

**APPENDIX B IRISH CREEK CAPACITOR BANK
NEED ASSESSMENT**

Voltage Performance Assessment for Irish Creek Substation Capacitor Bank Addition

June 5, 2015

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Executive Summary

The key objective of conducting a long term plan assessment is to facilitate the planning of the Alberta transmission system in a timely manner that ensures reliable transmission facilities are available when needed. The AESO load and generation forecast is one of the key factors in determining the need for transmission system development. Also taken into consideration is the need to eliminate operational constraints that are presently managed through RASs and operational measures.

The AESO published its 2013 Long-term Transmission Plan in 2014¹. The Central Region Plan (part of the 2013 Long-term Transmission Plan) includes new 240 kV transmission lines and substations intended to alleviate existing congestion and facilitate the integration of new wind generation projects in the Central Region. Reactive power support in the form of capacitor banks at the Irish Creek 706S, Whitby Lake 819S, and Strome 223S substations has been proposed for the near term, and the AESO will file the related needs identification documents with the Alberta Utilities Commission in 2015-2016. The 2013 Long Term Plan used the AESO 2012 Long Term Outlook (2012LTO). Since the publication of the 2013 Long Term plan, the AESO has issued its 2014 Long Term Outlook (2014LTO), which has an updated load and generation forecast that reflects the latest customer connection requests.

This document assesses the need for a capacitor bank at the Irish Creek substation based on the 2014LTO load and generation forecast. The study area was limited to the Irish Creek substation which is located in the Lloydminster area (AESO planning area 13). The reactive power support for other substations in neighboring areas will be considered in a future long term plan.

Long Term Planning reviewed and assessed the need for the Irish Creek capacitor bank component of the Central Region plan and determined the following:

- The capacitor size assessment indicates a need for an approximately 23 MVar to 28 MVar (at 138 kV) capacitor bank at Irish Creek 706S substation in the 2017WP scenario. Considering the long-term reactive power studies for the region, the 23 MVar capacitor bank (25 MVar at 144 kV) proved to be sufficient to alleviate the observed voltage violations at this time.
- Reactive power support for neighboring areas will be filed with the AUC under separate applications.

¹ <http://www.aeso.ca/transmission/30379.html>

1 Irish Creek Substation Capacitor Bank Assessment

The reactive power support in the Central East Region was identified in the published 2013 AESO Long Term Plan for the Central Region². This plan, which used the 2012 Long Term Outlook (2012LTO), proposed 25 MVar (at 144 kV) capacitor banks at the Irish Creek 706S, Whitby Lake 819S, and Strome 223S substations in 2017.

Since the publication of the 2013 AESO Long Term Plan, the AESO released a new load forecast, the 2014 Long Term Outlook (2014LTO), which has an updated load and generation forecast that reflects the latest customer connection requests.

This report reassesses the need for the Irish Creek capacitor bank component from the system long term planning perspective using the 2014LTO. Power flow analysis for 2017 summer peak (2017SP) and 2017 winter peak (2017WP) scenarios were performed to identify any thermal and voltage criteria violations. The 2017 summer light (2017SL) scenario was used to ensure the addition of the capacitor bank at the Irish Creek substation will not adversely impact the voltage performance under the light load condition. The study area was assumed to be the Lloydminster Area (Area 13), which includes the Irish Creek 706S substation. The substations in other areas were excluded from this assessment. They will be considered in a future long term plan.

A capacitor sizing analysis was carried out under the 2017SP and 2017WP scenarios to determine the reactive power support required at the Irish Creek substation.

Power flow analysis was performed for 2017SP, 2017WP, 2017SL, 2020SP, 2020WP, 2020SL, 2025SP, 2025WP, and 2025SL with the addition of the Irish Creek capacitor bank to ensure the reliability criteria are not violated.

1.1 Load and Generation Forecast

1.1.1 Load Assumptions

Table 1-1 shows the AESO 2014LTO corporate forecast for the Central Region at Central Region peak load for the study years 2017, 2020, and 2025. In this study, the active power to reactive power ratios in the base cases was maintained when modifying the loads.

Table 1-1: Forecasted Region Load (2014LTO)

Region Name and Season		Forecast Peak Load (MW)		
		2017	2020	2025
Central*	SP	1602	1702	1872

² <http://www.aeso.ca/transmission/30379.html>

	SL	1186	1231	1342
	WP	1847	1914	2100
ALL w/o Losses	SP	11,434	13019	14588
	SL	8,245	9717	10798
	WP	12,790	14273	15835

*Note: The Central Region comprises the following AESO planning areas: 56, 13, 32, 37, 36, 42, 35, 39, 38, 30, 29, and 34.

The ATCO Heartland pump station (Project 1410) was assumed to be in service and modeled with 15.4 MW in the summer scenarios and 16.4 MW in the winter scenarios. The power factor of 0.9 was assumed for this load, which is aligned with the lowest historical power factor observed in the area to capture the worst-case scenario.

1.1.2 Generation Assumptions

The existing non-wind generators and their dispatch levels in the study area are listed in Table 1-2. All the wind generation units are at zero output. In order to stress the system from the voltage performance perspective, the Primrose generation unit in the Cold Lake Area (Area 28) was assumed to be out of service (N-G).

Table 1-2: Summary of Existing Non-Wind Generators around the Study Area

Generator	2017 SP	2017WP	2017SL	2020SP	2020WP	2020SL	2025SP	2025WP	2025SL
Battle River #3	149	149	91	0	0	0	0	0	0
Battle River #4	155	155	93	155	155	127	155	155	127
Battle River #5	385	385	157	385	385	304	385	385	304
Sheerness #1	332	367	144	332	332	199	367	367	199
Sheerness #2	367	390	144	367	367	144	390	390	144
Foster Creek G1, G2	89	94	91	88	94	91	89	94	91
Mahkeses G1, G2	137	178	157	137	175	157	139	176	157
Nabiye G1,G2	113	128	96	113	128	96	113	128	96
Primrose	OFF	OFF	79	OFF	OFF	79	OFF	OFF	79

1.2 Voltage Profile Assumption

Table 1-3 shows the key bus voltages around the study area. The Desired Range bus voltages were used as a guidance to set the bus voltages in the pre-contingency condition (Category A).

Table 1-3: Summary of Voltage at Key Nodes around the Study Area

Area	Substation Name and Number	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)
13	Lloydminster A716S	144	137	142-149	151
	Hill A751S	144	137	143-149	151
28	Bonnyville A700S	144	140	147-150	155
	Leming Lake A715S	144	140	144-150	155
	Whitefish Lake A825S	240	253	255-265	275
	Marguerite Lake A826S	240	252	255-268	275
		144	141	148-151	155
32	Hardisty T377S	138	140	140-144	145

The extreme minimum and maximum limits were used to identify Category B system violations. Table 1-4 shows the acceptable steady-state voltages for different transmission voltage classes.

Table 1-4: Acceptable Range of Steady State Voltage (kV)

Nominal (kV)	Extreme Minimum (kV)	Normal Minimum (kV)	Normal Maximum (kV)	Extreme Maximum (kV)
500	475	500	525	550
240	216	234	252	264
260 (Northeast and 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

1.3 Power Flow Analysis

Power flow studies for Category A (N-0) and Category B (N-1) contingencies were performed for the 2017SP and 2017WP scenarios. The results of the power flow studies show the following:

- No voltage violation in 2017SP under N-0 and N-1 conditions
- Voltage range violation and voltage deviation under the N-1 condition in 2017WP at the Irish Creek substation

Details of these studies are presented in the following subsections.

1.3.1 2017 Summer Peak (2017SP)

System Normal (N-0) Condition - 2017SP

Neither voltage criteria violations nor thermal violations were observed for this scenario.

Single Element Contingency (N-1) Condition - 2017SP

Neither voltage criteria violations nor voltage deviations exceeding 10% were observed for this scenario.

1.3.2 2017 Winter Peak (2017WP)

System Normal (N-0) Condition – 2017WP

No voltage criteria violations were observed for this scenario at the Irish Creek substation.

Single Element Contingency (N-1) Condition – 2017WP

Table 1-5 shows the voltage criteria violations and voltage deviations exceeding 10% under the 7L53 (700S Bonnyville to 706S Irish Creek) contingency.

Table 1-5: Voltage Performance, N-1, 2017WP

System Condition	Bus	Voltage (kV)	POD % Deviation (±10%)
N-1: 7L53\7LA53 (700S Bonnyville to 706S Irish Creek)	1377 (706S Irish Creek) 144 kV	124	-
	19377 (706S Irish Creek) 25 kV	-	12%
	18377 (706S Irish Creek) 25 kV	-	11%

1.4 Capacitor Bank Sizing Analysis

A capacitor bank sizing analysis was carried out to determine the reactive power margin for the system under 2017WP conditions and 2017SP conditions at Irish Creek Substation 2019S (bus 1377). In this analysis, the following assumptions were made to simulate the worst case condition:

- Tap adjustments were not allowed
- Locked DC taps
- Locked switchable shunts
- Use Fast Decoupled Newton Raphson solution (FDNS)

Details of this analysis are presented in following subsections.

1.4.1 2017 Summer Peak (2017SP)

A series of power flow simulations were carried out with the addition of a variable capacitor bank with Q [MVar] capacity at the Irish Creek substation (bus 1377). It was found that the contingency of 7L53\7LA53 (700S Bonnyville to 706S Irish Creek) is the most critical N-1 contingency. It will result in a higher reactive power requirement in the 2017SP scenario. The reactive power support (Q [MVar]) and the voltage at the Irish Creek 138/144 kV bus are shown in Table 1-6. It shows that 14 MVar of reactive power is required to keep the voltage at the Irish Creek 144 kV bus at 137 kV (normal minimum voltage from Table 1-4) under the most critical contingency.

Table 1-6: Capacitor Bank Sizing Analysis, 2017SP

System Condition	Voltage (kV)	Q (MVar)
N-1: 7L53\7LA53 (700S Bonnyville to 706S Irish Creek)	138	17
	137	14
	135	11
	134	8

1.4.2 2017 Winter Peak (2017WP)

Similar to the 2017SP, a series of power flow simulations were carried out with the addition of a capacitor bank with (Q [MVar]) capacity at the Irish Creek substation (bus 1377). It was found that the contingency of 7L53\7LA53 (700S Bonnyville to 706S Irish Creek) is the most critical contingency. It will result in a higher reactive power requirement in the 2017WP scenario. The reactive power support (Q [MVar]) and the voltage at the Irish Creek 138/144 kV bus are shown in Table 1-7.

Table 1-7: Capacitor Bank Sizing Analysis, 2017WP

System Condition	Voltage (kV)	Q (MVar)
N-1: 7L53\7LA53 (700S Bonnyville to 706S Irish Creek)	138	32
	137	28
	135	25
	134	22

The results show that 28 MVar of reactive power is required to keep the voltage at the Irish Creek 144 kV bus at 137 kV (normal minimum voltage from Table 1-4) under the most critical contingency.

The capacitor bank sizing analysis conducted using the 2014LTO forecast indicates that a capacitor bank of approximately 23 MVar to 28 MVar is required at the Irish Creek substation to meet the voltage criteria. In the following subsections, the results of simulations that analyzed the addition of both 23 MVar and 28 MVar capacitor banks under the 2017SP, 2017WP, 2017SL, 2020SP, 2020WP, 2020SL, 2025SP, 2025WP, and 2025SL scenarios are discussed.

1.4.3 2017 Summer Peak (2017SP) with Irish Creek Capacitor Bank Addition

System Normal (N-0) Condition – 2017SP

No voltage criteria violations were observed at the Irish Creek substation for this scenario with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

Single Element Contingency (N-1) Condition – 2017SP

No voltage criteria violations were observed under the N-1 condition with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

1.4.4 2017 Winter Peak (2017WP) with Irish Creek Capacitor Bank Addition

System Normal (N-0) Condition – 2017WP

No voltage criteria violations were observed at the Irish Creek substation for this scenario with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

Single Element Contingency (N-1) Condition – 2017WP

No voltage criteria violations were observed under the N-1 condition with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

The power flow result indicates that the Irish Creek capacitor bank removed the voltage range violation and the voltage deviation observed in the Irish Creek substation.

1.4.5 2017 Summer Light (2017SL) with Irish Creek Capacitor Bank Addition

The summer light scenario was tested with the addition of a 23 MVar capacitor bank and with the addition of a 28 MVar capacitor bank to ensure there is no voltage criteria violation under the light load condition.

System Normal (N-0) Condition – 2017SL

No voltage criteria violations were observed for this scenario at the Irish Creek substation. Table 1-8 shows that under the normal condition and with different power factor assumptions at the Irish Creek substation the voltage at Irish Creek will not violate the voltage criteria. It should be noted that the maximum voltage under the normal condition is 151 kV.

Table 1-8: Irish Creek Voltage under Different Power Factor Assumptions, N-0, 2017SL

System Condition (N-0)	Irish Creek Bus Voltage (kV)	
	23 MVar	28 MVar
Unity power factor at the Irish Creek substation	150	150.2
0.9 power factor at the Irish Creek substation	147.7	147.8

Single Element Contingency (N-1) Condition – 2017SL

No voltage criteria violations were observed under the N-1 condition at the Irish Creek substation. Table 1-9 shows that under the most critical N-1 contingency (7L53\7LA53, Bonnyville to Irish Creek), and with different power factor assumptions at the Irish Creek substation, the voltage at Irish Creek will not violate the voltage criteria. It should be noted that the maximum voltage under the N-1 condition is 155 kV.

Table 1-9: Irish Creek Voltage under Different Power Factor Assumptions, N-1, 2017SL

System Condition (N-1, 7L53)	Irish Creek Bus Voltage (kV)	
	23 MVar	28 MVar
Unity power factor at the Irish Creek substation	151.5	153.6
0.9 power factor at the Irish Creek substation	146.6	148.6

1.4.6 2020 Summer Peak (2020SP) with Irish Creek Capacitor Bank Addition

System Normal (N-0) Condition – 2020SP

No voltage criteria violations were observed for this scenario at the Irish Creek substation with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

Single Element Contingency (N-1) Condition – 2020SP

No voltage criteria violations were observed under the N-1 condition with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

1.4.7 2020 Winter Peak (2020WP) with Irish Creek Capacitor Bank Addition

System Normal (N-0) Condition – 2020WP

No voltage criteria violations were observed for this scenario at the Irish Creek substation with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

Single Element Contingency (N-1) Condition – 2020WP

No voltage criteria violations were observed under the N-1 condition with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.

Slight voltage deviations were observed with the addition of a 23 MVar capacitor bank at the Irish Creek substation. These voltage deviations are shown in Table 1-10.

Table 1-10: Voltage Deviation, N-1, 2020WP

System Condition	Bus	POD % Deviation (±10%)
N-1: 7L161 (MahNo 909S to Nabiye 942S)	19377 (706S Irish Creek) 25 kV	10.4%
	18377 (706S Irish Creek) 25 kV	10.1%
N-1: 7L105 (Mahihkan 837S to MahNo 909S)	19377 (706S Irish Creek) 25 kV	10.4%
	18377 (706S Irish Creek) 25 kV	10.1%

1.4.8 2020 Summer Light (2020SL) with Irish Creek Capacitor Bank addition

The summer light scenario was tested with the addition of a 23 MVar capacitor bank and with the addition of a 28 MVar capacitor bank to ensure there is no voltage criteria violation under the light load condition.

System Normal (N-0) Condition – 2020SL

Voltage criteria violations were observed for this scenario at the Irish Creek substation when considering a unity power factor for the load at the Irish Creek substation. Table 1-11 shows the voltage at the Irish

Creek substation for both a unity power factor and a 0.9 power factor. It should be noted that the maximum voltage under the normal condition is 151 kV.

Table 1-11: Irish Creek Voltage under Different Power Factor Assumptions, N-0, 2020SL

System Condition (N-0)	Irish Creek Bus Voltage (kV)	
	23 MVar	28 MVar
Unity power factor at the Irish Creek substation	151.2	152.22
0.9 power factor at the Irish Creek substation	148.8	149.8

Single Element Contingency (N-1) Condition – 2020SL

No voltage criteria violations were observed under the N-1 condition at the Irish Creek substation. Table 1-12 shows that under the most critical N-1 contingency (7L53\7LA53, Bonnyville to Irish Creek) and with different power factor assumptions at the Irish Creek substation, the voltage at Irish Creek will not violate the voltage criteria. It should be noted that the maximum voltage under the N-1 condition is 155 kV.

Table 1-12: Irish Creek Voltage under Different Power Factor Assumptions, N-1, 2020SL

System Condition (N-1, 7L53)	Irish Creek Bus Voltage (kV)	
	23 MVar	28 MVar
Unity power factor at the Irish Creek substation	152.7	154.5
0.9 power factor at the Irish Creek substation	148.2	150

1.4.9 2025 Summer Peak (2025SP) with Irish Creek Capacitor Bank Addition

System Normal (N-0) Condition

No voltage criteria violations were observed for this scenario at the Irish Creek substation with addition of either a 23 MVar capacitor bank or 28 MVar capacitor bank.

Single Element Contingency (N-1) Condition – 2025SP

A marginal voltage criteria violation was observed at Irish Creek substation under the N-1 condition with the addition of a 23 MVar capacitor bank. The voltage range violation is shown in Table 1-13.

Table 1-13: Voltage Range Violation, N-1, 2025SP

System Condition	Bus	Voltage (kV) With 23 MVar
N-1: 7L53\7LA53 (700S Bonnyville to 706S Irish Creek)	1377 (706S Irish Creek) 144 kV	129.5

No voltage criteria violations were observed under the N-1 condition with the addition of a 28 MVar capacitor bank.

1.4.10 2025 Winter Peak (2025WP) with Irish Creek Capacitor Bank addition

System Normal (N-0) Condition

A voltage criteria violation was observed for this scenario at the Irish Creek substation with the addition of a 23 MVar capacitor bank and with the addition of a 28 MVar capacitor bank. The voltages at Irish Creek substation are shown in Table 1-14.

Table 1-14: Voltage Range Violation, N-0, 2025WP

System Condition	Bus	Voltage (kV) With 23 MVar	Voltage (kV) With 28 MVar
N-0	1377 (706S Irish Creek) 144 kV	135.6	136.9

Single Element Contingency (N-1) Condition – 2025WP

Voltage violations were observed at the Irish Creek substation under the N-1 condition with the addition of a 23 MVar capacitor bank and with the addition of a 28 MVar capacitor bank. The voltage violations are listed in Table 1-15. Voltage deviations were also observed with the addition of a 23 MVar capacitor bank and with the addition of a 28 MVar capacitor bank. These are shown in Table 1-16.

Table 1-15: Voltage Range Violation, N-1, 2025WP

System Condition	Bus	Voltage (kV) With 23 MVar	Voltage (kV) With 28 MVar
N-1: 7L53\7LA53 (700S Bonnyville to 706S Irish Creek)	1377 (706S Irish Creek) 144 kV	119	121
N-1: 7L161 (MahNo 909S to Nabiye 942S)	1377 (706S Irish Creek) 144 kV	127	128
N-1: 7L105 (Mahihkan 837S to MahNo 909S)	1377 (706S Irish Creek) 144 kV	127	128
N-1: 7L50 (Buffalo Creek 526S to Battle River 757S)	1377 (706S Irish Creek) 144 kV	123	123
N-1: Buffalo Creek 526S Transformer	1377 (706S Irish Creek) 144 kV	129.7	-

Table 1-16: Voltage Deviation, N-1, 2025WP

System Condition	Bus	POD % Deviation ($\pm 10\%$) With 23 MVar	POD % Deviation ($\pm 10\%$) With 28 MVar
N-1: 7L53\7LA53 (700S Bonnyville to 706S Irish Creek)	19377 (706S Irish Creek) 25 kV	14%	13%
	18377 (706S Irish Creek) 25 kV	13%	12%
N-1: 7L95 (Mahkeses 889S to Leming Lake 715S)	19377 (706S Irish Creek) 25 kV	17%	16%
	18377 (706S Irish Creek) 25 kV	15%	15%

1.4.11 2025 Summer Light (2025SL) with Irish Creek Capacitor Bank addition

The summer light scenario was tested with the addition of a 23 MVar capacitor bank and with the addition of a 28 MVar capacitor bank to ensure that there is no voltage criteria violation under the light load condition.

System Normal (N-0) Condition – 2025SL

No Voltage criteria violations were observed for this scenario at the Irish Creek substation with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank. Table 1-17 shows the voltage at the Irish Creek substation for both a unity power factor and a 0.9 power factor. It should be noted that the maximum voltage under the normal condition is 151 kV.

Table 1-17: Irish Creek Voltage under Different Power Factor Assumptions, N-0, 2025SL

System Condition N-0	Irish Creek Bus Voltage (kV)	
	23 MVar	28 MVar
Unity power factor at the Irish Creek substation	145.4	146.4
0.9 power factor at the Irish Creek substation	142	143

Single Element Contingency (N-1) Condition – 2025SL

No voltage criteria violations were observed under the N-1 condition at the Irish Creek substation. Table 1-18 shows that under the most critical N-1 contingency (7L53\7LA53, Bonnyville to Irish Creek), and with different power factor assumptions at the Irish Creek substation, the voltage at Irish Creek will not violate the voltage criteria. It should be noted that the maximum voltage under the N-1 condition is 155 kV.

Table 1-18: Irish Creek Voltage under Different Power Factor Assumptions, N-1, 2025SL

System Condition (N-1, 7L53)	Irish Creek Bus Voltage (kV)	
	23 MVar	28 MVar
Unity power factor at Irish Creek substation	147	148
0.9 power factor at Irish Creek substation	140	142

2 Summary and Conclusions

The summary of the reassessment of the Irish Creek capacitor bank requirement is as follows:

- 2017SP:
 - There is neither a voltage range criteria violation nor a voltage deviation under Category A (N-0) and Category B (N-1) in the 2017SP scenario with and without the Irish Creek capacitor bank.
- 2017WP
 - There is no voltage range criteria violation under Category A (N-0) at the Irish Creek substation in the 2017WP scenario with and without the Irish Creek capacitor bank.
 - There are voltage range violations and a voltage deviation under Category B (N-1) at the Irish Creek substation in the 2017WP scenario without the Irish Creek capacitor bank.
 - The Irish Creek capacitor bank will remove the voltage range violations and the voltage deviation under Category B (N-1) at the Irish Creek substation in the 2017WP scenario.
- 2017SL:
 - There is neither a voltage range criteria violation nor a voltage deviation under Category A (N-0) and Category B (N-1) in the 2017SL scenario with the Irish Creek capacitor bank.
 - Different load power factors assumptions at the Irish Creek substation were made and tested and the tests showed no voltage criteria violation under the N-0 condition and the N-1 condition.
- 2020SP:
 - There is neither a voltage range criteria violation nor a voltage deviation under Category A (N-0) and Category B (N-1) in the 2020SP scenario with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.
- 2020WP:
 - There are slight voltage deviations under Category B (N-1) in the 2020WP scenario with the addition of a 23 MVar capacitor bank. No voltage criteria violation was observed under this scenario.
- 2020SL:
 - Marginal voltage criteria violations were observed for this scenario at the Irish Creek substation with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank under a unity power factor for the load at the Irish Creek substation.
- 2025SP:

- There is no voltage range criteria violation under Category A (N-0). A marginal voltage violation was observed at the Irish Creek substation under the Category B (N-1) condition with the addition of a 23 MVar capacitor bank.
- 2025WP:
 - A voltage criteria violation was observed under Category A (N-0) in this scenario at the Irish Creek substation with the addition of either a 23 MVar capacitor bank or a 28 MVar capacitor bank.
 - Voltage criteria violations as well as a voltage deviation were observed under Category B (N-1) at the Irish Creek substation.
- 2025SL:
 - No voltage criteria violations were observed for this scenario at the Irish Creek substation with the addition of a 23 MVar capacitor bank and with the addition of a 28 MVar capacitor bank under the unity power factor for the load at the Irish Creek substation.

Conclusions

- The assessment indicates that the Irish Creek capacitor bank of 25 MVar at 144 kV (23 MVar at 138 kV) sufficiently removes the voltage criteria violation observed in the Irish Creek substation in 2017.
- Additional reactive power support might be need at Irish Creek in the medium term and the need applications for reactive power support in the neighboring areas will be filed with AUC based on future long term planning studies.