Most Severe Single Contingency (MSSC) Evaluation for Alberta

Nov. 4, 2021

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AESO Stakeholder Engagement Framework

Stakeholder participation

The participation of everyone here is critical to the engagement process. To ensure everyone has the opportunity to participate, we ask you to:

- Listen to understand others' perspectives
- Disagree respectfully
- Balance airtime fairly
- Keep an open mind

Introduction

Dennis Frehlich, P. Eng.
Vice President, Grid Reliability

Session purpose and objectives

- Provide stakeholders with a foundational understanding of the concept of Most Severe Single Contingency (MSSC)
- Review current limits of MSSC
  - Provide the technical requirement for the current Static MSSC Limit
- Present the AESO's analyses of higher Static MSSC Limit, including explaining the AESO's methodology and assumptions used, and seek stakeholder feedback
  - Provide the reliability and economic implications of increasing the Static MSSC Limit above the currently set 466 MW limit

Agenda

Time	Agenda Item	Presenter
9:00 – 9:15	Welcome, introductions, purpose and session objectives	Dennis Frehlich
9:15 – 9:45	Overview of MSSC	Biju Gopi
9:45 – 10:00	Key Technical Challenges to Raising the Static MSSC Limit	Biju Gopi
10:00 – 10:30	Key Tie-Line Path Protection Schemes for System Reliability • Q&A	Ralph Liu
10:30 -10:45	Break	
10:45 – 11:15	Key Findings - Market & Economics Analysis • Q&A	Nick Jansen
11:15 – 11:30	Session summary and next steps	Dennis Frehlich

Registrants (as of Oct. 28, 2021)

- ABO Wind
- Alberta Newsprint Company
- AltaLink Management Ltd.
- Alberta Utilities Commission (AUC)
- BBA Consultants
- Best Consulting Inc.
- Boost Energy Ventures Inc.
- Capital Power Corporation
- City of Medicine Hat
- Customized Energy Solutions Ltd.
- DePal Consulting Limited
- ENMAX
- EPCOR
- Greengate Power Corporation
- Heartland Generation Ltd.
- Hitachi Energy
- IBI Group
- Independent Power Producers Society of Alberta (IPPSA)
- Industrial Power Consumers Association of Alberta (IPCAA)
- Lionstooth Energy Inc.
- Market Surveillance Administrator (MSA)
- NorthPoint Energy Ltd.
- Power Advisory LLC
- Power Grid Specialists Corporation (PGSC)
- Powerex Corp.
- Stantec
- Suncor Energy
- TC Energy
- TransAlta
- WCSB Power

Overview of MSSC

Biju Gopi

Manager, Operations Engineering & Market Support

What is MSSC?

- The Most Severe Single loss of supply Contingency that the power system can absorb without impacting reliability and tripping customer load
  - A single generator trip or the loss of a combined-cycle plant configured as a single unit
  - A transmission line tripping off connected generating plants
- Different MSSC states to consider
  - Static MSSC : based on study analysis
  - Real-time MSSC : based on actual output at the time

Current Static MSSC Limit is 466 MW

- System reliability limit to manage frequency risk
  - If exceeded, instantaneous tie-line inrush risks tie-line tripping and consequent triggering of under-frequency load shed (UFLS) across the province
  - Sets MSSC limit in real time operations
  - Reduced to 425 MW if Alberta is islanded
- Coordinated with neighboring jurisdictions to manage power balancing obligations
  - Reserve planning and reporting to Reserve Sharing group
- Limits single size of new connection projects and cumulative exposure to a single line trip or remedial action scheme (RAS)

Why are we assessing increasing or decreasing the Static MSSC Limit now?

- Various industry changes are driving the need to assess whether to increase, decrease or keep the current Static MSSC Limit
  - Reasons to increase
    - Larger single connection projects
    - Larger coal-to-gas conversion projects
    - Increasing penetration of renewables and distributed energy resources (DERs)
  - Reasons to decrease
    - Primary frequency response capability and recent UFLS events
    - Increasing penetration of renewables leading to declining system inertia
    - Generation curtailment during islanded conditions

Numerous trade-off implications when assessing the Static MSSC Limit

- Reliability/Technical
  - UFLS not permitted for the loss of the Static MSSC Limit
    - When connected to WECC or islanded from WECC
    - For the next contingency
  - Any MSSC increase may result in an equal reduction to total transfer capability (TTC) on the tie-line Paths
  - Any increase requires WECC and neighboring jurisdiction support to ensure no material reliability impact on their power systems due to instantaneous power inrush for loss of MSSC
- Economic/Market
  - Assess costs incurred if Static MSSC Limit is increased
  - Assess benefits achieved if Static MSSC Limit is increased
  - Maintain a level playing field

Key Technical Challenges to Raising the Static MSSC Limit

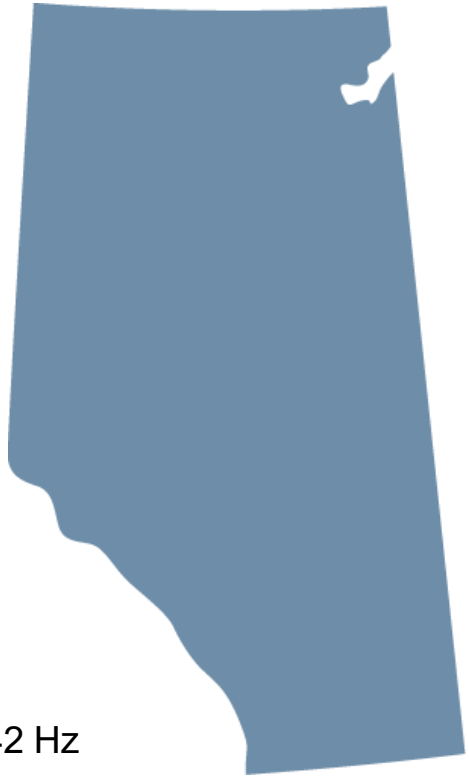
Biju Gopi

Manager, Operations Engineering & Market Support

Recent system events in Alberta indicate a growing frequency response challenge

June 7, 2020
- AB-BC Intertie Trip
- Frequency dropped to 59.15 Hz
- UFLS activated (235 MW)
- LSSi activated (188 MW)

October 16, 2020
- Islanded Mode of Operation, Internal Generation (267 MW) trip
- Frequency dropped to 59.57 Hz for such a small disturbance
- No UFLS was triggered



February 21, 2021
- AB-BC Intertie Trip
- Frequency dropped to 59.44 Hz
- UFLS activated (125 MW)
- No LSSi activated

February 22, 2021
- AB-BC Intertie Trip
- Frequency dropped to 59.48 Hz
- No UFLS activated
- LSSi activated (208 MW)

June 3, 2021
- AB-BC Intertie Trip
- Frequency dropped to 59.42 Hz
- UFLS activated (177 MW)
- LSSi activated (93 MW)
- 60 MW of DERs tripped

October 23, 2021
- Islanded Mode of Operation, Internal Generation (395 MW) trip
- Frequency dropped to below 59.5 Hz for 4 seconds
- No UFLS was triggered

Key reliability and technical considerations

- System Reliability
  - Recent UFLS events have shown challenges with increased penetration of renewable resources and DERs, declining inertia, inconsistent system response, and generation pull-back
  - Increasing MSSC levels increases the probability of UFLS events until mitigation plans are implemented and proven effective
- Contingency Reserve Requirements
  - The AESO, as the Balancing Authority for Alberta, must carry sufficient operating reserves to manage MSSC
  - Increasing MSSC may increase ancillary service costs to the Alberta ratepayer
- Mode of Operation
  - Connected to the WECC
    - Interties can provide system support during internal contingencies
  - Operating as an island or weakly connected to the WECC
    - Entirely dependent on internal generation and load response during internal contingencies

Technical Reasons for Current MSSC Static Limits

- Each Path's TTC is determined by the most limiting of thermal rating, voltage, transient stability or path rating
  - Path 1 (BC) : Import TTC = 800 MW
    - Limited by facility thermal rating of Bennett transformer, and then by voltage stability
  - Path 83 (MATL) : Import TTC = 310 MW
    - Limited by path rating, and then by voltage stability

- Instantaneous power inrush on tie-line Paths will split based on the system impedance and corresponding distribution factor (DF)
  - DF between Path 1 and Path 83 is approximately 4 to 1
  - 80% flows on Path 1 and 20% flows on Path 83
  - If 100 MW of internal supply is lost, 80 MW would rush in on Path 1 and 20 MW would rush in on Path 83
  - The loss of internal supply must not result in exceedance of our system operating limit (SOL) per reliability standards

Examples of impact on TTC from increased Static MSSC Limit

Total SOL 1600 MW
Path 1 SOL 1200 MW Thermal Rating (Bennett Transformer)
Path 83 SOL 400 MW Voltage Stability Limit

Tie-line available capacity 466 MW	Total TTC 1,110 MW Path 1 TTC 800: 1200 – (466 X .8) Path 83 TTC 310: 400 – (466 X .2)
Tie-line available capacity 600 MW	Total TTC 1,000 MW Path 1 TTC 720: 1200–(600 X .8) Path 83 TTC 280: 400–(600 X .2)

Key Technical Findings

- While interconnected to the WECC, increasing the Static MSSC Limit would be technically acceptable if, *and only if*:
  - There is sufficient available capacity on the tie-lines to handle the instantaneous power inrush

and

  - The loss of a higher Static MSSC Limit does not result in a reliability violation and/or tripping of the tie-lines due to triggering tie-line RAS/ protections

and

  - Sufficient contingency reserves can be procured
- While islanded from the WECC or weakly connected
  - Static MSSC limit set at 425 MW, based on technical studies
  - Improved primary frequency response is needed in order to consider raising this limit

Key Tie-Line Path Protection Schemes for System Reliability

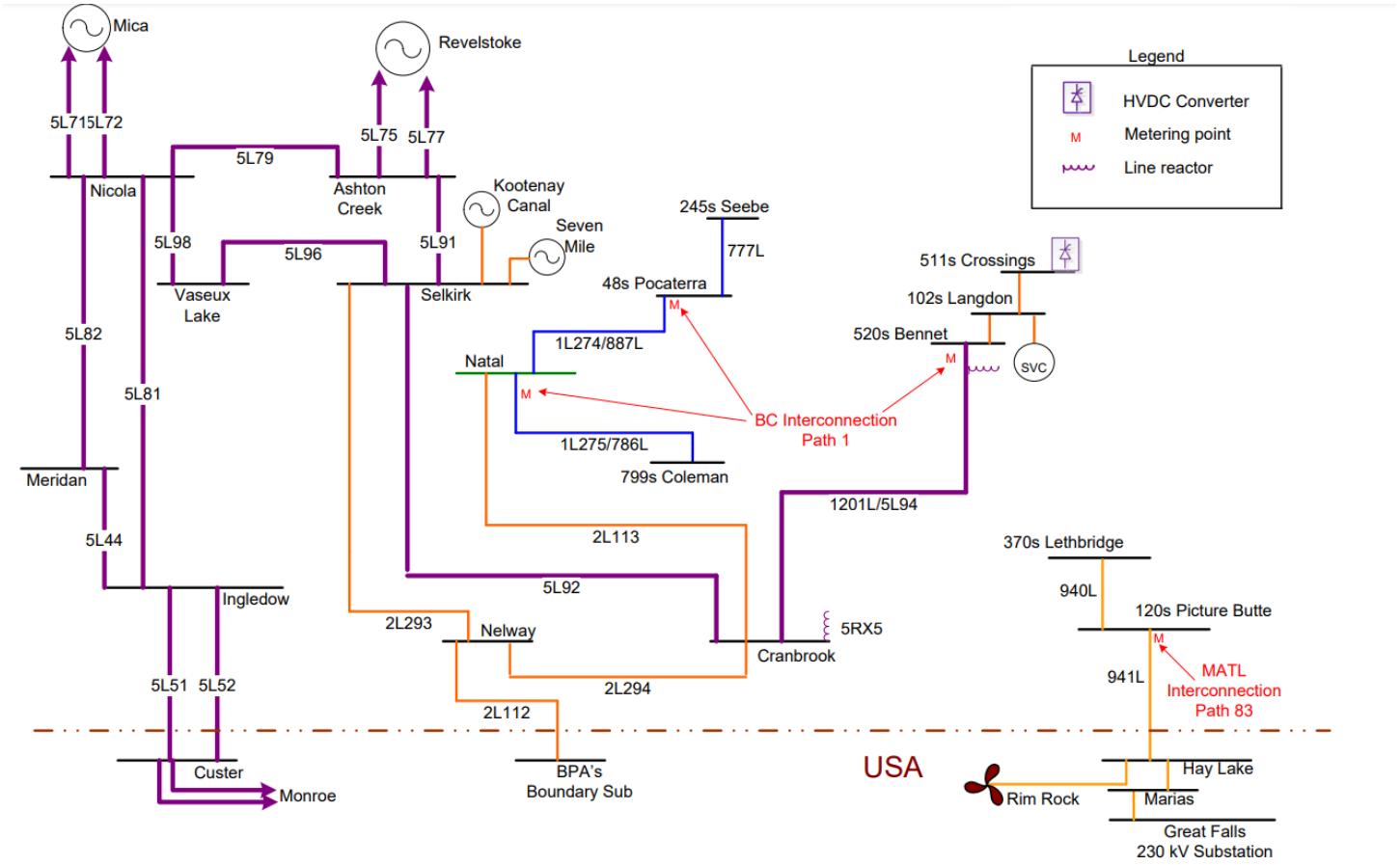
Ralph Liu

Senior Engineer Specialist,

RAS, Operations Planning

Several critical RASs to enable controlled separation from our neighbours

- Any changes to these RASs/schemes (referred to as RASs) would require collaboration, joint review, technical studies & operating agreements with neighbouring reliability coordinators (RCs)

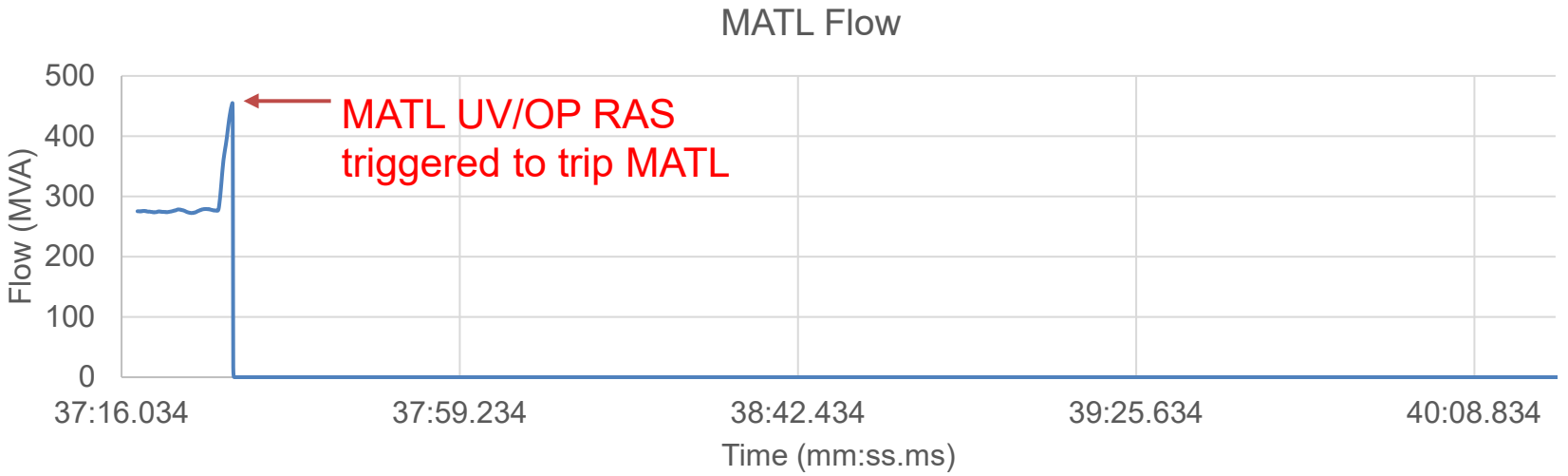


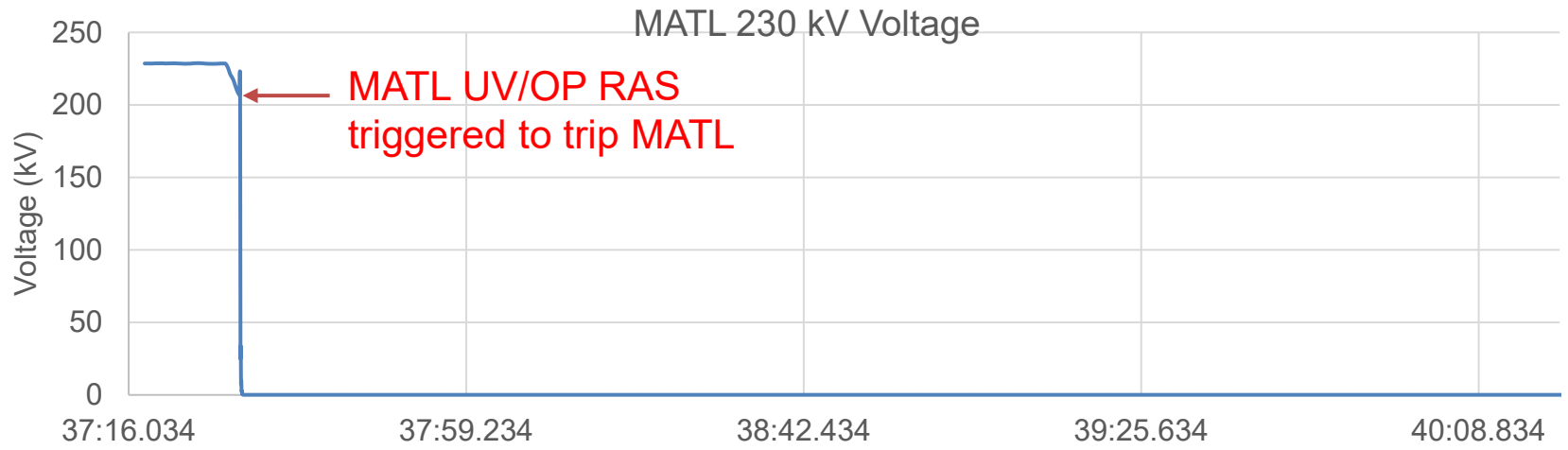
Key RASs protecting the tie-line Paths

- The Alberta interconnected electric system (AIES) is at the tail end of the WECC and is therefore intentionally planned with controlled separation and sensitive tie-line Path tripping
- These RASs have been studied with Static MSSC Limit of 466 MW
- #137 MATL Local Detection RAS (one module shown below): trip Path 83 (MATL)
  - MATL flow into Alberta > 430 MVA AND
  - (230 kV bus voltage at 120S <0.92 p.u. for 0.33 sec) or (230 kV bus voltage at 120S < 0.87 p.u. for 0.25 sec)
- #6 Cranbrook Undervoltage or Overpower RAS: trip 5L94/1201L (BC)
  - Cranbrook 500 kV bus voltage <421 kV for 0.5 sec
- #9 Natal Undervoltage RAS : trip 138 kV tie-lines on Path 1 (BC)
  - Natal 138 kV bus voltage <117.3 kV for 0.5 sec
- #136 Direct Transfer Trip to MATL : trip Path 83 (MATL)
  - Loss of 1201L Path to BC

April 4, 2021 ~670 MW supply loss demonstrates importance of these RASs

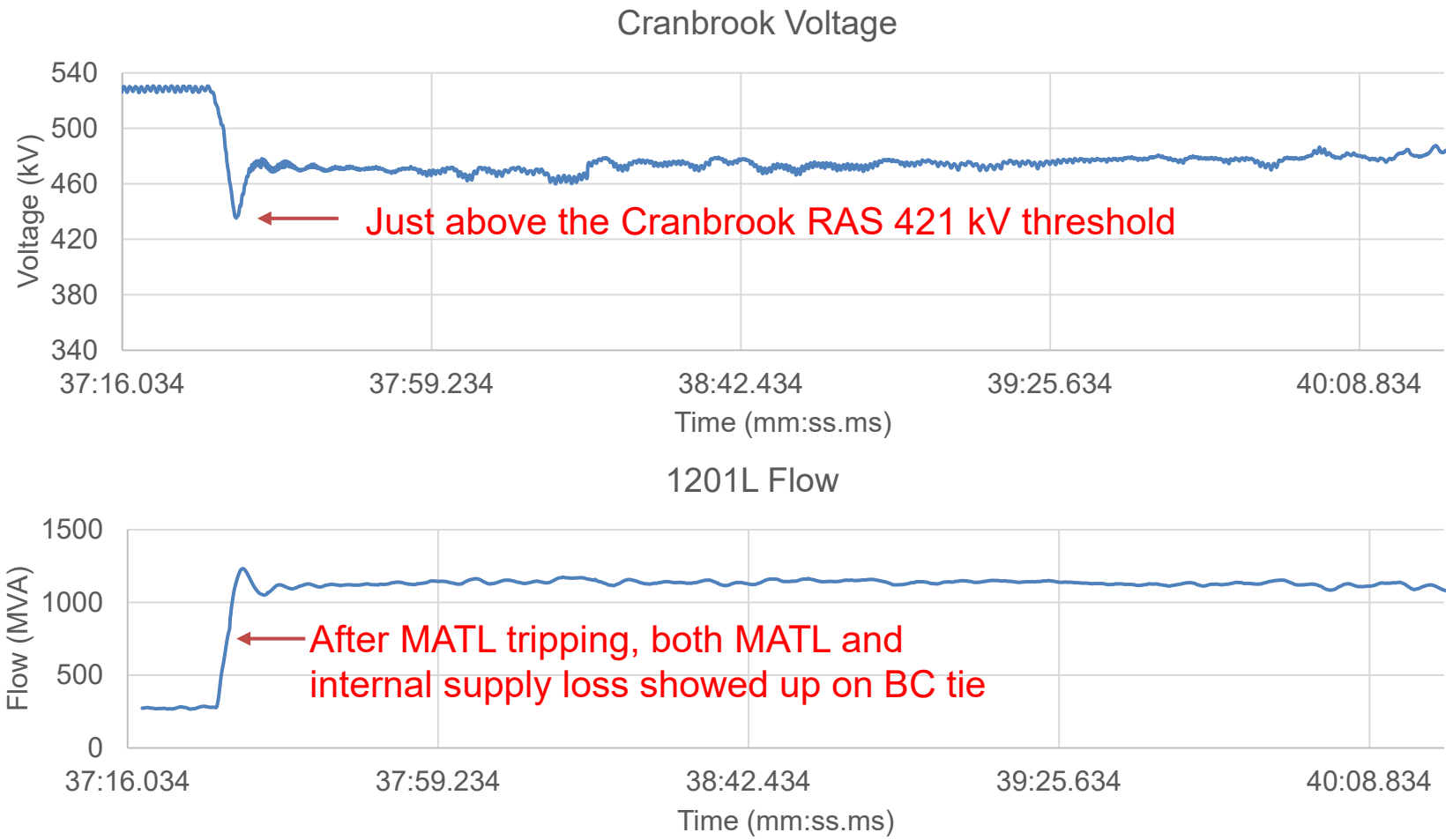
- Path 83 could not handle the power flow inrush, tripped by the Undervoltage and Overpower (UV/OP) RAS





April 4, 2021 ~670 MW supply loss demonstrates importance of these RASs

- Fortunately, Path 1 was lightly loaded at the time and handled the power flow inrush without tripping



Connection project considerations

- Increasing the Static MSSC Limit would enable more connection project configuration flexibility
- Connection projects must respect the current Static MSSC Limit
  - Large combined-cycle projects applied various generation configurations to stay below MSSC limit (e.g. Cascade, “2-on-1” configuration with Shepard)
  - Renewable projects have relied on automatic control to limit Maximum Capability (MC)
  - Some projects must connect with in/out rather than T-tap
  - Cumulative generation on a single RAS must be managed
    - MSSC limit not directly applicable to cumulative MC tied to RAS in planning/connection stage due to diversity factors
    - Cumulative MW tripped by RAS in real time must respect Static MSSC Limit
    - Typically, other limits are reached first (e.g. N-0 thermal, voltage)

Key reliability/technical takeaways

- Determining a safe Static MSSC Limit relies upon complex technical analysis that is difficult to simulate precisely
- Increasing Static MSSC Limit increases reliability risk on the entire system and exposes customers to higher outage risk
- Exceeding Static MSSC Limit can result in cascading tie-line tripping exacerbating reliability risk
- Neighbouring jurisdictions may be impacted by increasing the Static MSSC Limit and may need to be supportive of any changes
- Import TTC may be reduced 1:1 for any increase in Static MSSC Limit to avoid tie-line SOL exceedance for the loss of MSSC

Questions?

Break

Key Findings - Market and Economic Analysis

Nick Jansen

Senior Economist

Two main economic factors to consider when increasing Static MSSC Limit

Analyzed one option, the impact of increasing the Static MSSC Limit by reducing the TTC of the BC and MATL tie lines, which would:

1. Reduce the ATC on the BC and MATL tie-lines, thereby reducing import volumes and, by extension, LSSi arming

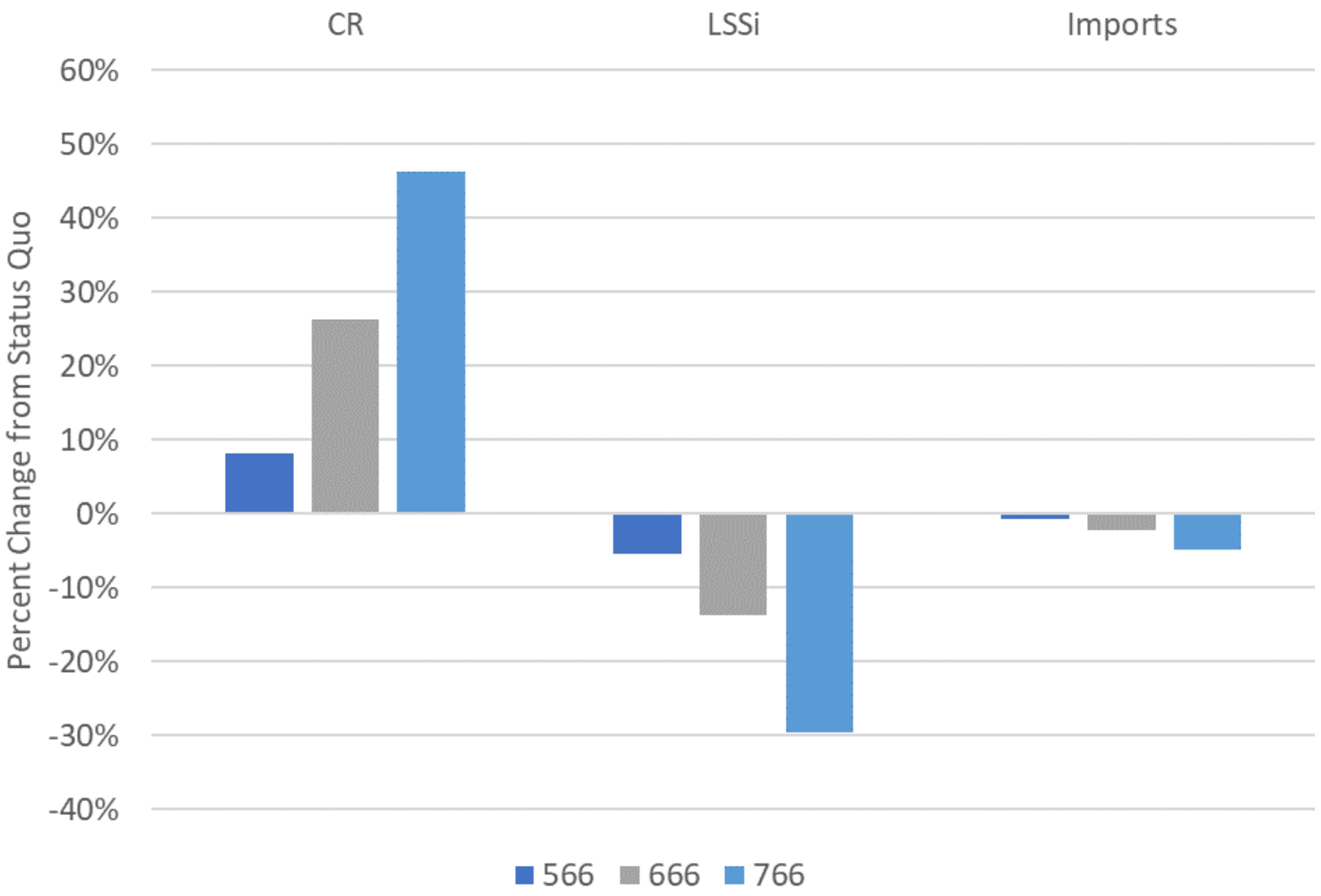
2. Increase the amount of active contingency reserves (CR) needed to rebalance after loss of supply

   – *The AESO must procure CR to meet greater of MSSC or 3&3 volume*

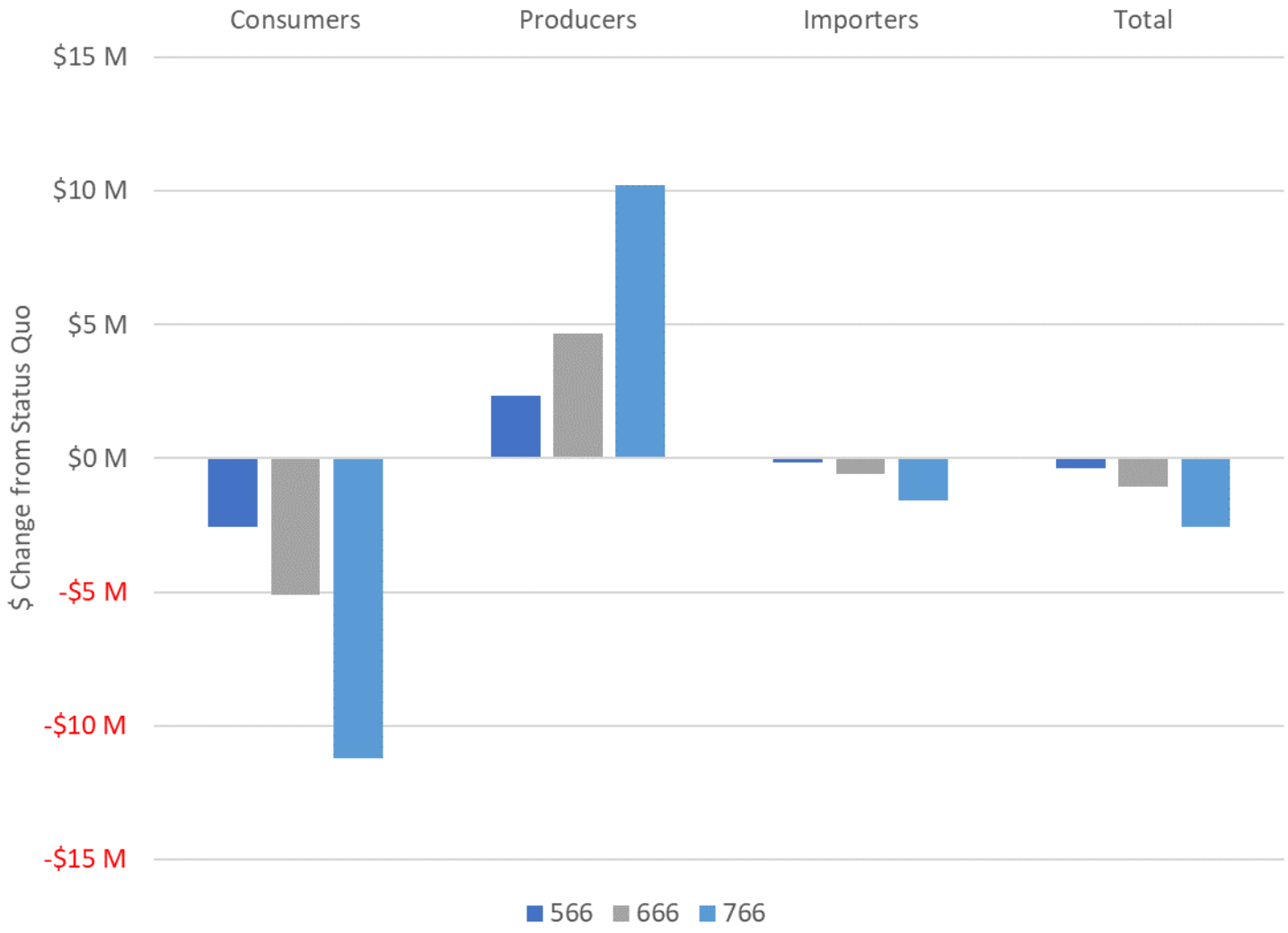
Counterfactual analysis performed to assess directional economic impacts

- Used 2016 - 2020 (inclusive) as test years, since they capture a broad range of recent market conditions
- Evaluated three MSSC levels: 566 (+100), 666 (+200), and 766 (+300) MW
- Estimated the change from status quo in required CR volume, armed LSSi volume, and import volume
- These volume changes were then used to estimate cost impact to overall ancillary service costs and the energy market
- **All else being equal**, decreasing imports removes in-merit generation from the energy market.
  - Causes dispatch up the merit order and an increase in pool price
  - Pool price increase reduces consumer surplus, increases producer surplus; importers gain on existing imports but lose on lost imports, so impact on importer surplus is ambiguous
  - Overall, total surplus must decrease, since it equals increase in energy production cost from replacing lower-cost imported generation with higher-cost domestic generation

Annual Change in Volume (2016 - 2020), by Static MSSC Limit

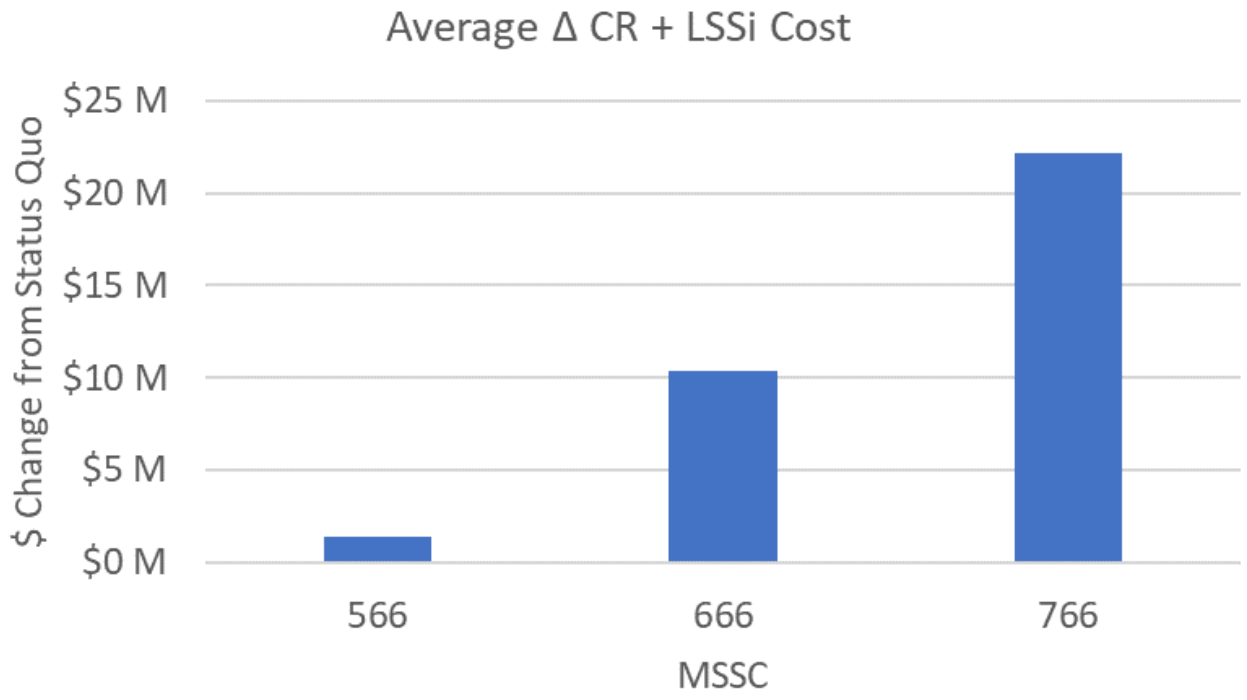


Annual Change in Economic Surplus (2016 - 2020), by Static MSSC Limit



Annual Change in net AS Cost (2016 – 2020), by Static MSSC Limit

- Net ancillary services costs consider higher CR costs offset by lower LSSi costs



Key economic/market analysis takeaways

- Ancillary service costs and energy market impacts increase non-linearly with a higher Static MSSC Limit
- There is an expected net increase in ancillary service costs to enable a higher Static MSSC Limit
- A higher pool price due to lower import volumes would transfer money from Alberta consumers to Alberta generators; total surplus would decrease
  - Importers would be less impacted as a pool price increase would partially offset the reduction in import volume due to a lower TTC
- A higher Static MSSC Limit would create a larger gap to the current limit of 425 MW when islanded, resulting in potentially higher costs during islanded operation

Questions?

Next Steps

AESO decision making on Static MSSC Limit

- The AESO will first make a decision on whether to consider increasing the Static MSSC Limit
  - Stakeholder feedback will be considered in our decision making
  - FEOC will be a key principle in our decision making
  - Key decision factors will be:
    - Reliability risk to Alberta consumers
    - Economic cost/benefit to Albertans
    - The complexity of enabling any change with neighbouring jurisdictions
- If the AESO determines to pursue an increase in the Static MSSC Limit, we will then move forward with:
  - Determining the level of increase that can be accommodated
  - Engaging neighbouring jurisdictions, including WECC, on potential barriers to increasing levels of our Static MSSC Limit
  - Determining how best to coordinate this change with other AESO initiatives

Next Steps

- We appreciate your engagement today and would ask you take a moment to provide your quick feedback on this session through this Zoom poll
- We invite all interested stakeholders to provide their input to us on this important topic through the **Evaluation of MSSC Stakeholder Comment Matrix on or before Nov. 19, 2021**. The matrix is currently available on our website at Evaluation of MSSC » AESO
- Stakeholder comments will be available on our website by Nov. 26, 2021
- We will have a follow-up stakeholder session in Q1 2022 to share our decision on whether the AESO will be considering an increase to the Static MSSC Limit or not, and why

Contact the AESO

- ***Twitter:*** *@theAESO*
- ***Email:*** *info@aeso.ca*
- ***Website:*** *www.aeso.ca*
- Subscribe to our stakeholder newsletter

Thank you

Appendix – Acronyms

Key Acronyms

- AIL = Alberta Internal Load
- AS = ancillary service
- CR = contingency reserve
- CS = consumer surplus
- LSSi = Load Shed Service for imports
- MATL = Montana Alberta Tie-Line
- MC = maximum capability
- MSSC = Most Severe Single Contingency
- OR = operating reserve
- RAS = remedial action scheme
- RC = reliability coordinator
- SOL = system operating limit
- TCR = transmission constraint rebalancing
- TTC = total transfer capability
- UFLS = underfrequency load shedding
- WECC = Western Electricity Coordinating Council