

Intertie Restoration Information Session

May 28, 2015

1:30 pm – 4:00pm

Westin Hotel (Bow Valley Room)

1. Welcome and Introduction – Kevin Dawson, Director, Market Design
2. 2015 Summer Limit Changes and 2015/2016 Winter Limit Changes – Ming Jiang, Senior Engineer, Operation Planning
3. Load Shed for Services for Import (LSSi) – Dilhan Rodrigo, Program Manager, Interties
4. Break (15 min)
5. Joint AESO/BCH Intertie Restoration Planning Study – Ebrahim Rahimi, Manager, Long Term Planning
6. Next Steps Regarding Intertie Restoration – Dilhan Rodrigo, Program Manager, Interties
7. Closing – Kevin Dawson, Director, Market Design

2015 Summer and 2015/2016 Winter Intertie Transfer limits

Presented by: Ming Jiang
Senior Engineer, Operation Planning

2015 Summer Intertie Transfer Limit Changes

- Operation planning study has been completed to assess the 2015 summer Alberta import and export capabilities under system normal and various N-1 conditions
- Study based on updated system models incorporating latest and planned transmission upgrades including the Foothills Area Transmission Development East (FATD East) project and the Western Alberta Transmission Line (WATL)

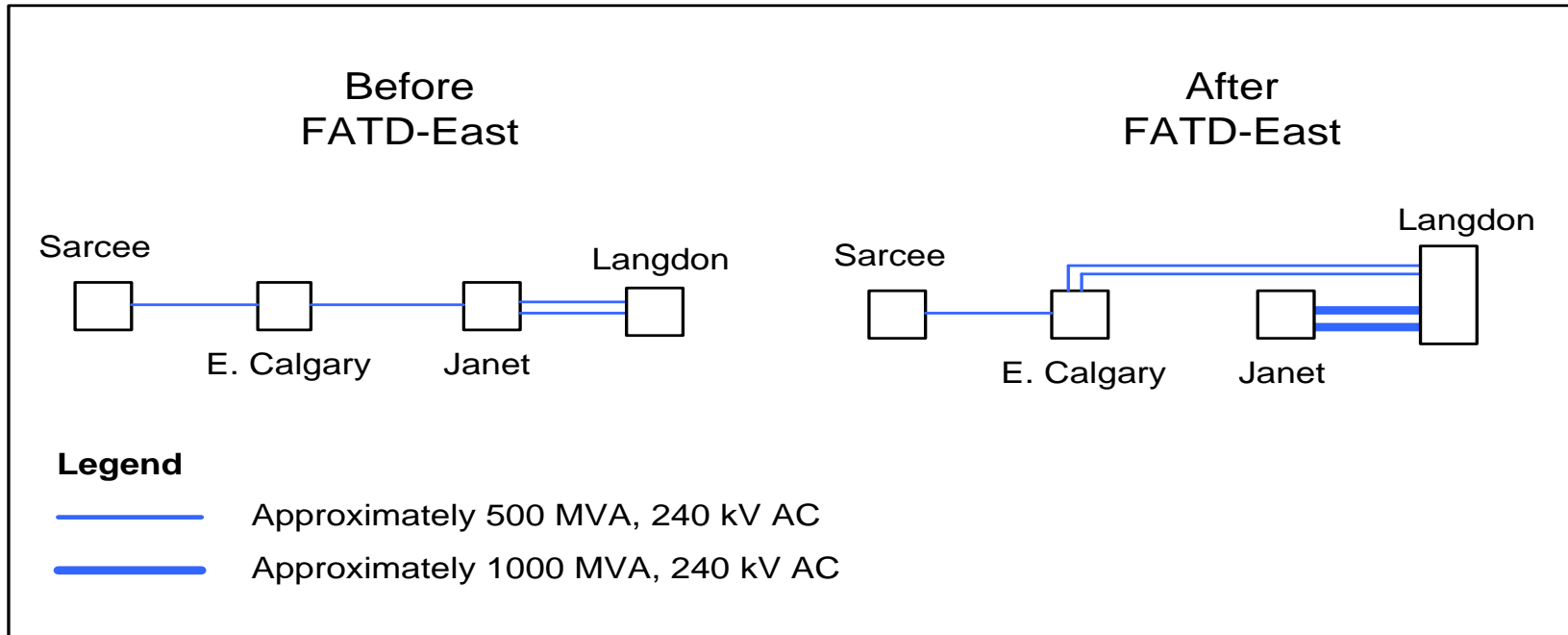
2015 Summer Intertie Transfer Limit Changes



- On April 16, the AESO posted letter with updated ID # 2011-001R which contains the changes to transfer limits
 - A subsequent letter was posted on May 26 regarding a minor correction
- Changes are planned to take effect on June 4 at HE 10
- The summer limit changes are dependent on the completion of the FATD East project which has a planned ISD of May 31
 - If the FATD East ISD is delayed, stakeholders will be notified of a revised effective date for the summer limit changes

Foothills Area Transmission Development (FATD-East) Project

- Part of the FATD-East project is to replace the two 240 kV lines (936L and 937L) between the Langdon substation and Janet substation with higher capacity lines and additional lines between Langdon and East Calgary
 - Expected ISD is May 31, 2015



BC Intertie – 2015 Summer Import Limit Changes

- The results of the study indicate that outage of 936L, 937L, one of the North-South 240 kV lines, 911L or 912L will no longer constrain the BC import
 - This is mainly due to the transmission upgrades from the FATD project
- BC Import TTC will be 800 MW under system normal conditions (unchanged from current limit)

BC Intertie – 2015 Summer Import Limit Changes



New Summer BC Import TTC

AIL	System Normal Import TTC		1201L is out of service	102S Langdon SVC is out of service	
	In	Out	Out	In	Out
All AIL	800 MW	700 MW	65 MW	800 MW	650 MW

BC Intertie – 2015 Summer Export Limit Changes



- The study results indicate that most of the constraints to BC export, such as outage to 936L, 937L, one of the North-South 240 kV lines, or Calgary area capacitor bank, have been eliminated
- The export limit dependency on Alberta internal load level (AIL) is also removed
- The BC export TTC under system normal conditions is 1,000 MW

BC Intertie – 2015 Summer Export Limit Changes



New Summer BC Export TTC

AIL	System Normal		1201L is out of service	102S Langdon SVC is out of service	
	In	Out	Out	In	Out
All AIL	1,000 MW	1,000 MW	80 MW	900 MW	1,000 MW

Combined BC/MATL Import Limit – 2015 Summer Limit Changes

- The Summer combined BC/MATL import limit is 1,110 MW (compared to 800 MW before) under system normal conditions

New Summer Combined BC/MATL Import Limit

AIL	System Normal Import Limit	1201L is out of service
All AIL	1,110 MW	65 MW

Combined BC/MATL Export Limit – 2015 Summer Limit Changes

- The Summer combined BC/MATL export limit is 1,000 MW (compared to 800 MW before) under system normal conditions

New Summer Combined BC/MATL Export limit

AIL	System Normal Export Limit	1201L is out of service
All AIL	1,000 MW	80 MW

Discussion on MATL Operation Without 1201L in Service

- AESO, North Western Energy (NWE), and MATL have discussed the possibility of leaving MATL in service when 1201L is planned to be out of service
- The main concern is the power flow fluctuation which may occur on the MATL line during normal operation due to Alberta system variability if MATL is in service and 1201L is out of service
- NWE cannot accept high levels of power flow fluctuation during normal operation in their system
- It was agreed that MATL cannot operate when 1201L is out of service and therefore no change was required to the ID

2015/2016 Winter Intertie Transfer Limit Changes

- Operation planning study on winter limits in progress
- Study target for completion in summer
- Expect to be similar to summer limits
- Planned for effective date of November 1, 2015
- Stakeholders will be notified of the new limits in Q3 2015

Load Shed Services for Import (LSSi) Updates

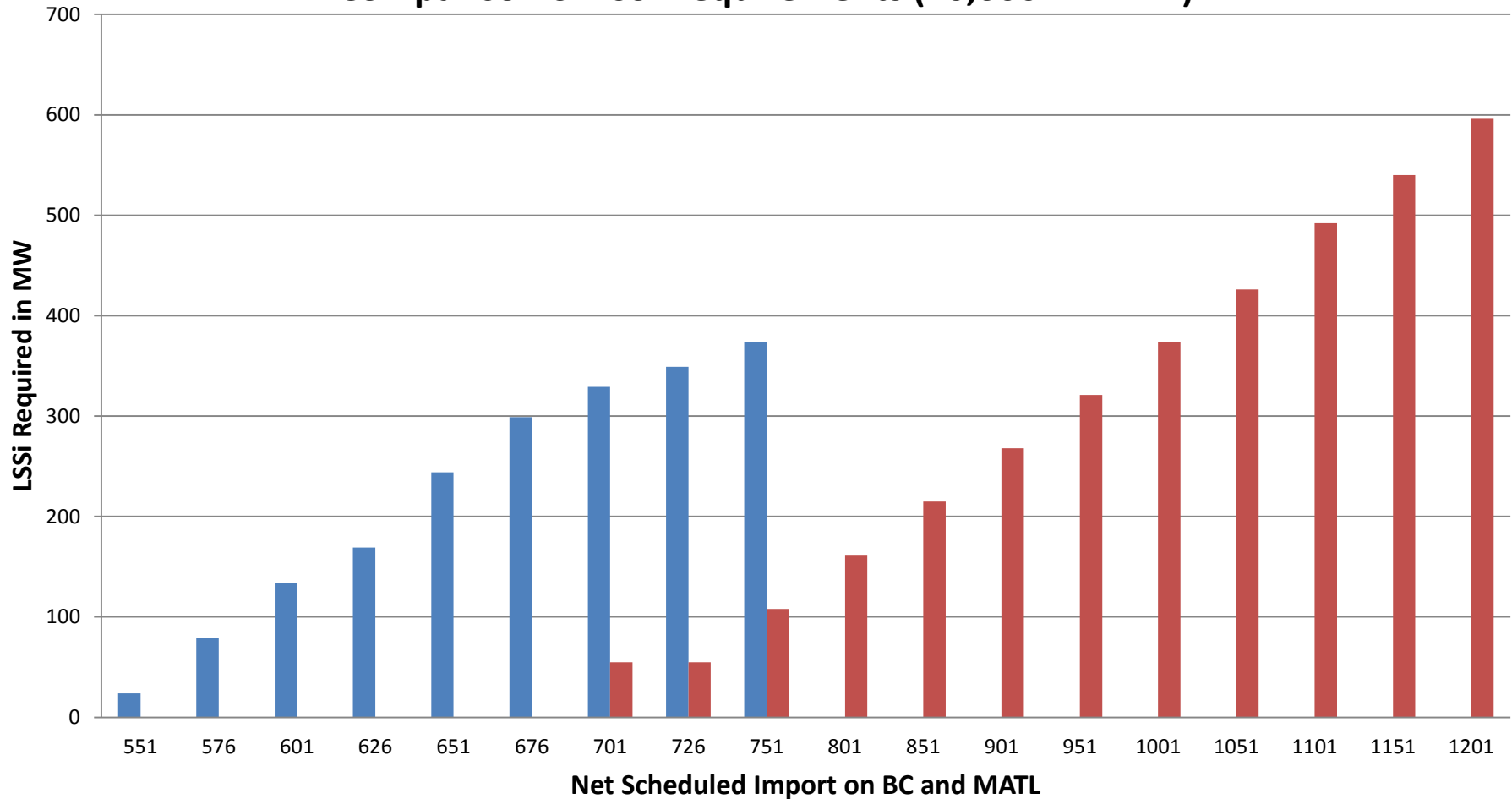
Presented by: Dilhan Rodrigo
Program Manager, Interties

- An LSSi study was completed to review the LSSi volumes required to mitigate intertie trips
- The study determined the amount of LSSi that is required to be armed for scheduled import conditions on the BC and MATL interties at various Alberta load levels (AIL)
- LSSi requirements are determined in order to meet system performance criteria such that the tripping of the LSSi load will prevent operation of the under-frequency load shed (UFLS) program blocks upon a trip of the interties

- LSSi load is modeled in the study to trigger and trip at 59.5 Hz in 200 msec or 12 cycles
- The study used the validated case in which the governor models and load frequency characteristics were tuned based on the data recordings for the July 3, 2012 and June 3, 2013 events where a tie trip resulted in under-frequency excursion in the Alberta system
- Study results were implemented in updates to the LSSi table in ID #2011-001R effective December 11, 2014
- The LSSi requirements in general are lowered
 - For example, at combined BC and MATL import level of 676 MW and AIL of 10,000 MW, LSSi requirement is 0 MW as compared to 299 MW before

LSSi Requirements Have Been Reduced

Comparison of LSSi Requirements (10,000 MW AIL)



■ LSSi Requirements Before Dec 11, 2014

■ LSSi Requirements on and after Dec 11, 2014

Contingency Reserve Requirements Increased

- The lowered LSSi requirements, in some situations, may result in high volume of contingency reserves being required
- If sufficient contingency reserves have not been procured, import ATC will be reduced

Example:

- Combined BC and MATL import = 700 MW
- Armed LSSi = 0 MW
- Contingency reserve required = 700 MW
- Contingency reserve procured day-ahead:
Active = 500 MW Standby = 100 MW
- Shortfall of contingency reserve = $700 \text{ MW} - 600 \text{ MW} = 100 \text{ MW}$
- Import on the BC and MATL interties will need to be reduced by 100 MW

- Reviewing options to improve import forecast and the availability of reserve products and operational processes to ensure import capability is maintained
- **Next Steps:**
 - Identify longer term potential products and/or processes
 - Implementation will follow the AESO process

- A Request For Proposal (RFP) for LSSi service was conducted from December 12, 2014 to March 13, 2015
- The competitive RFP was well received by the marketplace and was successful in attracting both existing and new respondents
- The AESO will execute the new LSSi contracts, subject to Board approval in June, for a 3-year term effective July 1, 2015

LSSi RFP and Contracts

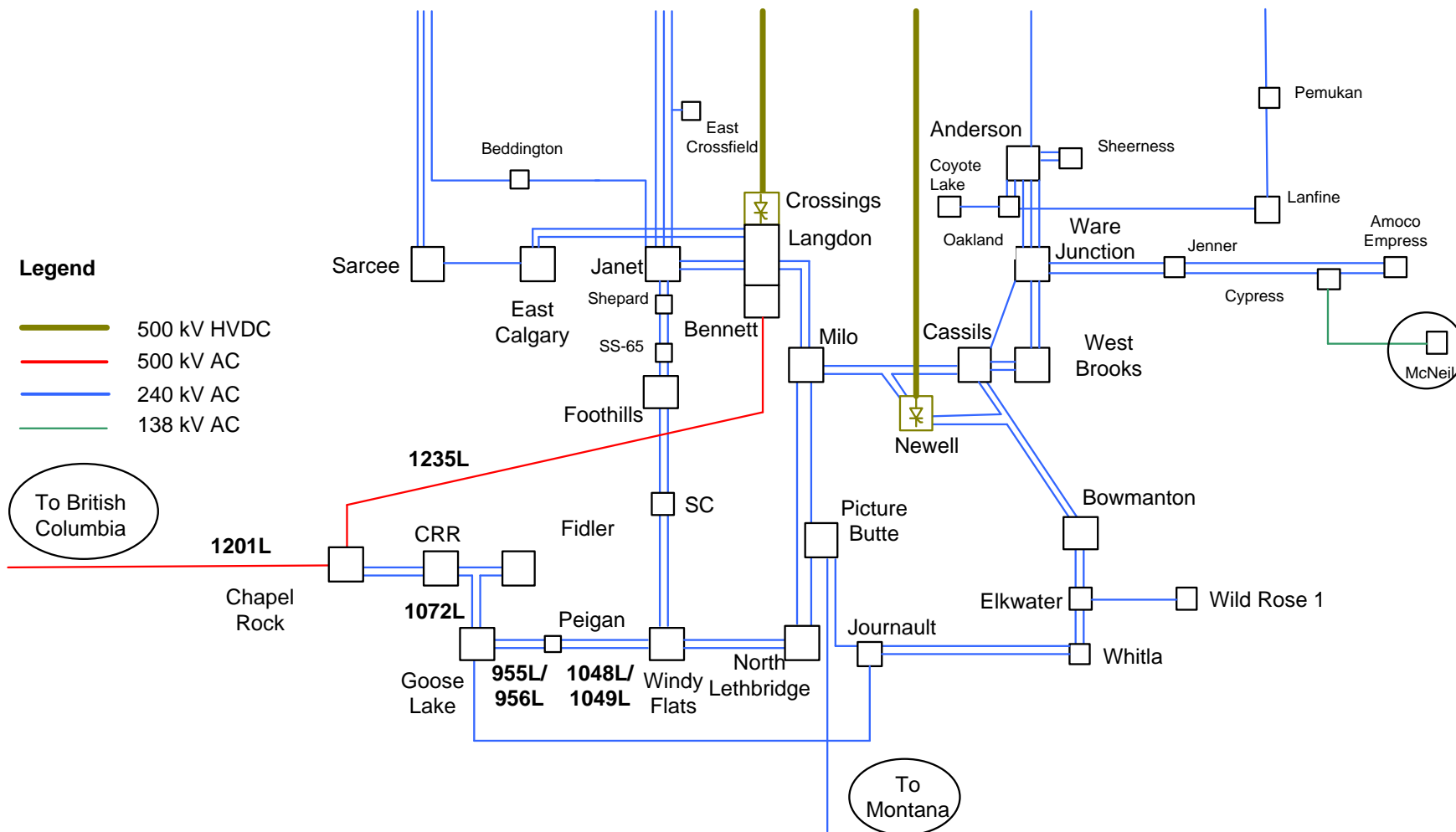
- The RFP sought to procure 350 - 450 MW of LSSi

Combined BC/MT/SOL Import Level (MW) (Note 2 below)	Combined BC/MT ATC Import Level (MW) (Note 2 below)	Minimum LSSi load required (MW) (Note 3 below)											
		AIL (MW) (Note 1 below)											
		less than or equal to 7499	7500 to 7999	8000 to 8499	8500 to 8999	9000 to 9499	9500 to 9999	10000 to 10499	10500 to 10999	11000 to 11499	11500 to 11999	12000 to 12499	12500 to 12999
Below 715	Below 650	0	0	0	0	0	0	0	0	0	0	0	0
716 to 765	651 to 700	75	0	0	0	0	0	0	0	0	0	0	0
766 to 815	701 to 750	128	99	81	73	66	63	55	0	0	0	0	0
816 to 865	751 to 800	182	157	133	129	118	114	108	101	88	69	64	0
866 to 915	801 to 850	240	212	187	182	171	166	161	154	139	120	115	67
916 to 965	851 to 900	302	267	242	232	225	221	215	208	196	178	171	116
966 to 1015	901 to 950	349	323	293	282	278	272	268	264	252	235	222	170
1016 to 1065	951 to 1000	408	375	348	336	333	326	321	317	306	291	272	228
1066 to 1115	1001 to 1050	473	430	394	392	386	383	374	372	360	345	325	274
1116 to 1165	1051 to 1100	517	494	453	449	433	428	426	423	413	398	386	338
1166 to 1215	1101 to 1150	577	562	510	496	494	484	492	485	473	460	446	394
1216 to 1265	1151 to 1200	641	615	569	555	553	542	540	539	533	517	499	453
1266 to 1315	1201 to 1250	678	669	632	612	606	599	596	596	590	575	552	499

Joint AESO-BC Hydro Intertie Restoration Planning Study

Presented by: Ebrahim Rahimi
Manager, Long Term Planning

Alberta System in the South after FATD and Chapel Rock



Study Stages

- Stage 1 – Steady state analysis, focus on AB system
- Stage 2 – Intertie trip dynamic analysis
- Stage 3 – Joint studies with BC Hydro

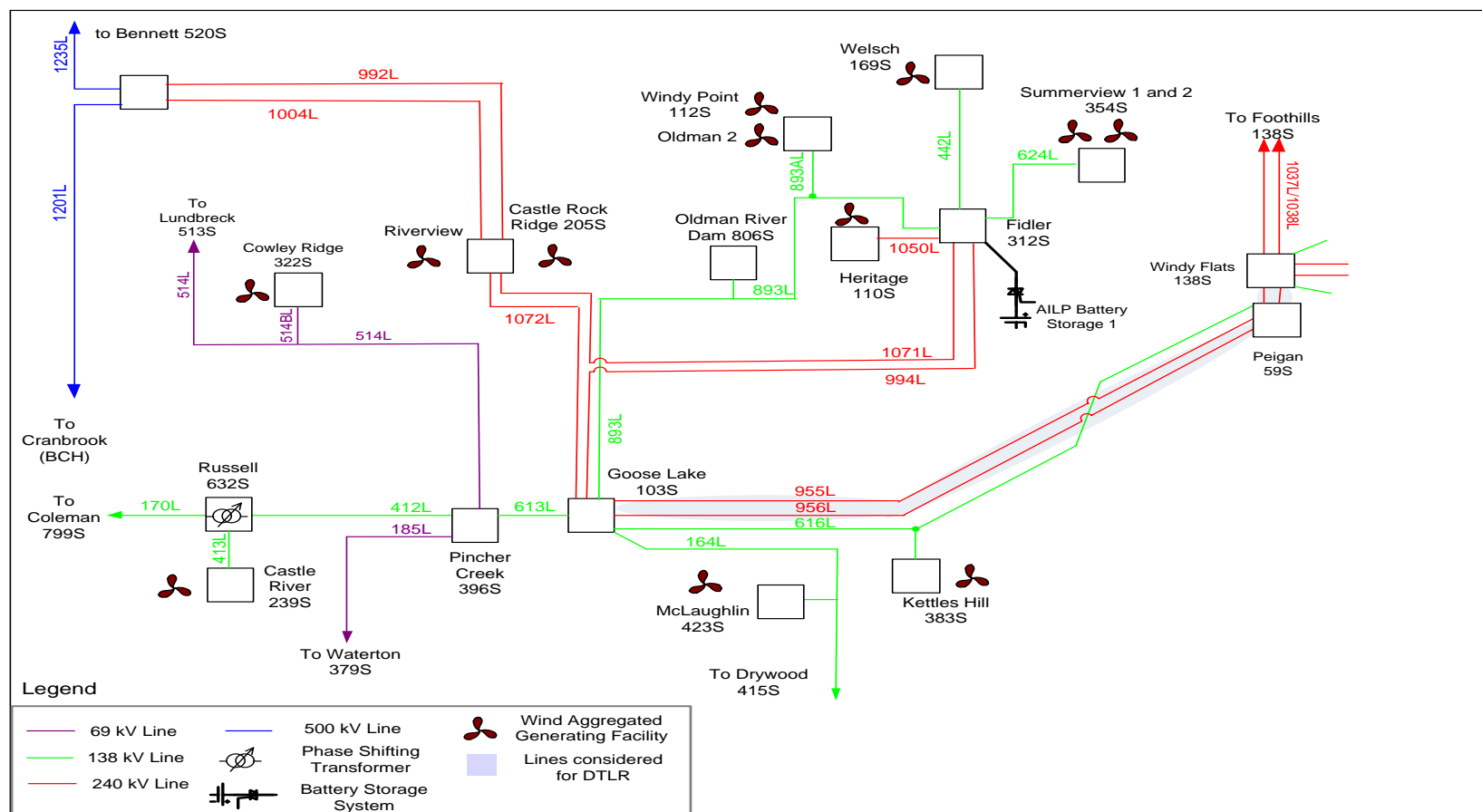
Conclusions of Stage 1 and 2

- From AIES perspective:
 - After Chapel Rock connection, the maximum total import capability is around 1,200 MW assuming 480 MW armed LSSi, winter peak and low wind conditions, and typical load/gen response
- This study confirms Path 1 rating and shows that after Chapel Rock connection, the TTC on Path 1 could be 1,200 MW under certain scenarios
 - Based on WECC Path Rating process, a path rating could be established if the path could operate at the rated value under one credible scenario
- AESO plans the AIES so that the anticipated in-merit energy could flow without congestion under normal conditions
- Intertie flows up to the path ratings are considered to be in-merit energy

- The following scenarios were considered in the studies
 - High import (1,200 MW on BC tie and 310 MW on MATL) and zero to 100% wind
 - High export (1,000 MW on BC tie and 315 MW on MATL) and 100% wind
 - Winter peak, summer peak, and summer light
- The above scenarios were considered in 2014, 2017 without Chapel Rock, 2017 with Chapel Rock and 2022
- The reason for analyzing multiple scenarios with varying levels of wind generation is the inter-dependency of wind in the Pincher Creek area and the Path 1 import capability

Wind Generation in Pincher Creek Area

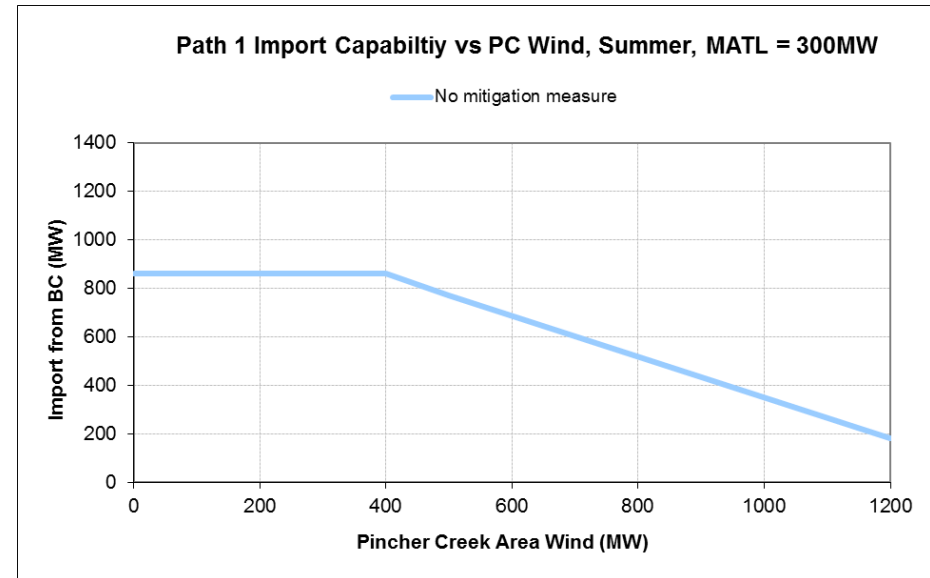
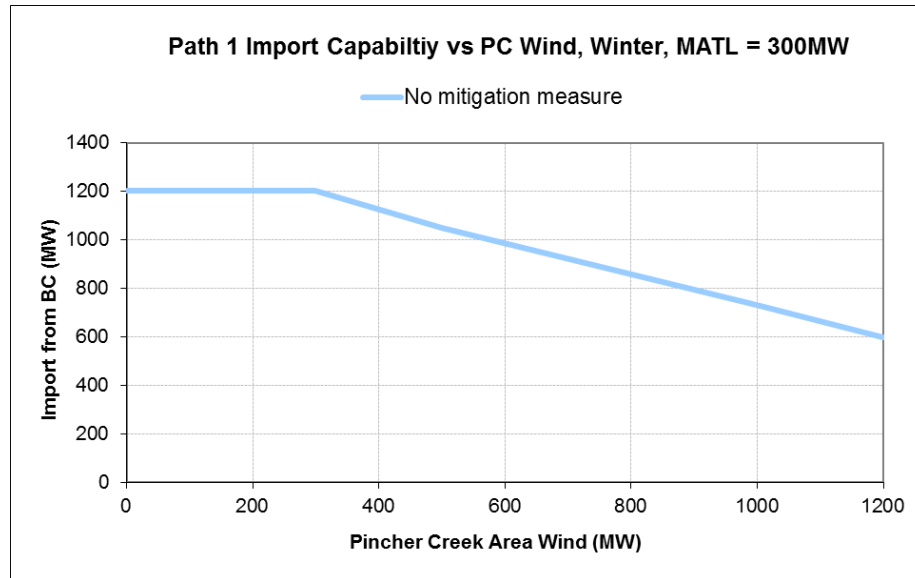
- Currently 456 MW of wind generation is connected in the Pincher Creek area and considering the project list, the total wind generation in the area may reach around 1000 MW in the next 10 years



Pincher Creek area transmission system after Chapel Rock

Path 1 Import Capability vs Wind After Chapel Rock¹ Before any Mitigation

Path 1 import capacity vs wind in Pincher Creek area after Chapel Rock



¹ Considering thermal and voltage performance with contingencies in AB only

Summary of Potential Issues under High Import

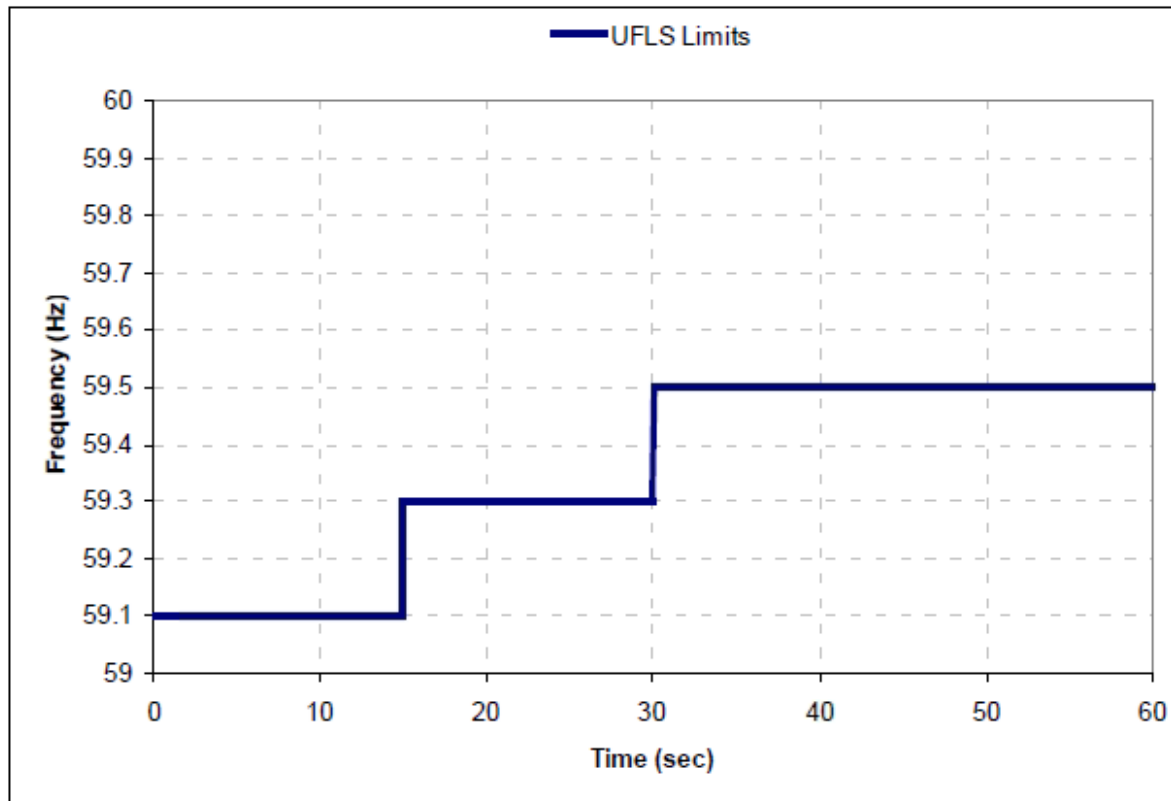
- Overload on 1201L from Chapel Rock to BC border
- Overload on Goose Lake to Windy Flats lines
- Overload on Goose Lake to Castle Rock Ridge line (1072L)
- Overload on 1235L from Chapel Rock to Bennett
- Overload on Bennett 1200MVA transformer
- Overload issues on the Natal to Pocaterra 138 kV transmission path
- Voltage issues at Cranbrook and southern Alberta
- Voltage issues along MATL line
- Frequency management following an intertie contingency

Summary of Potential Issues under High Export

- The overload issues at maximum export are:
 - 1201L from Chapel Rock to BC border
 - Overload issues on the Natal to Pocaterra 138 kV transmission path

AIES Frequency Response Guideline

- Under-Frequency:



- Over-Frequency: Maximum is 61 Hz

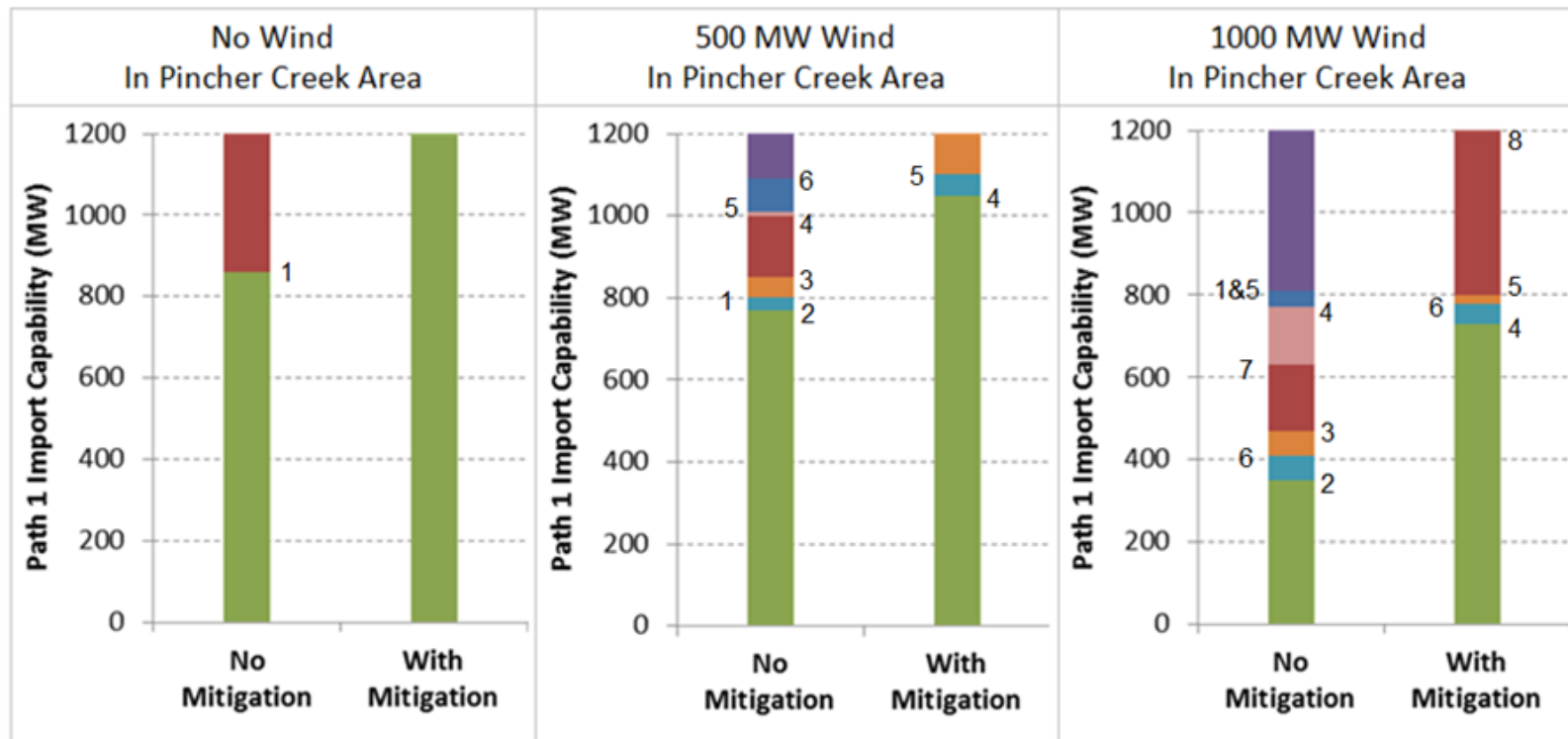
- Assuming a typical load/gen response and 480 MW of armed LSSi, AES can handle 1,200 MW total loss of combined BC and MATL import
- To manage total BC and MATL import above 1,200 MW, the following options could be considered to meet frequency criteria:
 - Increase LSSi
 - MATL HVDC
 - New reserve product
- Frequency response following the intertie trip would be a challenge if the total export is beyond around 1,000 MW
- Possible solutions are:
 - MATL HVDC
 - GSSe (Generation Shedding Scheme for export)

- Upgrade 1201L from Chapel Rock to BC border
- Dynamic transmission line rating (DTLR) on 955L/956L/1048L/1049L
- RAS to trip the intertie for the outage of 1235L under high import and high wind scenarios
- HVDC on MATL (back-to-back HVDC converter)
- Resolve the issue on the 138 kV path from Natal to Pocaterra
 - BC Hydro's current plan is to open the 138 kV line under high transfer

Impact of Mitigation Measures in Summer

- After Chapel Rock and with the assumption that studied mitigation measures are implemented:

Impact of Mitigation Measure on Path 1 Import Capability in Summer



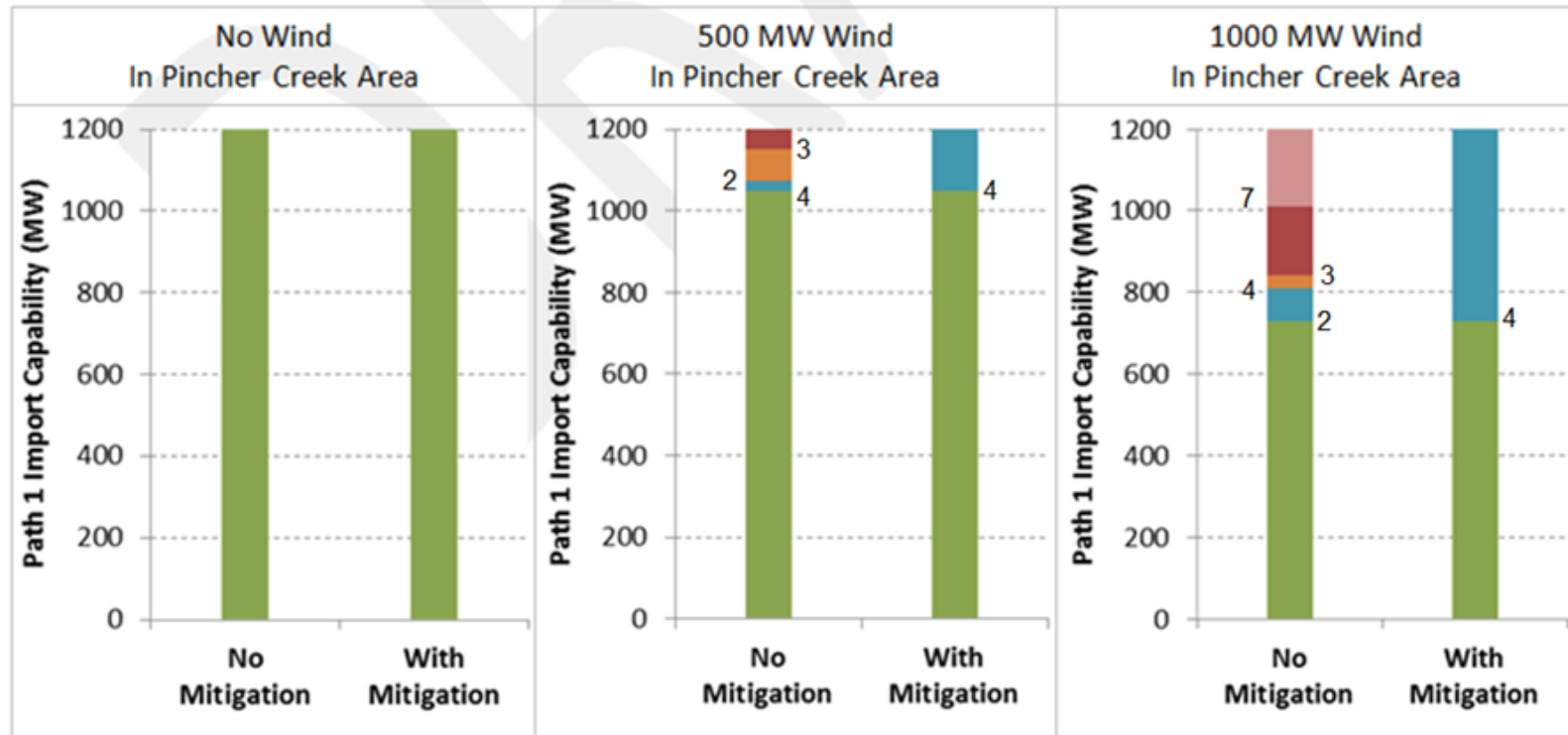
- 1: 1201L overload – Genesee 3 outage
- 2: 1049L overload – 1235L outage
- 3: 955L overload – 1235L outage
- 4: Bennett Tx overload – Genesee 3 outage
- 5: 1235L overload – Genesee 3 outage
- 6: 1049L overload – 1048L outage
- 7: 1072L overload – 1235L outage

- 2: 1049L overload – 1235L outage
- 4: Bennett Tx overload – Genesee 3 outage
- 6: 1049L overload – 1048L outage
- 8: Intertie Trip (CBK low voltage) – Genesee 3 outage

Impact of Mitigation Measures in Winter

- After Chapel Rock and with the assumption that studied mitigation measures are implemented:

Impact of Mitigation Measure on Path 1 Import Capability in Winter

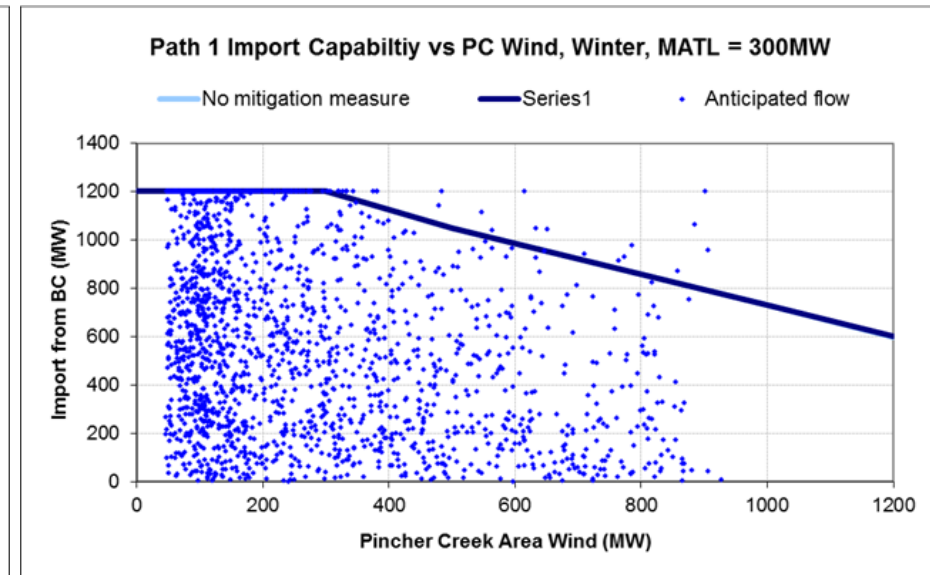
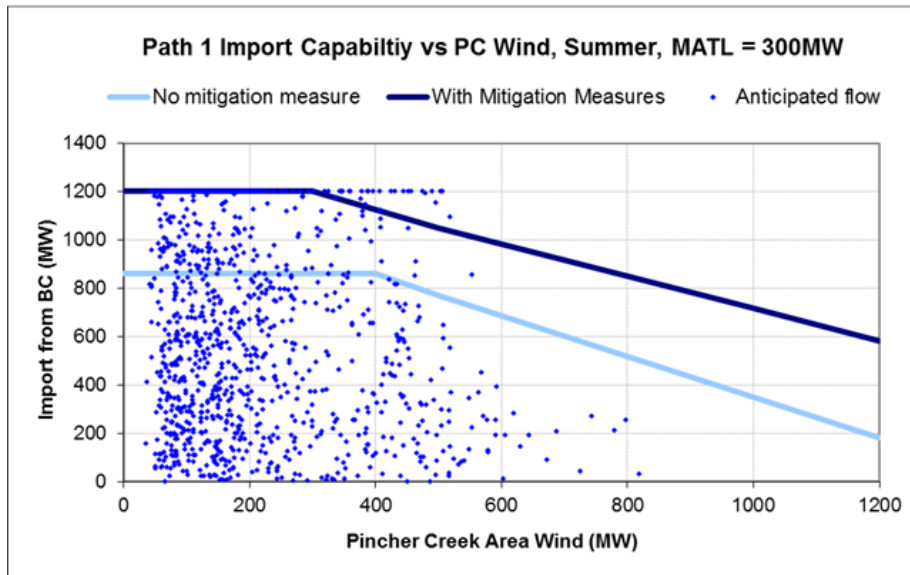


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- 4: Bennett Tx overload – Genesee 3 outage
- 6: 1049L overload – 1048L outage
- 8: Intertie Trip (CBK low voltage) – Genesee 3 outage

System Capability vs Anticipated Flow

- Comparison of the import + wind capability vs the anticipated flow
- The anticipated flows are for year 2022 and are based on AESO's 2012LTO forecast (base line scenario)
- For this analysis, it is also assumed around 50% of wind generation will be in Pincher Creek area



Impact of Mitigation Measures in Reducing Constraints

Scenario	Congestion in Summer (% of time)	Congestion in Winter (% of time)
Without Mitigation Measures	28.8%	1.5%
With Mitigation Measures	4.0%	1.5%

- BC Hydro has also completed an intertie restoration study using jointly prepared base cases
- The study evaluated intertie transfer capabilities from the BC Hydro System perspectives

- For details on the Joint Intertie Restoration Planning Study, please see the following study reports
 - AESO's study report at:
<http://www.aeso.ca/market/20238.html>
 - BC Hydro's study report at:
http://transmission.bchydro.com/transmission_system/engineering_studies_data/studies/interregional.htm

Intertie Restoration Next Steps

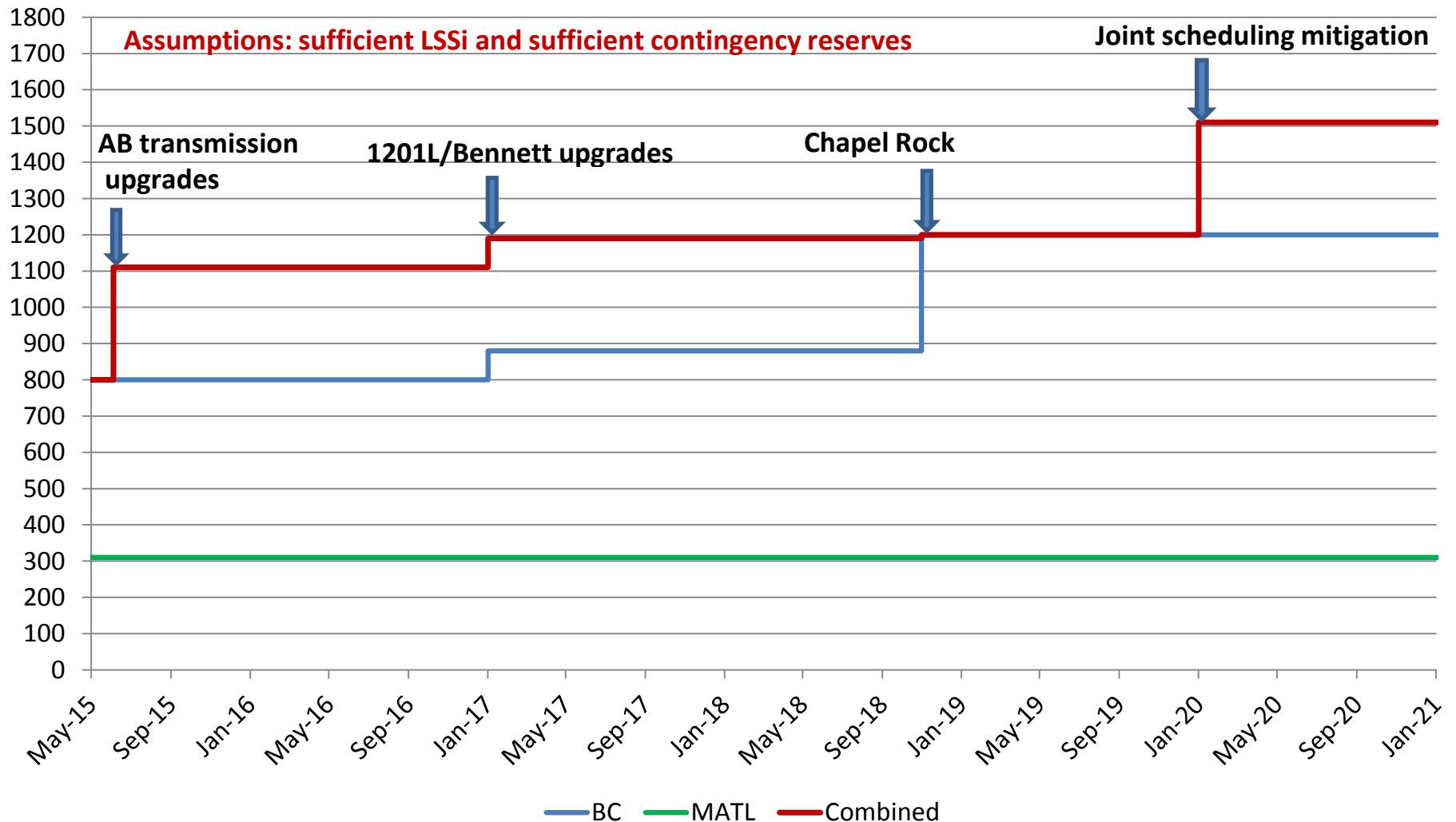
Presented by: Dilhan Rodrigo
Program Manager, Interties

Studied Mitigation Measures the AESO Intends to Pursue Further

- DTLR on Goose Lake to Windy Flats lines
- RAS to trip Path 1 following 1235L outage
- Resolving the overload issue on 1201L from Chapel Rock to BC border
- Resolving over and under frequency issues
 - First step is economic analysis of DC converter on MATL vs potential viable alternatives
- Resolving the issues on the 138 kV Natal to Pocaterra by opening the line
- The system will be monitored and other mitigation measures pursued if AIES reaches its capability
 - Imports will be curtailed in rare instances of simultaneous high wind and maximum import

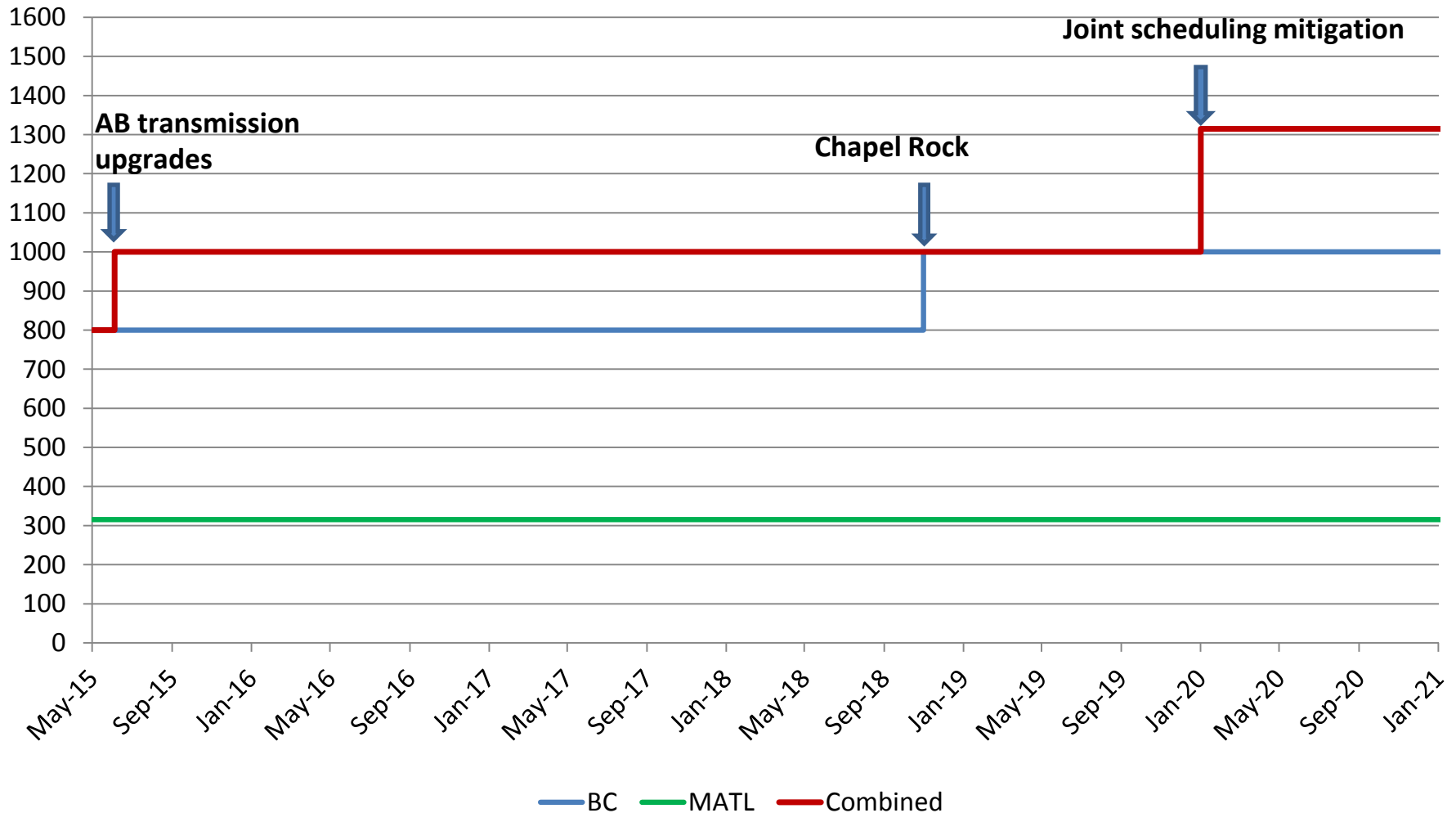
Approximate Timeline for Import Limits

Approximate Timeline for Import Limits Changes



Approximate Timeline for Export Limits

Approximate Timeline for Export Limits Changes



1201L and Bennett Transformer Upgrades

- The AESO is investigating potential upgrades to 1201L and the Bennett transformer which may:
 - Allow increase to BC import TTC to approximately 880 MW and combined BC/MATL TTC to 1,190 MW before Chapel Rock
 - Increase capability to accommodate high BC import and high wind generation in the Pincher Creek area post Chapel Rock
- Will increase the thermal static capacity of 1201L and increase the Bennett transformer emergency rating
- Direction letter for 1201L and Bennett transformer rating assessment and mitigation measures cost estimates issued to AML

Chapel Rock – Key Milestones

- Proposal to Provide Service Cost Estimate (PPS)
 - August 2015
- Facility Application
 - End 2015
- Expected Permit and License
 - Q4 2016
- Planned In-Service Date
 - October 2018
- Risks to ISD includes TFO facility application process taking longer than one year as planned

- The objective is to facilitate combined import TTC of up to 1,510 MW (1,200 MW on BC and 310 MW on MATL) and combined export TTC of up to 1,315 MW (1,000 MW on BC and 315 MW on MATL)
- Currently conducting an options analysis on possible frequency mitigation solutions that includes:
 - A back-to-back HVDC converter on MATL
 - Procuring additional LSSi
 - Developing new products
 - Use of emerging technologies such as storage, etc.
- We currently expect this exploratory work to be completed by the end of Q4 2015
- **Next steps:**
 - Implement solution(s) following AESO process

Thank you!