Question text	Answer Text
In the Regional Inertia studies, whether the system was split into north, south , east and west and then the studies were performed or it was interconnected?	They are interconnected. Regional frequency dynamics do not need region islanding to manifest. The inertia regionalization algorithm identified areas with high risks of regional inertia and frequency issues due to weak connection and low regional inertia levels.
On Zhang's slide 10, what determines the number of optimal clusters? What's already on the system and how to optimize what's there?	To determine the optimal number of clusters, we developed an index that reflects how much each of the clusters are electrically tight within and loose from outside. This index reflects the physics of the system and is used to compare different potential clustering candidates.
Specifically, how is the SLI defined? Is it loss of the largest generator machine in the region or is it loss of the whole plant?	SLI stands for single largest infeed. It can be the largest generator trip/plant outage/infeeding intertie trip/etc. As for whether it should be the generator or the whole plant, that is up to what is the actually credible, largest event for that region. The algorithm can take either of them.
Can SCR screening be correlated with regional inertia screening?	These are two aspects of a interconnection but there could be correlation to certain extend among the two as they could be influenced by certain resources at the same time. That's exactly the value of the multi-perspective clustering. Comparing these clusters help us understand how much correlation there is among different aspects and that informs decision making.
Was cluster 4 the least in H value and was the cause for the maximum freq nadir in that region or were there other finding to the characteristics of that area	It's a combination of low inertia value in the region and the weak connection to the rest of the system. Both the regional inertia and the connection strength play roles.
it seems like the inertia localization and voltage control areas estimated using simplified models of generators. Is that correct?	That's correct. The formulation uses the swing equation to capture only the electromechanical dynamics between generators.

Why do some grid codes ask for RoCoF as high as 5Hz/s with time window of 0,5 s? What is the significance of time windows ?	Measurement of RoCoF can be tricky. Ideally, the shorter the time window, the better, because this minimizes the impact of other factors on RoCoF, such as fast frequency response, governor response, load response, etc. However, in reality, shorter time windows bring uncertainties and inaccuracies due to measurement noise, frequency estimation algorithms, and the determination of the event start points. To find a balance, typical time windows used are 0.1 ~ 0.5 seconds.
Apart from the simulations, were any kind of mathematical calculations performed to understand or observe the effect of FFRs on the grid stability and response	The goal of this is to screen for instabilities without the need for simulations. Eigen-analysis on an approximate state matrix was used to study the stability.
How ofen would you recommend the screening shown on slide 20 should be performed?	It can be used both on the planning stage and operation stage for credible operation conditions to identify potential risks.
Do the clusters change with operating conditions?	Yes, it is possible the clusters change with different operating conditions, which can bring different distribution of the rotating mass and the connection between them.
Did you observe any difference in the FFR response of a GFM & a GFL to a distubance?	Yes, there are differences between GFM and GFL's frequency response to disturbances, but with properly parameterized GFLs, the differences are minimal and mostly in the first few cycles after the disturbance based on our observations so far.
Can you explain how did the disturbance in US affected the some Canadian grid part the most?	The Alberta region is loosely connected to the rest of the system. They are the furthest to the disturbance but the loose connection resulted in big swings in the regions and led to oscillations and low frequency nadirs in the process.
Where FFR is causing instability in some areas what would the recommended mitigation be in this case?	This is something we will be working on but potential solutions include but are not limited to: properly allocating frequency response reserve across the regions, adding damping controls, adjusting the speed of the frequency response, etc.

How is FFR different from GF grid forming technology	Grid forming technology is one of the ways to control the power electronic converters that interface the energy source with the grid. FFR is fast frequency response delivered to the grid in an event of frequency disturbance. FFR can be delivered by both GFM and GFL converters as long as there are sufficient energy reserve and the converters are configured for such response.
in Slide 25, what is the mix of GFL and GFMs and their impact on ROCOF?	All IBRs providing frequency response in this study are with inverters that are assumed to not have blackstart capability.
For IBR distribution in each of the cluster was any information about the %of GFM v/s %of GFL inverter distribution causing frequency performance differently.	All IBRs in the study are inverters that cannot provide blackstart but are parameterized to provide FFR. Both GFM and GFL inverters can be configured to provide similar fast frequency response. The only minor difference is in the first few cycles, where GFM have a different response. This is expected to not bring significant changes to system frequency nadir. For the sole purpose of frequency response, FFR is usually sufficient. In cases where RoCoF is a concern for loss-of-main protections, the benefit of responses that go beyond FFR can be analyzed and quantified, which may further inform procurement and market designs.
Have you done an analysis to examine how the type, shape and duration of the disturbance affect frequency responce?	The type, shape and duration of the disturbance can affect the manifestation of the frequency response you get from the same system, especially when the frequency responding resources have dead bands configured. The pre-disturbance operating frequency can also have an impact on that.
In the SRP study have you considered that UFLS will have a measurement and respons delay and will not react instantaneously? Do these delays matter?	In this study we did not consider UFLS delays - we used the marginal case where the SRP frequency almost touches the UFLS for IBR frequency support studies. The UFLS delays are usually designed to avoid unnecessary/incorrect load sheddings. However, we may not want to rely on the delay and plan/operate a system near the UFLS margin.
Are the plots showing the rotor speeds of generators or the frequency estimated at	The plots are bus frequencies measured at various locations. In the weak locations, the rotor speed can have much more drastic RoCoF than the bus

What would the simulations show in a situation with high penetration of IBRs with headroom and just a simple 5% droop without any intentional delay?	It depends. A high penetration level means lower inertia level but faster frequency response if parameterized properly - these two factors together determine the frequency transient. With lower inertia, the initial frequency drop will be faster (higher RoCoF), but the faster frequency response that follows benefits the dynamics. We would suggest to use faster and stronger support from IBRs in high penetration systems to buy time (in a high RoCoF reality) for remaining slower generators to ramp up. For BESS energy management when desirable, the IBR support can be tapered down once the generators ramp up.
How easy is to contact the IBR owners and do the required parametrization? How to make sure the IBR owners did update the parameters as required?	There are different processes in each jurisdiction that allow for parameterization of model with close collaboration with IBR owners. Subsequently, validation and verification tests can be carried out to evaluate the impact of the parameter change.
Mr. Zhang mentioned the Grid Strength Assessment Tool. What indicators are used to measure grid strength?. Do these indicators consider BESS or HVDC as IBR?	The grid strength tool uses 5 different indicators (i) SCR, (ii) WSCR, (iii) CSCR, (iv) Remaining MVA, (v) FRT capability. Both BESS and HVDC are considered as IBR in the analysis
How do you envision IBRs having headroom available for frequency response? Wouldn't it mean loss of ravenue for them?	Market incentives are important for these resources to actively participate in fast frequency support. There are ongoing effort on advancing the understanding of the benefit of these resources and integrating them into the market design.
Are there any protection devices like the Frequency relay that are used to protect IBRs in the case of changes in RoCof?	Some OEMs and some IBR types may have such protection devices in place. Additionally it depends on the source behind the inverter
How does the ROCOF value from 13 compared to IEEE 2800 requirement?	In IEEE 2800, the plant is expected to sustain a RoCoF of upto 5Hz/s, when evaluated over a window of 0.1s
National Grid ESO (in GFM requirements) mentions phase jump power limits the initial local ROCOF in the area of incidence. Did you observe this in simulations?	This is possible, but it also depends upon the time inverter over which RoCoF is evaluated and how much power/energy is injected by a resource