Fast Frequency Response Pilot Lessons Learned

Date: June 26, 2023

Classification: Public

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1. Purpose

The Alberta Electric System Operator (AESO) conducted the Fast Frequency Response Pilot (FFR Pilot) to evaluate the technical feasibility and effectiveness of new technologies, including Battery Energy Storage Systems (BESS), in providing fast-acting transmission reliability services. The FFR Pilot aimed to assess the capability of new technologies, such as BESS, to respond rapidly to frequency deviations in the Alberta Interconnected Electric System (AIES), thereby enhancing system stability and accommodating additional scheduled imports.

The AESO has a legislative mandate to restore transmission intertie capability and to direct the safe, reliable and economic operations of the AIES. Fast Frequency Response (FFR) service is a frequency response product used to help arrest and stabilize under-frequency excursions to mitigate the impact of a sudden supply loss from interties and/or internal generation.

This report documents the outcomes and lessons learned from the FFR Pilot, providing insights into the performance of BESS and its potential as a reliable FFR resource. It presents an overview of the pilot program, including background information, facility details, testing results, and key findings.

The report identifies and addresses important considerations that emerged during the FFR Pilot, such as:

- Payment mechanism
- Offer timing requirements
- Response time
- Response duration
- IT tool requirements
- Potential technical challenges with distribution-connected FFR facilities
- ISO rule compliance
- Other lessons learned

By analyzing these factors, the report provides recommendations and insights to support the future implementation of FFR services. Learnings from the FFR Pilot will support the long-term implementation of FFR service.

2. Introduction

2.1 Background

The FFR Pilot was undertaken in conjunction with the AESO implementing its *Energy Storage Roadmap*[1] (ESR). The AESO leveraged the ESR progress updates to incorporate FFR Pilot announcements and key messaging to align with industry across multiple related initiatives. These ESR progress updates fostered active participation from more than 90 industry attendees, including the Market Surveillance Administrator (MSA), distribution facility owners (DFOs), transmission facility owners (TFOs), and numerous market participants, particularly BESS developers and consultants.

The AESO competitively procured FFR contracts that were awarded to two successful bidders who submitted qualified proposals. The two successful proponents, their respective facilities and contract volumes are listed in Figure 1. The service term with each successful bidder was one year from the service start date (March 2022).

Figure 1. Facility information of FFR service providers.

Facility Name	**Summerview (SUM1)**	**eReserve1 Rycroft (ERV1)**
Commencement of Service Term	March 30, 2022	March 07, 2022
Battery Ownership	Canadian Hydro Developers, Inc.	Enfinite LP
Contract Volume	10 MW	20 MW
Battery Manufacturer	Tesla	Tesla
Battery Technology	Lithium Ion (Tesla Megapack)	Lithium Ion (Tesla Megapack)
Configuration	Hybrid (Wind)	Standalone
Connection to Transmission or Distribution	Transmission	Distribution
Planning Area	53-Fort Macleod	20-Grande Prairie

2.2 Testing

Prior to the commencement of the service term, the service provider was required to demonstrate their capability to the AESO by providing a certified report and Supervisory Control and Data Acquisition (SCADA) communication confirmation. Testing was required to ensure their ability to provide FFR service, and at least one additional capability test could have been scheduled at a time mutually agreed upon between the parties.

The testing required each service provider to demonstrate compliant FFR response times under multiple scenarios and system conditions. FFR response times were evidenced using actual energy discharges to the AIES by on-site simulation of transient events on the power grid. FFR service providers were originally required to respond within 12 cycles (0.2 seconds) when system frequency of 59.5 Hz or less was detected, which is consistent with the FFR service response time currently provided by loads participating in Load Shed Service for imports (LSSi).

Following testing, it was determined that neither service provider could consistently meet the original requirement of responding within 12 cycles (0.2 seconds) when the system frequency reached 59.5 Hz.

[1] https://www.aeso.ca/grid/grid-related-initiatives/energy-storage/

Based on the results of the initial response time tests, in an effort to enable the continuation of the FFR Pilot, the AESO conducted further analysis of the response time requirements and determined that a response within 18 cycles (0.3 seconds) at 59.6 Hz was acceptable.

The proforma agreement was amended to reflect the revised response requirements. The response time for LSSi remains at 12 cycles (0.2 seconds) when the system frequency drops to 59.5 Hz. Response time is discussed further in Section 3.3 of this report.

Near the conclusion of the FFR service term, the DFOs raised potential concerns about distributed energy resources (DERs) providing FFR because of potential overvoltage at the point of common coupling due to the fast injection of power during a response. Although the service term has concluded, an additional study is underway, which will be followed by additional facility testing, to assess the impact of fast power injection on voltage within the distribution system. This is discussed further in Section 3.6 of this report.

3. Lessons Learned

3.1 Payment Mechanism

The pilot used the same payment mechanism as LSSi to conduct a direct comparison between products which included three distinct revenue streams—availability payment, arming payment and response payment.

- **Availability Payment |** Availability price of $6.00/MW multiplied by the available volume offered by the service provider. This ensures that service providers are paid for their available volume offered for FFR service.
- **Arming Payment |** Arming price (which the service provider competitively bid) multiplied by the volume armed by the AESO. The AESO assessed and armed the necessary volume of FFR service based on the net import levels on the British Columbia and Montana transfer paths, as well as Alberta's internal load. Consequently, service providers did not control arming revenues, as the arming volume was determined by the AESO.
- **Response Payment |** Response price, set at $1,000/MW by the AESO, multiplied by the volume provided in response to under-frequency detection.

Participant business drivers influenced payment mechanism sentiment. One service provider expressed satisfaction with the current payment mechanism, as the fixed-bid pricing system enabled diversification of payment streams between the energy market, operating reserves market and FFR service. This service provider supports a fixed-price bid for the procurement of future FFR services. However, the other service provider expressed a preference for an alternative payment mechanism that indexes the arming payment to the pool price. This alternative could incent participation in FFR regardless of pool price.

> *During the FFR Pilot, the availability of service providers was inversely related to pool price, similar to LSSi.*

However, this relationship was not influenced by the input costs of electricity, which is typically the case for loads. The driving factor during the FFR Pilot was the revenue opportunity that arose from the operating reserves market where pricing is indexed to pool price.

A service provider emphasized that their decision-making was driven by economic factors and the desire to optimize returns. This service provider emphasized that availability payments were too low to incent FFR at higher pool prices. The service provider emphasized that future participation in FFR can be incented with a payment mechanism that provides greater compensation based on the potential for arming. Furthermore, this service provider also suggested that the AESO should consider implementing a day-ahead market, similar to the operating reserves market, to procure FFR services for the subsequent day.

3.2 Offer Timing

The agreement specified that service providers who choose to offer FFR must adhere to certain offer timing requirements, which facilitate importing electricity on the combined British Columbia and Montana interconnected path into the AIES. These timing requirements include submitting their available FFR volume for the next scheduling hour at least 25 minutes prior to that hour to accommodate a 10-minute ramp prior to the scheduling hour, and last until 10 minutes after the scheduling hour.

Additionally, they must ensure their capability to remain armed 10 minutes before the hour, throughout the entire 60-minute duration of the hour, and 10 minutes after the hour, totalling 80 minutes. If these timing requirements are not adhered to, it may result in the AIES operating in an unreliable state, with electricity being transferred into Alberta without the necessary FFR capacity to arrest and stabilize frequency decay in the event of an intertie loss.

Throughout the term of the FFR Pilot, both service providers expressed a desire to modify this arming window. They found it challenging to transition between participating in operating reserves and FFR, as complying with the offer timing requirements in the agreement often leads to lost revenue. For instance, if a service provider is committed to providing operating reserves for the Hour Ending (HE) 6 period, they are unable to make themselves available for FFR at 5:35 to participate in HE7. Consequently, they would need to opt out of both markets for HE7 to be available for HE8 in FFR.

To address this issue, both service providers prefer a one-hour timeframe to allow for greater flexibility between markets. This change would further enable FFR participation and increase their overall revenue potential.

3.3 Response Time

Our learnings on response time in this section are based on the test data as there were no response events during the FFR Pilot. At the initiation of the FFR Pilot, the agreement required a response time of 0.2 seconds (12 cycles). Although neither service provider was able to consistently achieve a response time within 0.2 seconds (12 cycles) during the FFR Pilot, both service providers are optimistic about the future potential for attaining a faster response time at current or future facilities.

> *A further assessment performed by the AESO has determined that a response within 0.2 seconds (12 cycles) at 59.5 Hz meets the same need as a response within 0.3 seconds (18 cycles) at 59.6 Hz.*

One service provider is investing in software and hardware improvements to achieve the original response time of 0.2 seconds (12 cycles). However, this service provider emphasized the importance of a streamlined configuration to provide the fastest response time, which may reduce operational flexibility. Implementing additional logic to enable a proportional frequency response, as opposed to the current discrete response, or allocating a facility's volume between FFR and another market could delay response times. Conversely, one service provider has made a strategic decision to not make any further software and hardware improvements until they understand how the AESO intends to utilize FFR services in the future.

3.4 Response Duration

The agreement required that the FFR facility be able to provide a response continuously for up to 60 minutes following an under-frequency event. The reason for the 60-minute duration is to complement contingency reserves with FFR service to facilitate imports to Alberta for each scheduling hour.

One service provider acknowledged their preference to maintain the current response duration of one hour, as per the FFR Pilot. In contrast, the other service provider advised that revising the response duration may provide flexibility in facility design allowing for diverse pricing structures based on FFR service conditions. A shorter response duration could decrease capital and rate demand transmission service costs, ultimately leading to lower pricing. This service provider emphasized that this relationship between response duration and lower pricing is contingent upon a guaranteed, long-term contract to recover their capital cost. This service provider expressed that a guaranteed contract would reduce the need to maintain the operational capabilities to participate in alternative markets such as operating reserves. From an organizational standpoint, they expressed apprehension to invest in an asset with limited operational flexibility unless it was supported by guaranteed, long-term revenues.

3.5 Tool Considerations

One service provider employed a third party for asset optimization and facility dispatch, without raising any concerns regarding the necessary IT tools required to participate in FFR and the operating reserve market. However, the other service provider raised concerns with respect to challenges in coordinating offers between FFR and the operating reserve market using two different systems: SCADA for FFR and the Energy Trading System (ETS) for operating reserves. This service provider had instances of inadvertently offering the same capacity in both FFR and the operating reserves market. This service provider implemented process and IT system changes and has also proposed either integrating or consolidating offer platforms for participating in each market which would enable additional system-based solutions to minimize future errors and non-compliance events.

3.6 Distribution Connected FFR Facilities

As noted previously in Section 2.2 of this report, near the conclusion of the FFR Pilot, the DFOs expressed concern about voltage limits being respected within distribution networks when FFR was provided by DERs.

> *Incremental power injection could potentially cause high voltages within the distribution network, leading to a trip of a DER while providing FFR. Studies are underway to assess further, which are anticipated to be completed in Q3 2023. Upon the completion of these studies, the AESO will provide an update to stakeholders.*

In general, a DER must quickly ramp its output when providing FFR, and the incremental power injection has transient and steady state effects on voltage. DFOs may have ramp rate limits to mitigate the voltage effects of fast ramping (or for other reasons). Such limits could conflict with the technical requirements for providing FFR. Furthermore, the DFO could trip the DER to mitigate the voltage effects.

Through the FFR Pilot, DFOs required additional transient studies addressing distribution network voltage impacts for DERs with high ramp rates. The AESO endorses a process whereby engineering studies are completed when a prospective FFR provider connects to a distribution network to determine whether the provision of FFR is compatible with the reliable operation of the distribution network. The studies should assess the risk that a DER fast ramping event could cause transient or steady state voltages outside applicable limits at the DER’s point of interconnection, the point of connection with the transmission network, or within the intervening distribution network; and mitigations should be proposed as needed. An FFR provider must respect DFO DER interconnection requirements, particularly voltage limits during fast ramp and must not create a tripping condition caused (in whole or in part) by provision of this service.

> *DFO Consent on Fast Ramp | The AESO requires DFO consent on fast ramp when a DER provides FFR service*

Theoretically, voltage regulation by a DER could mitigate over-voltages caused by its ramping. However, DFOs typically do not allow a DER to regulate voltage within a distribution network using an Automatic Voltage Regulator (AVR) in voltage control mode. The above engineering studies may consider voltage regulation or an equivalent solution as a mitigation, within the bounds of what is allowed by the DFO.

3.7 ISO Rule Compliance

The MSA granted forbearance[2&3] to the AESO and the FFR market participants relating to the FFR Pilot and specific ISO rules. Forbearance was based on the MSA being satisfied that contraventions of the ISO rules in relation to the FFR Pilot are unlikely to unduly impair the safe, reliable, and economic operation of the AIES. The MSA included the following ISO rules in the list of FFR Pilot Impact Rules set out in their letter granting forbearance:

- Section 3 of ISO rule 203.1, Offers and Bids for Energy
- Sections 2 and 4 of ISO rule 203.3, Energy Restatement
- Sections 2, 3, 4, 6, and 7 of ISO rule 203.4, Delivery Requirements for Energy
- Sections 4, 5, and 6 of ISO rule 205.2, Issuing Dispatches and Directives for Operating Reserves
- Section 10 of ISO rule 205.5, Spinning Reserve Technical Requirements and Performance Standards
- Section 6 of ISO rule 205.6, Supplemental Reserve Technical Requirements and Performance Standards
- Sections 3(2) and 9 of ISO rule 303.1, Load Shed Service for Imports

As described above, there were some instances of capacity being inadvertently offered in both FFR and the operating reserves market. The AESO will continue to consider appropriate mechanisms to help ensure compliance and discourage duplicative offers. The AESO intends to consider these updates and others in view of the feedback provided by the Service Providers as well as the AESO's broader market pathways initiative.

Further updates may be required to the ISO rules to reflect the provision of FFR services.

[2] https://www.aeso.ca/assets/Uploads/market/2022-02-02-Updated-Ltr-re-FFR-pilot-AESO-Req-for-Forbearance.pdf

[3] https://www.albertamsa.ca/assets/Documents/MSA-AESO-FFR-Pilot-Letter.pdf

4. Conclusion

In conclusion, the FFR Pilot:

- Demonstrated that BESS has the potential to provide value to the AESO and Albertans in mitigating the impacts of frequency decay on the AIES resulting from sudden supply losses, such as interties.
- Provided insights into potential opportunities and challenges associated with service providers offering FFR services while also participating in operating reserves and the energy market.
- Revealed that prospective DERs who seek to provide FFR service must work with the DFO to ensure fast ramping is technically feasible in the area.

Learnings from the FFR Pilot will inform future FFR service. By enabling new technologies and engaging with stakeholders, the AESO is evaluating opportunities to enhance the reliability and efficiency of the AIES. The successful implementation of FFR service is expected to contribute to system stability by mitigating the impacts of sudden supply losses, ultimately benefiting the Alberta energy market as a whole.

5. Next Steps

The AESO is exploring competitive procurements for technology-agnostic FFR services for when the AIES is in islanded and interconnected conditions. Please refer to AESO Engage for updates on the FFR Services Procurement.

Future FFR services will be further discussed at the AESO Stakeholder Symposium on June 27, 2023.