Information Document
Aggregated Facilities Technical Requirements
ID #2018-014R

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1 Purpose

This information document relates to the following authoritative document:

- Section 503.2 – *Maximum Authorized Real Power and Maximum Authorized Charging Power* ("Section 503.2")
- Section 503.3 – *Reactive Power* ("Section 503.3");
- Section 503.4 – *Voltage Regulation* ("Section 503.4");
- Section 503.5 – *Voltage Ride-Through* ("Section 503.5");
- Section 503.6 – *Frequency and Speed Governing* ("Section 503.6"); and
- Section 503.13 – *Synchrophasor Measurement System* ("Section 503.13").

The purpose of this information document is to provide general information relating to aggregated facilities. Division 503 contains technical and operating requirements for all types of facilities including aggregated facilities, generating units and energy storage resources.

2 Aggregated Facility

An aggregated facility can have many generating units, energy storage resources (ESRs) and other equipment connected through the collector system system to the collector bus. The equipment within the facility can affect the real power, reactive power, and voltage delivered to the collector bus. Section 503.2 and Section 503.3 requires that the determination of the real and reactive power capability is done using 1.0 per unit voltage at the collector bus.

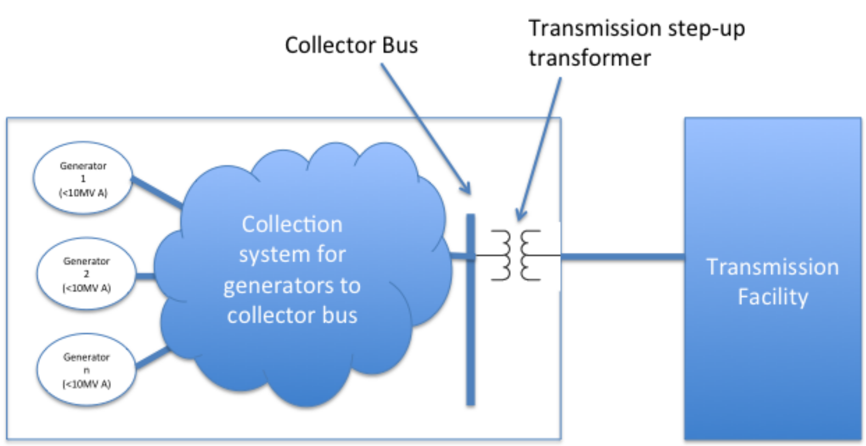

Figure 1

As shown in Figure 1, the collector system can be very simple or it can have a complex arrangement of lines, generators, energy storage resources, and other equipment. The generating units can be powered by solar, wind, hydro, natural gas, or other energy sources.

[1] "Authoritative documents" is the general name given by the AESO to categories of documents made by the AESO under the authority of the *Electric Utilities Act* and associated regulations, and that contain binding legal requirements for either market participants or the AESO, or both. Authoritative documents include: the ISO rules, the reliability standards and the ISO tariff.

The collector bus can be a simple arrangement of a connection to the low voltage side of the transmission step-up transformer to a physical bus where multiple collection feeders connect prior to the connection of any transmission step-up transformers.

3 Reactive Power Requirements (Section 503.3)

This section provides guidance on the reactive power requirements in Section 503.3.

Some key considerations related to reactive power include the physical point at which reactive power is determined, the voltage level at which reactive power is determined, the minimum amount of dynamic reactive power, and the use of fixed reactive resources such as capacitors or reactors.

An aggregated facility can have various equipment interconnected by its collector system, including generating units and ESRs, which can affect the real and reactive power produced by the facility and the collector bus voltage. Figure 1 illustrates the location of a collector bus. Because some reactive devices (such as shunt capacitors) supply or absorb an amount of reactive power that depends on voltage, Section 503.3 establishes 1.0 per unit as the voltage at which the reactive power is determined.

As set out in subsection 2(3) of Section 503.3, the reactive power range, from 0.9 power factor supplying to 0.95 power factor absorbing, is to be fully dynamic. The reactive power capability of an aggregation of resources can be limited when some of the resources are not connected or not in service - for example, when solar inverters or wind turbine generators are offline for repair. The facility is expected to provide reactive power across the full active power range of all resources that are online, even when only a subset of the resources are providing active power. To help further clarify, the following three examples are provided:

1. For a solar aggregated facility with a maximum authorized real power of 100 MW, and all resources online and producing at MARP in aggregate: the capability requirement is 48.43 MVAr supplying and 31.22 MVAr absorbing, or a range from supplying to absorbing of 79.65 MVAr.
2. For the same facility with all resources available, but producing 50% of MARP in active power output due to solar irradiance conditions: the capability requirement is 48.43 MVAr supplying and 31.22 MVAr absorbing, or a range from supplying to absorbing of 79.65 MVAr.
3. For the same facility, but with only 75% of its resources available due to feeder or equipment outages: the capability requirement would be based on 75 MW active power capability, and the facility would be expected to be capable of 36.32 MVAr supplying and 23.42 MVAr absorbing, or a range from supplying to absorbing of 59.74 MVAr.

In many cases the dynamic reactive power is produced by generating units. In some facilities, such as those with extensive collector systems, the dynamic reactive power produced by the facility may be offset by collector system losses. In such cases, shunt compensation may be used.

If a legal owner finds, for example, that the facility has an adequate range of dynamic reactive power but cannot achieve 0.9 power factor supplying or 0.95 power factor absorbing at the collector bus, the facility design could incorporate fixed shunt devices to correct the dynamic reactive power range to the required power factor requirements at 1.00 per unit voltage on the collector bus. If the legal owner uses fixed shunt devices, the AESO will accept a load flow study report as evidence that full dynamic reactive power will be available at the collector bus level and fixed shunt devices will only be used to compensate internal system losses.

If fixed shunt devices are required at specific real power levels to achieve 0.9 power factor supplying and 0.95 power factor absorbing, the shunt devices may or may not be under the control of the voltage regulation system.

a. Voltage Regulation Requirements (Section 503.4)

This section provides guidance on the voltage regulation requirements in Section 503.4.

Some key considerations for voltage regulation include where voltage is measured for voltage regulation purposes versus where the voltage is controlled, and the response time of a voltage regulation system.

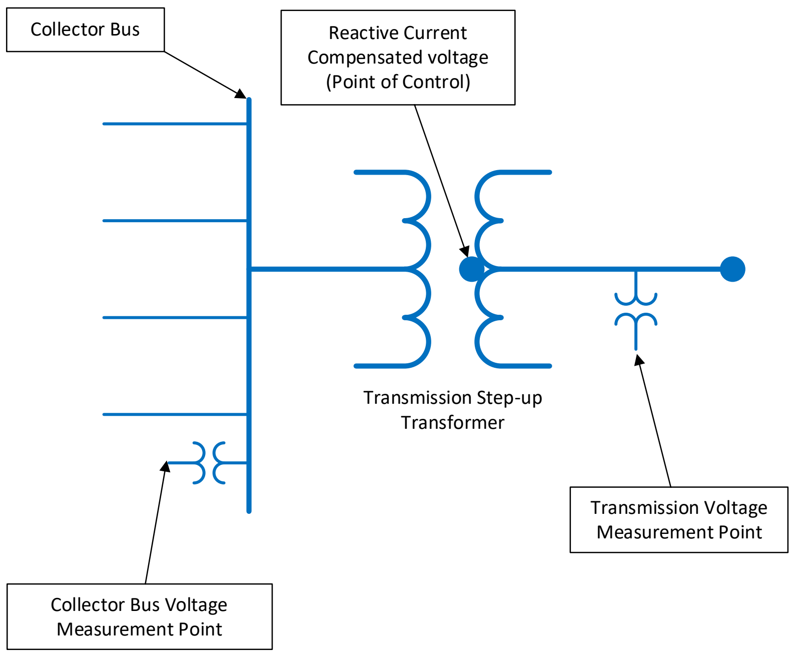

Figure 2

As set out in subsection 2(2) of Section 503.4 of the ISO rules, the AESO does not permit any generating unit, ESR or aggregated facility to directly control transmission voltage. Transmission voltage may be measured, but not controlled directly. Instead, as illustrated in Figure 2, reactive current compensation is required to create a voltage control point between the collector bus and the transmission step-up transformer.

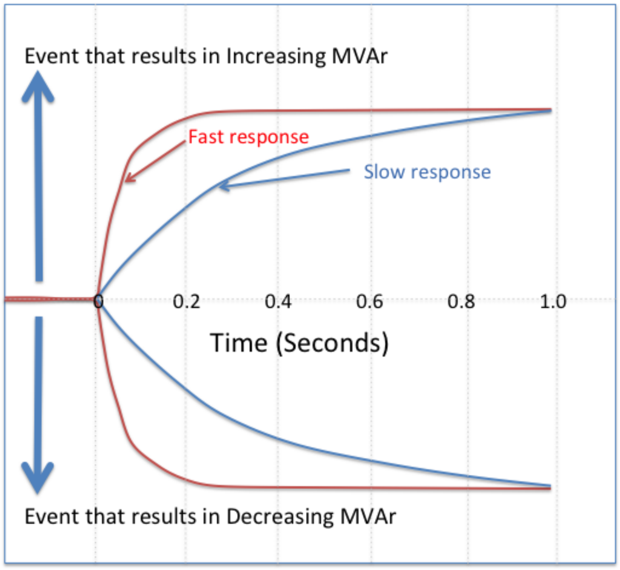

Figure 3

Subsection 2(4) of Section 503.4 outlines a response time for voltage regulating systems or automatic voltage regulators of “no sooner than zero point one (0.1) seconds and no later than 1.0 second following a step change in voltage”. The intent of a response of no later than 1.0 second is to ensure reasonable response time to coordinate voltage regulation with other generation facilities. The intent of a response of no sooner than 0.1 seconds is to prevent system instability that may result under weak system conditions, which can occur with transmission line outages. Figure 3 is a simple illustrative example of the reactive power response. Actual reactive power response will depend on many factors and will not likely match the simple example shown in Figure 3.

b. Voltage Ride-Through Requirements (Section 503.5)

The voltage ride-through requirements set out in Section 503.5 pertain to the transmission voltage at the point of connection. An aggregated facility is required to remain connected to the transmission system for the conditions described in subsection 2 and Appendix 1 of Section 503.5. When transmission voltages rise above or drop below a threshold and time duration, a facility may trip, but tripping is not required. The voltage ride-through requirements are “must ride-through” requirements and **not** “must trip” requirements.

Voltage excursions seen on the transmission system may include rapid changes (step changes), swings, or oscillations, as shown for example in Figure 4. As set out in subsection 2(2)(b) of Section 503.5, if the transmission voltage at the point of connection of an aggregated facility rises above or drops below a voltage threshold indicated in Appendix 1 of Section 503.5 for the corresponding period of time, then the facility is permitted to trip. For example, the facility may trip if voltage exceeds 1.2 p.u. instantaneously, or drops below 0.65 p.u. for 0.3 seconds. These examples are shown in Figure 5.

Voltage ride-through constraints may appear in the functional specification of a facility. When they do, the facility should obey the set of all constraints in Section 503.5 and the specification, taken together.

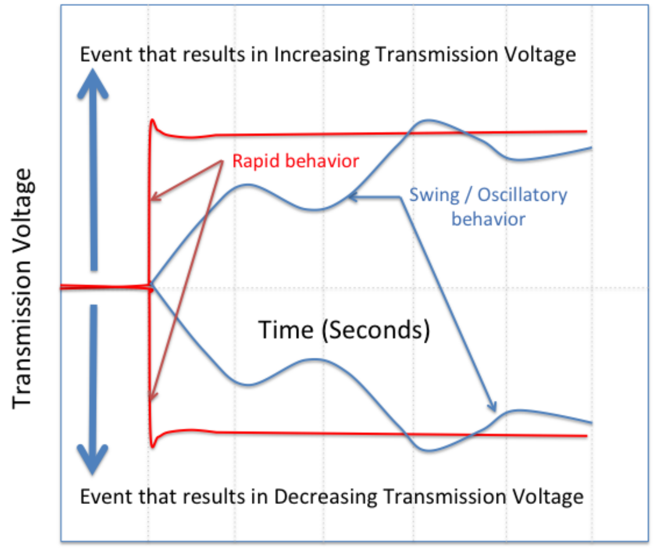

Figure 4

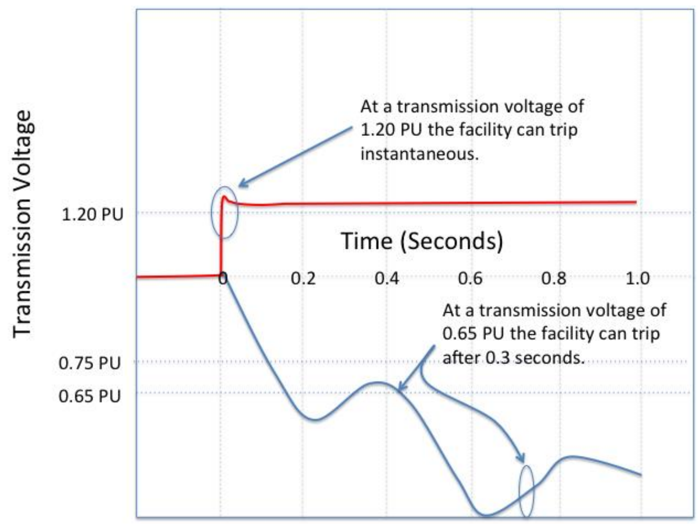

Figure 5

c. Frequency and Speed Governing Requirements (Section 503.6)

This section provides guidance on the frequency and speed governing requirements in Section 503.6. Subsection 3 specifies how a governor system must be designed to respond to frequency excursions. Subsection 5 specifies whether a facility is permitted to trip when a frequency excursion occurs.

System frequency can increase or decrease and exhibit swings or oscillatory behavior. The rate of change of frequency depends on system inertia in Alberta and interconnected systems.

System frequency will always have some movement up and down. Governor systems can have a deadband, up to ±0.036 Hz, and when frequency is within the deadband, no response is required. When frequency exceeds the deadband, such as in the over-frequency excursion shown in Figure 6, the aggregated facility should reduce its real power output in proportion to the governor droop setting[2]. As frequency returns to nominal, the frequency response is removed and the facility reverts to its nominal frequency output.

For an under-frequency excursion like that shown in Figure 7, the expected response is an increase in real power output. Aggregated facilities often produce their maximum potential real power output. When a facility is producing its maximum potential real power output, incremental real power is not required in response to an under-frequency excursion. However, a response should be provided whenever the facility is capable.

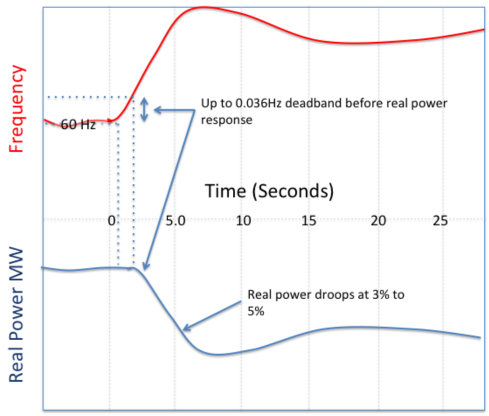

Figure 6

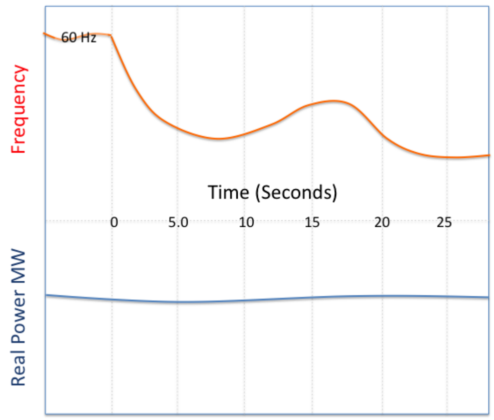

Figure 7

Subsection 5 of Section 503.6 relates to frequency disturbance ride-through. The frequency ride-through requirements are “must ride-through” requirements and **not** “must trip” requirements. The tripping of a unit should be based on equipment capabilities. Margins should be applied between the tripping characteristics of the facility and the ride-through region required in Section 503.6.

When a frequency excursion exceeds the frequency and time bounds of the envelope specified in Appendix 1 of Section 503.6, an aggregated facility is allowed to trip.

Figure 8 shows two examples where an aggregated facility is allowed to trip. The over-frequency example shows frequency exceeding 61.7 Hz, whereupon the aggregated facility is allowed to trip instantaneously. The under frequency example shows frequency dropping below 57.8 Hz for more than 7.5 seconds; and after this amount of time, the aggregated facility is allowed to trip.

[2] For example, if frequency increases from 60 Hz to 60.6 Hz, a 100 MW aggregated facility that has a governor with a 5% droop setting should decrease its real power output by 20 MW, subject to applicable limits on minimum stable output.

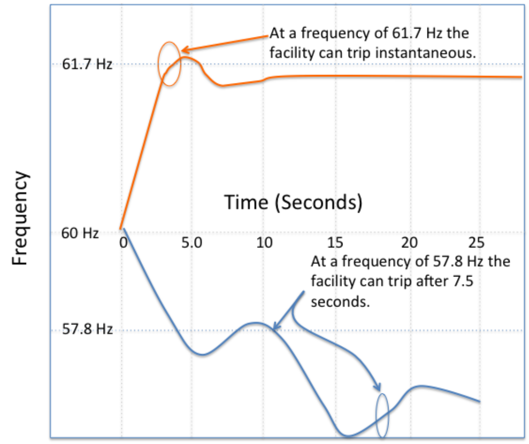

Figure 8

4 Synchrophasor Measurement System Requirements (Section 503.13)

The technical requirements for synchrophasor measurement systems are set out in Section 503.13 of the ISO rules, *Synchrophasor Measurement System*. Market participants are encouraged to review Section 503.13. The AESO specifies the sample rate and other required configuration parameters for synchrophasor measurement systems in a project's functional specification.

Revision History

Posting Date	Description of Changes
2024-04-12	Amendments to align ID with Energy Storage ISO Rule amendments and new definitions.
2020-06-22	Addition of subsection 4 regarding synchrophasor measurement system requirements. Administrative edits
2018-09-04	Initial release