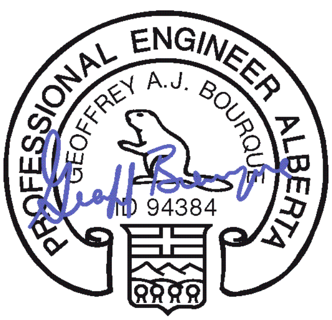
Cluster 1 Congestion Assessment

Central Cluster [CTRL-01]



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1. Introduction

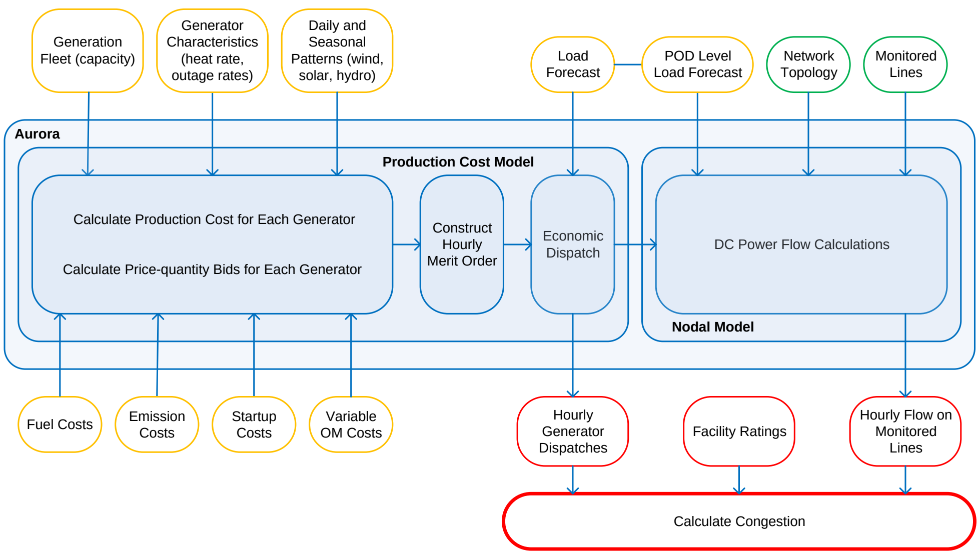
This report documents the Congestion Assessment for the projects in the Central cluster region (the Region).

Congestion occurs when the transmission system cannot accommodate all in-merit generation, because the resulting power flows would contravene reliability standards and/or ISO rules.[1] This Congestion Assessment forecasts congestion that may occur in the Region under three scenarios. This report also summarizes observations regarding supply surplus within the congestion modelling.

2. Method

The congestion assessment combines a production cost model with a transmission system network model. The production cost model simulates the hourly energy market economic dispatches required to supply the forecasted hourly demand. Then, the transmission system network model calculates the hourly power flows on each transmission facility that result from the hourly energy market dispatches and demand. Finally, congestion is calculated by comparing the hourly power flows on each transmission facility with its respective facility rating. Figure 1 illustrates the inputs and processes involved in the congestion assessment.

Figure 1 - Congestion Assessment Process



The Congestion Assessment forecasts the potential congestion resulting from thermal violations of normal facility ratings under the Category A condition and pre-contingency curtailment to prepare for the select Category B condition (contingency) of EATL.[2] Generation is dispatched as if the transmission system had no constraints and then the resulting power flows are compared to their respective facility ratings to identify congestion. For select pre-contingency curtailment, the resulting post-contingency power flows are compared to adjusted facility ratings that estimate the post-contingency system performance.

[1] The reliability standards and ISO rules are available on the AESO website.

[2] Eastern Alberta Transmission Line, also known as 13L50.

Except for select contingencies, the assessment does not forecast the potential congestion caused by curtailment to prepare for contingencies, most severe single contingency limits, or congestion associated with voltage or transient stability criteria violations. These items could increase the risk of congestion.

3. Assumptions

The Congestion Assessment forecasts congestion that may occur in the Region for the following assumptions.

3.1 Study Period

The Congestion Assessment studied all 8784 hours in the study year of 2028 to forecast congestion.

The Congestion Assessment assumes any modelled generating unit or transmission system project are in service prior to January 1st, 2028. Thus, every modelled generating unit and transmission system project were simulated as in-service for all of calendar year 2028.

3.2 Scenarios

The Congestion Assessment forecasts congestion that may occur in the Region within three scenarios:

i) **Post-PIC**: assumes projects that have met the project inclusion criteria[3] (PIC) across the entire province are energized;

ii) **Pre-cluster**: assumes post-PIC plus all Connection Assessment (CA) modelled projects[4] within the Region are energized; and

iii) **Post-cluster**: assumes pre-cluster plus Cluster 1 projects within the Region are energized.

Projects were included in the different scenarios as per the *AESO Connection Project List*[5] [6] from April 2024. The scenarios are reiterated in Table 1.

Table 1 – Projects Included in each Scenario

Scenario	In-flight Projects[7]		Cluster Projects[8]
	Projects that have met PIC across the province	CA Modelled Projects in the Region	Cluster Projects in the Region
Post-PIC	Yes	No	No
Pre-Cluster	Yes	Yes	No
Post-Cluster	Yes	Yes	Yes

[3] The definition of project inclusion criteria is available in the Connection Project List Guide on the AESO website.

[4] For the purpose of this assessment, CA Modelled projects are the non-Cluster 1 projects which are included in the assessment. The definition of CA modelled projects is available in the Connection Project List Guide on the AESO website.

[5] The AESO Connection Project List is available on the AESO website.

[6] P2441 Halkirk 2 had not reached project inclusion criteria as of the April connection project list, but met the criteria in mid-April. It is included in post-PIC results.

[7] CA Modelled projects outside the Region are not included in any scenario in this report.

[8] Cluster projects outside the Region are not included in any scenario in this report.

3.3 Generation and Demand

Generation

Table 2 provides the total, province wide installed generation capacity modelled in each scenario. The post-PIC scenario includes all existing generators. However, the pre-cluster and post-cluster scenarios only add generating units to the Region.

Table 2 – Assumed Installed Generation Capacity

Technology	Post-PIC (MW)	Pre-Cluster (MW)	Post-Cluster (MW)
Wind[9]	6,064	+1,131	+1,660
Solar[10]	3,535	+2,145	+4,239
Energy Storage[11]	383	+493	+1,983
Thermal	14,280	+686	+411
Hydro	894	0	0
Other	444	0	0
Additions		+4,455	+8,293
Total	25,600	30,055	38,348

Wind generating units were dispatched following forecasted hourly wind profiles which account for varying weather patterns and geographic locations.

Solar generating units were dispatched following forecasted hourly solar profiles which account for varying solar irradiance, weather patterns, geographic locations, and solar panel characteristics.

Energy storage assets were divided into three groups:

1. Hybrid assets, i.e. energy storage co-located with another generating unit. These storage units were modelled to only charge from their respective co-located generating units and discharge based on pool price.
2. Storage assets that are assumed to provide ancillary services. These storage generating units were modelled to not dispatch in the energy market.
3. Storage assets that are assumed to provide energy market dispatches. These storage generating units were modelled to optimize charging and discharging based on pool price arbitrage.

Each remaining generating unit was dispatched using production cost modelling which accounts for the costs and characteristics of its technology type.

[9] This includes wind generating units with hybrid storage. The storage, which charges from the wind generating unit, is not included in the wind total generation capacity.

[10] This includes solar generating units with hybrid storage. The storage, which charges from the solar generating unit, is not included in the solar total generation capacity.

[11] This includes the storage component of hybrid generating units with either wind and energy storage or solar and energy storage.

In the event of supply surplus, partial volume dispatches of $0 offers were assigned pro-rata to the generating units according to Section 202.5 of the ISO Rules, *Supply Surplus*.[12]

Demand

Demand was modelled at each point of delivery following the *2024 Long Term Outlook*.[13]

3.4 Transmission Topology

The transmission system topology was modelled as per the existing transmission system with the following additions:

1. Connection projects were included using the AESO-preferred connection alternative.
2. *Central East Transfer-Out Transmission Development*[14] (CETO) Stage 2 was included.
3. *Vauxhall Area Transmission Development*[15] (VATD) was included.

All of the above transmission system topology additions were assumed in-service before January 1st, 2028.

The existing facility ratings, provided by the legal owners of transmission facilities, were assumed in the transmission system model, except for the facility ratings that will be modified by any of the above additions.

Congestion is reported for transmission facilities in the Region that operate at 69 kV and above. Transformers are only reported if both sides of a transformer's voltage are at 69 kV and above.

4. Results

The Congestion Assessment forecasts the potential congestion resulting from thermal violations of normal facility ratings under the Category A condition and pre-contingency curtailment to prepare for the select Category B condition of EATL. Except for this select contingency, the assessment does not forecast the potential congestion caused by pre-contingency curtailment, most severe single contingency limits, or congestion associated with voltage or transient stability criteria violations.

The Congestion Assessment provides forecasted congestion frequency, congested energy, and the maximum loading on lines within the Region.

> *Note: The total amount of congested energy in a region is not the sum of all of the congested energy on the transmission facilities. This is because when a generating unit is curtailed, it may affect flows on multiple lines with different effectiveness. For example, 1,000 MWh of curtailed energy at a specific generator may prevent overloads on two transmission facilities that report 1,000 MWh and 500 MWh of congested energy. In this hypothetical example, taking 1,000 MWh of action at a generator leads to 1,500 MWh of Congested Energy relief on transmission facilities.*

The Congestion Assessment does not consider which generating units would be curtailed; all real-time curtailments are subject to Section 302.1 of the ISO Rules, *Real Time Transmission Constraint Management.*[16]

[12] *ISO Rule 202.5 – Supply Surplus* is available on the AESO website.

[13] The *2024 LTO* is available on the AESO website.

[14] AUC Decision 25469-D01-2021

[15] AUC Decision 27776-D01-2023

[16] *ISO Rule 302.1 – Real Time Transmission Constraint Management* is available on the AESO website.

The results are provided in the following sections for the three scenarios (as defined in Section 3.2): post-PIC, pre-cluster, and post-cluster. In addition, this report also summarizes observations regarding supply surplus within the congestion modelling.

4.1 Post-PIC Scenario

Figure 2 illustrates the forecasted congestion frequency and Figure 3 illustrates the forecasted congested energy. The results are provided in tabular format in Attachment A.

In the Central West, in the post-PIC scenario, congestion is observed on 138 kV transmission lines around 39S Bickerdike. In the Central East, congestion is observed on five of the 144 kV transmission lines connecting 801S Anderson to 266S Nevis, as well as two transmission lines from the Central region to the Southeast region, 7L132 (959S Lanfine – 767S Oyen) and 7L760 (767S Oyen – 7LA760 Tap). For 240 kV lines, congestion is observed on 9L59 (801S Anderson - 9LA59Tap) as well as 9L59 (972S Tinchebray - 9LA59 Tap). The congestion observed on 9L59 (972S Tinchebray - 9LA59 Tap), 174L (197S Bardo - 395S North Holden), and 7L16 (766S Nevis - 948S Heatburg) consider pre-contingency curtailment for an EATL contingency.

Figure 2 – Post-PIC Congestion Frequency Heatmap

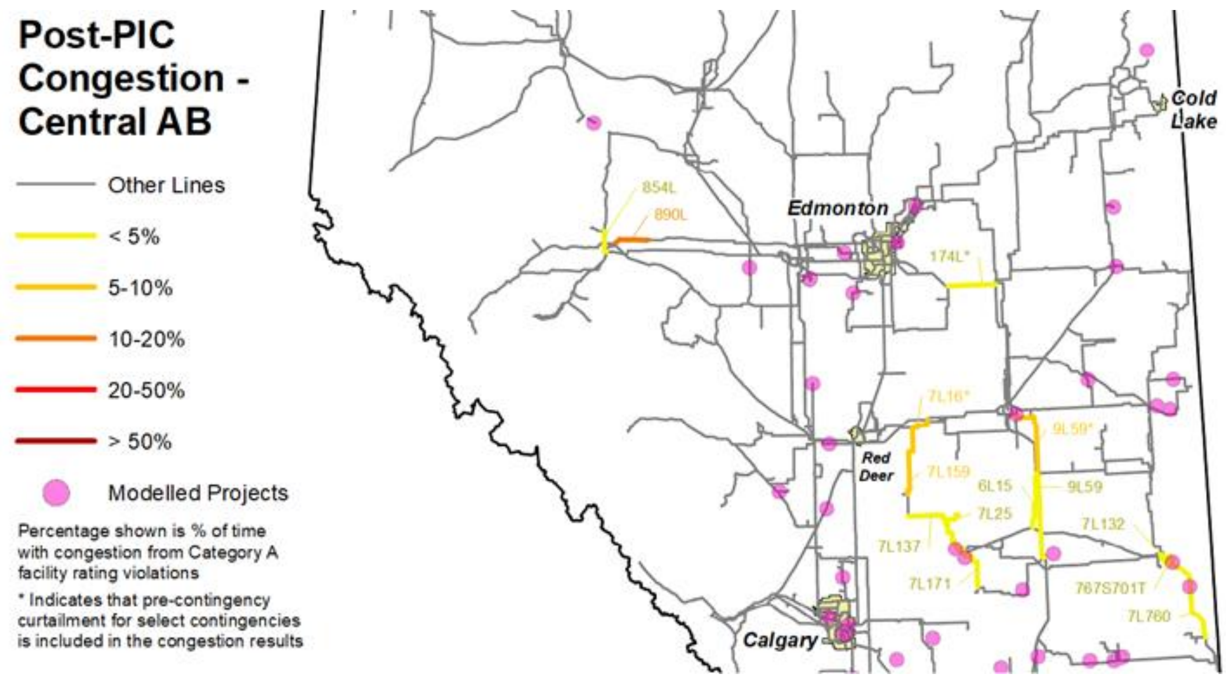
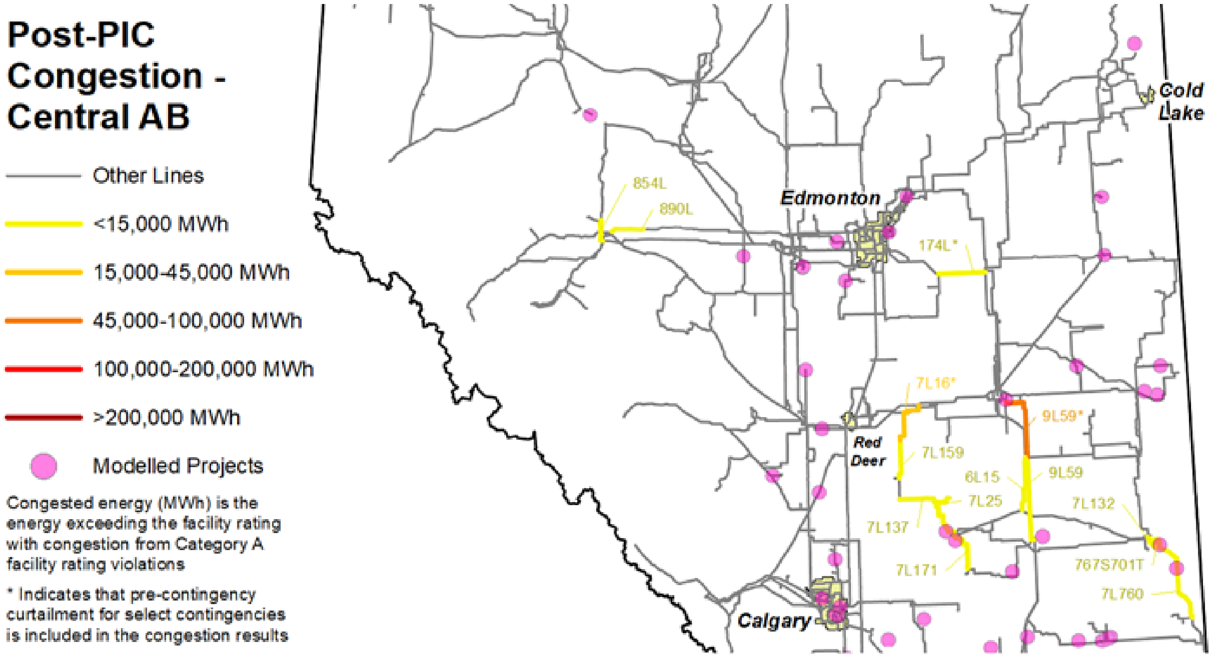


Figure 3 – Post-PIC Congested Energy Heatmap



4.2 Pre-Cluster Scenario

Figure 4 illustrates the forecasted congestion frequency and Figure 5 illustrates the forecasted congested energy. The results are provided in tabular format in Attachment A.

In the Central West, relative to the post-PIC scenario, additional congestion is observed on additional 138 kV transmission lines 744L (228S T.M.P.L.Niton - 207S Pinedale) and 740L (58S Edson - 39S Bickerdike). For 240 kV transmission lines, congestion is additionally observed on 948L/9L948 (650S Hansman Lake - 863S Paintearth), 900L (17S Benalto - 63S Red Deer) and 926L (310P Sundance - 17S Benalto). Finally, congestion is observed on additional 138/144 kV transmission lines within the underlying transfer-out paths to the north of the Central East region.

Figure 4 – Pre-Cluster Congestion Frequency Heatmap

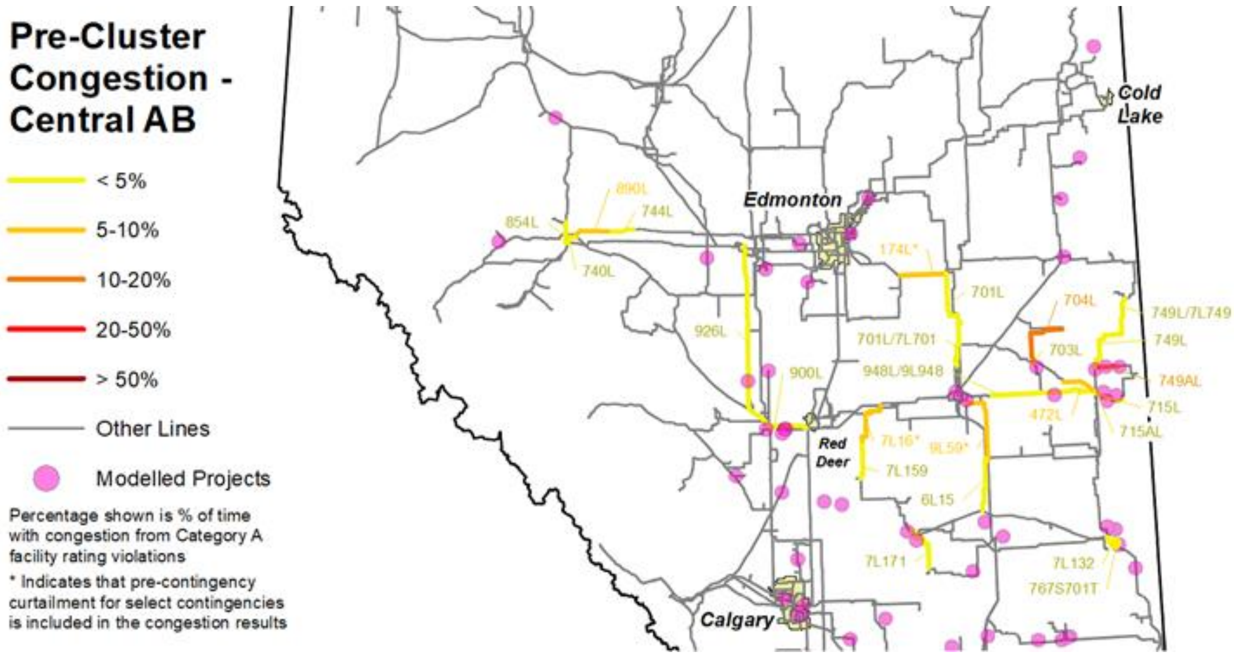
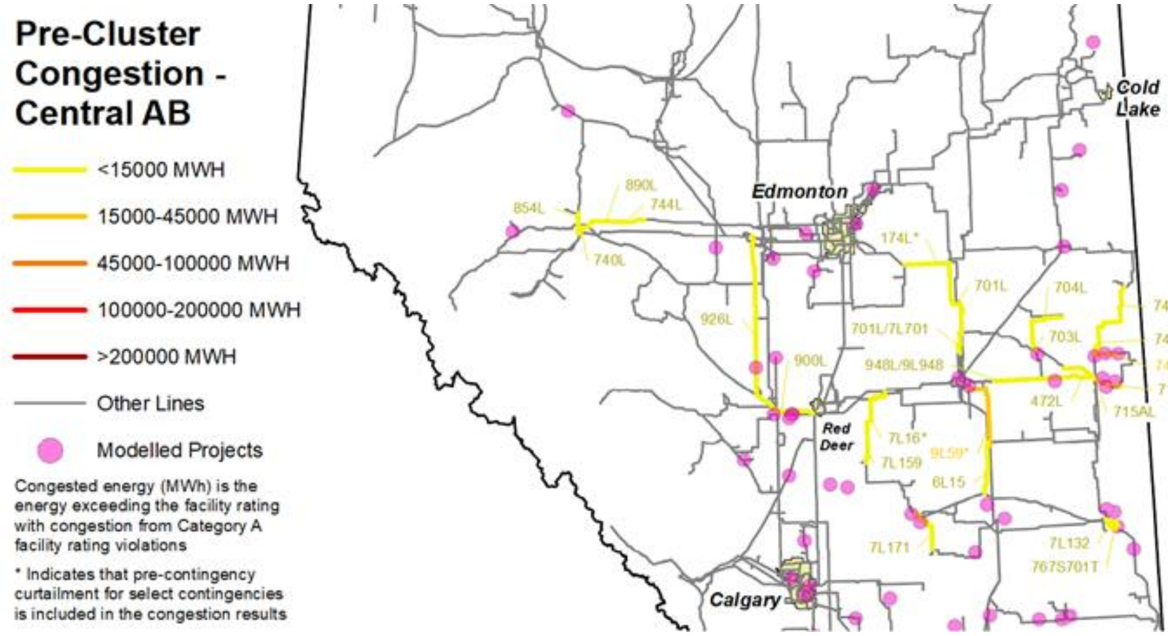


Figure 5 – Pre-Cluster Congested Energy Heatmap



4.3 Post-Cluster Scenario

Figure 6 illustrates the forecasted congestion frequency and Figure 7 illustrates the forecasted congested energy. The results are provided in tabular format in Attachment A.

In the Central West, relative to the pre-cluster case, congestion is observed on 202L (61S Lodgepole - 62S Brazeau). For the 240 kV infrastructure, congestion is observed on multiple 240 kV transmission lines forming a transfer-out path from the Central East region – connecting the Central East region to Edmonton via Red Deer. This includes 9L20, 912L, 900L, 914L and 1083L, as well as 926L and 900L. Congestion is observed on additional 138/144 kV transmission lines within the underlying transfer-out paths to the north of the Central East region.

Figure 6 – Post-Cluster Congestion Frequency Heatmap

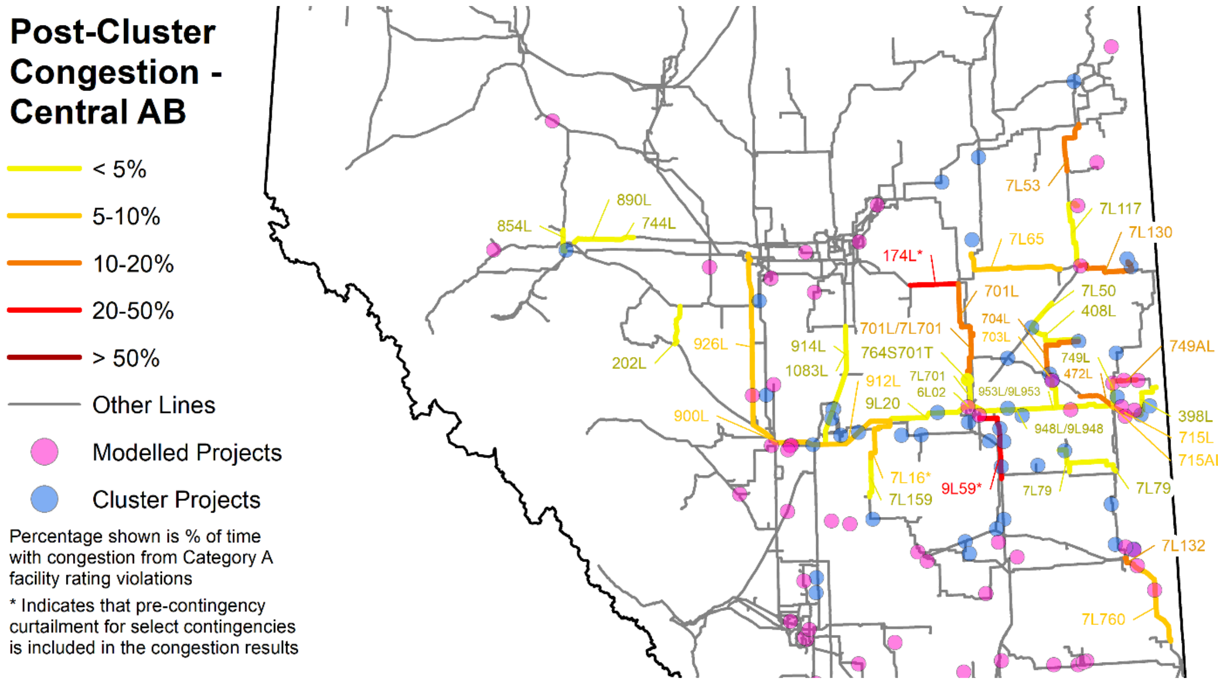
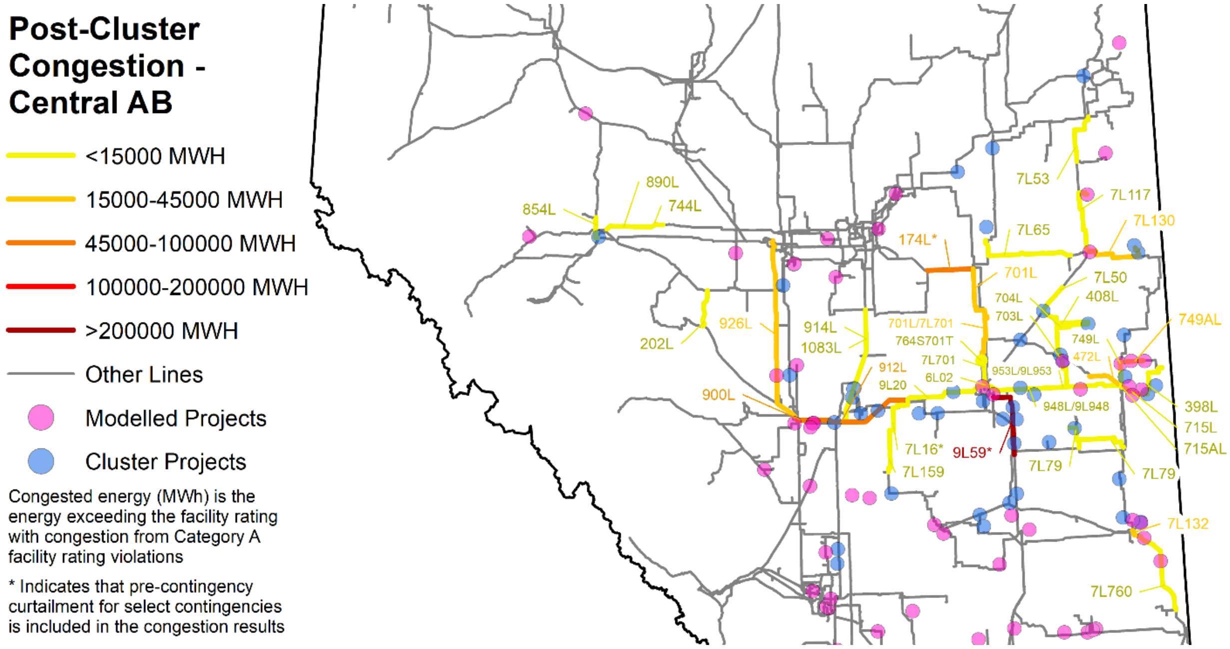


Figure 7 – Post-Cluster Congested Energy Heatmap



4.4 Trends in Supply Surplus

Supply surplus occurs when there is more $0 energy offered into the market than what is required to meet demand (including exports). Supply surplus results in partial-volume dispatches of flexible $0 offers. In contrast, congestion occurs when in-merit generation cannot be dispatched due to constraints on the transmission system, which results in generation curtailment.

Both supply surplus and congestion can impact a generating unit's ability to provide energy to the market. In order to forecast congestion, the assessment completes an economic dispatch, which includes calculating partial-volume dispatches of $0 offers during conditions of supply surplus. Energy that has only been partially dispatched during a supply surplus condition is not recorded as congested energy. Rather, these partial-volume dispatches decrease the generation that would make it to the local transmission system and potentially be congested. **Therefore, supply surplus influences congestion results and potentially understates the forecasted congestion if the supply surplus does not occur.**

Supply surplus results are sensitive to the assumptions of load and generation growth and are therefore provided for understanding of how these will affect congestion results. Supply surplus does not depend on the configuration or capability of the transmission system. Within the models for all cluster regions, the occurrence of supply surplus events and the volume of energy partially dispatched increases as the growth of supply that offers at $0 exceeds the growth of demand. This directional increase of supply surplus with variable renewable generation growth is shown in Table 3.

Table 3 – Supply Surplus Frequency and Foregone Energy

Installed Capacity (MW)	Technology	% of Time	% of Energy Foregone
Total: 25,600 *Wind:* 6,000 *Solar:* 3,500	Solar	3	1
	Wind	3	1
	Total	**3**	**1**
Total: 29,300 *Wind: 6,700* *Solar: 6,500*	Solar	12	5
	Wind	12	2
	Total	**12**	**3**
Total: 32,600 *Wind: 7,400* *Solar: 8,000*	Solar	16	8
	Wind	17	4
	Total	**18**	**6**
Total: 38,800 *Wind: 9,000* *Solar: 10,900*	Solar	31	26
	Wind	41	14
	Total	**41**	**19**
Total: 56,900 *Wind: 11,500* *Solar: 20,100*	Solar	39	48
	Wind	61	33
	Total	**61**	**40**

5. Conclusions

The Congestion Assessment forecasts the congestion for three scenarios: post-PIC, pre-cluster, and post-cluster.

- Congestion is forecasted in post-PIC scenario, primarily in the Central East.
- The addition of in-flight projects and cluster projects would increase and introduce new congestion risks to the Region due to high transfer-out flows from the Region.
- The occurrence of supply surplus events and foregone energy increases with additional generating units.

Attachment A

Table A1 – Congestion Assessment Detailed Results

Transmission Line	Nominal Rating (MW)[17]		Post-PIC		Pre-Cluster		Post-Cluster	
	Sum.	Wint.	Frequency (%)	Energy (MWh)	Frequency (%)	Energy (MWh)	Frequency (%)	Energy (MWh)
1083L (288S Wolf Creek - 63S Red Deer)	443	531					1	1,200
174L (197S Bardo - 395S North Holden)*	115	142	1	300	8	9,500	27	51,000
202L (61S Lodgepole - 62S Brazeau)	113	139					1	200
398L (545S Provost - 277S Hayter)	114	141					4	4,200
408L (252S Jarrow - 51S Wainwright)	71	83					3	1,700
472L (213S Hughenden - 472ALTap)	80	119			8	9,800	15	18,800
472L (648S Metiskow - 472ALTap)	115	143			6	7,000	14	18,000
6L02 (765S Mannix Mine - 757S Battle River)	54	67					1	400
6L15 (775S Sullivan Lake - 763S Hanna)	29	38	1	200	2	400		
701L (395S North Holden - 223S Strome)*	113	139			4	4,400	19	32,000
701L/7L701 (223S Strome - 7LA701Tap)*	135	181			4	3,900	17	29,000
703L (377S Hardisty - 703BLTap)	91	91			1	500	5	4,700
704L (51S Wainwright - 478S Tucuman)*	71	75			11	9,100	16	17,000
715AL (650S Hansman Lake - 715ALTap)	93	125			3	2,600	7	11,000
715L (545S Provost - 715ALTap)	93	125			3	2,700	8	11,000
740L (58S Edson - 39S Bickerdike)	106	128			1	300		
744L (228S T.M.P.L.Niton - 207S Pinedale)	71	75			3	700	1	100
749AL (267S Killarney Lake - 749ALTap)	115	141			11	22,000	17	34,000
749L (648S Metiskow - 749ALTap)	116	143					1	800
749L (899S Edgerton - 749ALTap)	116	143			1	700		
749L/7L749 (899S Edgerton - 7LB749Tap)	104	137			1	700		

[17] Facility ratings are converted from MVA to MW assuming a power factor of 0.95.

Transmission Line	Nominal Rating (MW)[18]		Post-PIC		Pre-Cluster		Post-Cluster	
	Sum.	Wint.	Frequency (%)	Energy (MWh)	Frequency (%)	Energy (MWh)	Frequency (%)	Energy (MWh)
764S701T (764S Heisler)	31	31					3	600
767S701T (767S Oyen)	12	12	3	200	2	100		
7L117 (706S Irishcreek - 710S Vermilion)	119	151					1	800
7L130 (710S Vermilion - 705S Kitscoty)	104	137					13	23,000
7L132 (767S Oyen - 959S Lanfine)	106	134	1	700	1	600	11	21,000
7L137 (770S Three Hills - 768S Rowley)	103	136	1	300				
7L159 (7LA16Tap - 948S Heatburg)	102	136	5	9,600	4	6,000	3	3,500
7L16 (766S Nevis - 948S Heatburg)*	102	136	9	20,000	9	14,800	7	8,400
7L171 (802S Michichi Creek - 804S Wintering Hills)	102	134	2	1,300	1	600		
7L25 (768S Rowley - 802S Michichi Creek)	104	140	1	800				
7L50 (526S Buffalo Creek - 491LTap)	104	137					1	900
7L53 (7LA53Tap - 700S Bonnyville)	118	147					10	13,000
7L65 (7LA65Tap - 709S Vegreville)	104	133					9	13,000
7L701 (7LA701Tap - 757S Battle River)	135	182					3	2,100
7L760 (7LA760Tap - 767S Oyen)	105	139	2	1,700			7	12,000
7L79 (771S Veteran - 892S Ribstone Creek)	104	132					1	2,700
7L79 (771S Veteran - 932S Pemukan)	104	132					1	1,300
854L (39S Bickerdike - 854ALTap)	155	250	1	500	2	1,900	1	700
890L (58S Edson - 207S Pinedale)	81	81	12	4,400	9	6,500	2	1,100
900L (17S Benalto - 63S Red Deer)	555	670			1	2,200	10	60,000
912L (63S Red Deer - 766S Nevis)*	482	609					10	47,000
914L (86S Bigstone - 87S Gaetz)	474	474					2	4,400
926L (310P Sundance - 17S Benalto)	229	426			2	3,100	9	22,000

[18] Facility ratings are converted from MVA to MW assuming a power factor of 0.95.

Transmission Line	Nominal Rating (MW)[19]		Post-PIC		Pre-Cluster		Post-Cluster	
	Sum.	Wint.	Frequency (%)	Energy (MWh)	Frequency (%)	Energy (MWh)	Frequency (%)	Energy (MWh)
948L/9L948 (650S Hansman Lake - 863S Paintearth)	288	485			1	1,700	1	1,000
953L/9L953 (574S Nilrem - 755S Cordel)	474	474					2	9,000
9L20 (766S Nevis - 755S Cordel)	408	513					4	13,000
9L59 (801S Anderson - 9LA59Tap)	474	474	1	2,800				
9L59 (972S Tinchebray - 9LA59Tap)*	513	686	8	60,000	6	28,000	22	216,000

* For these lines, pre-contingency curtailment for an EATL contingency is included in the congestion results.

[19] Facility ratings are converted from MVA to MW assuming a power factor of 0.95.