycles)					
240/138 kV						500/240 kV					
Fault on 240 kV Side			Fault on 138 kV Side			Fault on 500 kV Side			Fault on 240 kV Side		
240 kV Side	138 kV Side	2nd Ckt (for Breaker Fail)	138 kV Side	240 kV Side	2nd Ckt (for Breaker Fail)	500 kV Side	240 kV Side	2nd Ckt (for Breaker Fail)	240 kV Side	500 kV Side	2nd Ckt (for Breaker Fail)
12	6	14	15	5	24	9	5	11	12	4	14