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

Information documents are not authoritative. Information documents are for information purposes only and are intended to provide guidance. In the event of any discrepancy between an information document and any authoritative document(s)[1] in effect, the authoritative document(s) governs.

1 Purpose

This information document relates to the following authoritative document:

- Section 502.1 of the ISO rules, *Aggregated Generating Facilities Technical Requirements,* ("Section 502.1")

The purpose of this information document is to provide general information relating to aggregated generating facilities. Section 502.1 is focused on the design and build domain. For clarity, Section 502.1 requires that a market participant, while designing and building its facilities, design and build the facilities in accordance with the requirements and obligations set out in Section 502.1.

2 Aggregated Generating Facility

An aggregated generating facility can have many devices and apparatuses at the generating units, through the collection system to the collector bus that can affect the real power, reactive power, and voltage delivered to the collector bus. Section 502.1 requires that the determination of the real and reactive power is done at the voltage that is the 1.00 per unit voltage for the collector bus.

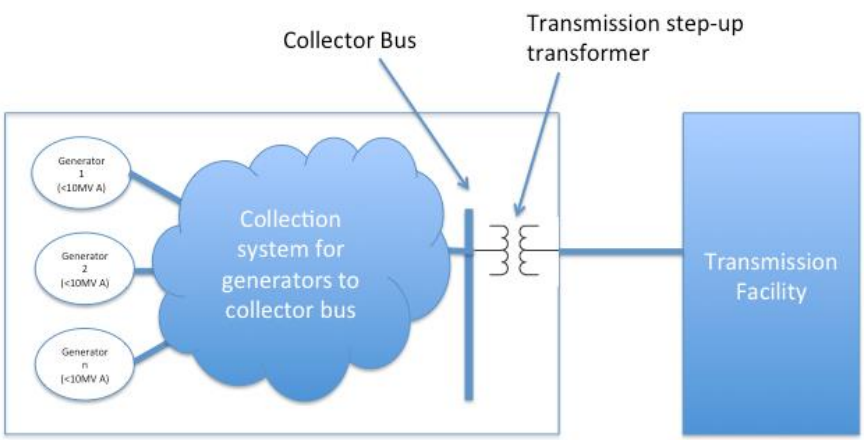

Figure 1

As shown in Figure 1, the collection system can be very simple to very complex, and can have lengthy arrangements of lines and apparatuses. The generating units can be sourced from energy such as solar, wind, hydro, or natural gas.

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

This section provides guidance on the reactive power requirements in subsection 4 of Section 502.1.

[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.

There are some key considerations for reactive power such as 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 generating facility can have many devices and apparatuses at the generating sources, through the collection system to the collector bus that can affect the real power, reactive power, and voltage delivered to the collector bus. Figure 1 illustrates the location of a collector bus. Because some reactive devices are voltage sensitive to the amount of reactive power that can be supplied or absorbed, Section 502.1 has set 1.00 per unit as the voltage at which the reactive power is determined.

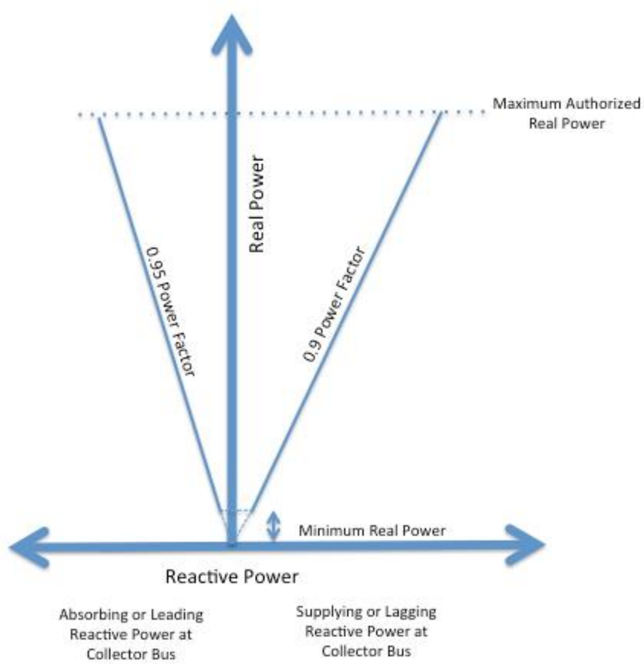

Figure -2

Another consideration for reactive power is that, as set out in subsection 4(3) of Section 502.1, the reactive power range from 0.9 power factor supplying to 0.95 power factor absorbing is to be fully dynamic. Figure 2 above illustrates that the minimum amount of reactive power supplied at the collector bus meets or exceeds 0.9 power factor for real power operation from a minimum real power level to the maximum authorized real power level. Figure 2 above also illustrates that the minimum amount of reactive power absorbed at the collector bus meets or exceeds 0.95 power factor for real power operation from a minimum real power level to the maximum authorized real power level. For example, if the maximum authorized real power is 100 MW, the requirement of 0.9 power factor would be 48.43 MVAr supplying and 31.22 absorbing, or a range from supplying to absorbing of 79.65 MVArs.

In many cases the dynamic reactive power is produced from the generating units. In some facility designs where the collection system is lengthy, it is possible that the dynamic reactive power may be offset by the reactive power characteristics of the collection system.

If a legal owner finds, for example, that the facility has an adequate range of dynamic reactive power but cannot achieve the required 0.9 power factor supplying, or 0.95 power factor absorbing, 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 satisfy the 0.9 power factor supply and 0.95 power factor absorbing requirements, these shunt devices may or may not be under the control of the voltage regulation system.

a. Voltage Regulation Requirements

This section provides guidance regarding the voltage regulation requirements in subsection 6 of Section 502.1. There are some key considerations for voltage regulation such as the difference between where a voltage can be measured and where the voltage is controlled, and the response time of a voltage regulation system.

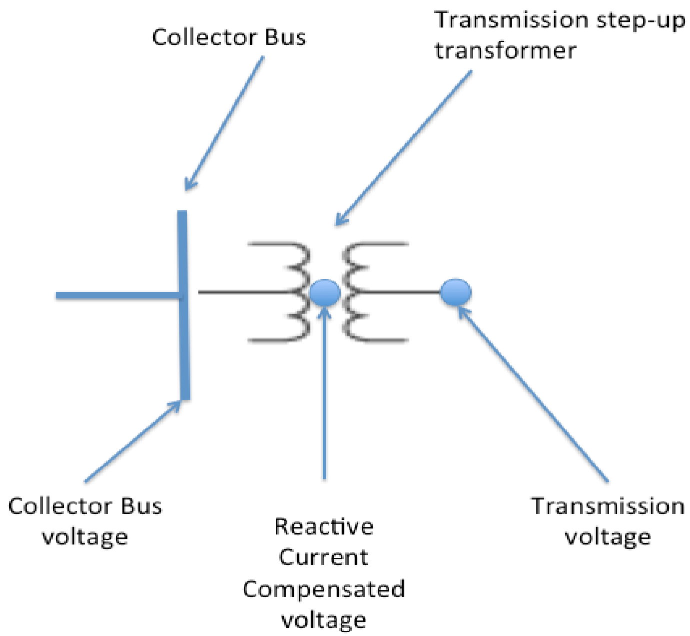

Figure 3

As set out in subsection 6(2) of Section 502.1 of the ISO rules, the AESO does not permit any generating unit or aggregated generating facility to directly control transmission voltage. It is possible to measure transmission voltage at a facility. However, reactive current compensation is required to create a voltage control point between the collector bus and mid-impedance of the transmission step-up transformer. Figure 3 illustrates 3 voltage points: 2 that can be directly measured and 1 that can be determined through measurement based on the impedance of the transmission step-up transformer.

Where the facility configuration is such that an aggregated generating facility is to measure the transmission voltage, the reactive current compensator would be set to a value where the voltage is determined closer to the collector bus. The voltage regulation system would use this compensated voltage and control the reactive resources to maintain collector bus voltage within the requirements set out in subsection 6 of Section 502.1.

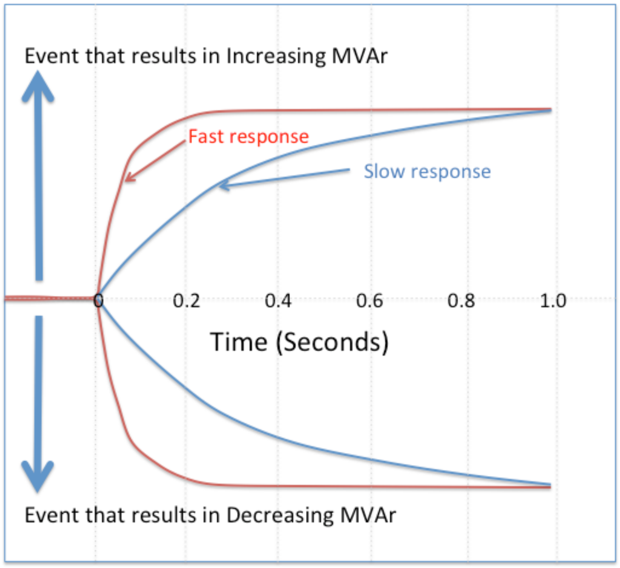

Figure 4

Subsection 6(10) of Section 502.1 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 4 is a simple illustrative example of the reactive power response. Actual reactive power response will be dependent on many conditions and will not likely match the simple example shown in Figure 4.

b. Voltage Ride-Through Requirements

The voltage ride-through requirements set out in subsection 5 of Section 502.1 are based on the 1.00 per unit voltage of the transmission voltage at the high voltage side of the transmission system step-up transformer (see Figure 3). An aggregated generating facility is required to remain connected to the transmission system for conditions described in subsection 5 and Appendix 1 of Section 502.1. When transmission voltages rise above or drop below a threshold and time duration, a facility may trip off. The voltage ride-through requirements are a “must ride-through” requirement and not a “must trip” requirement.

Transmission voltages can increase or decrease rapidly, or they may exhibit a swing or oscillatory type behavior as shown in Figure 4. Rapid behavior is often nearly instantaneous, and swings or oscillatory behavior could be at rates less than 1 Hz or rates up to 10 Hz or higher. These over and under voltage behaviors are illustrated in Figure 5.

As set out in subsection 5(2)(b) of Section 502.1, if the transmission voltage rises above or drops below the voltage thresholds and period of time described in Appendix 1 of Section 502.1, an aggregated generating facility is allowed to trip.

Figure 6 illustrates 2 transmission voltage behaviors where an aggregated generating facility is allowed to trip. The over voltage example is a rapid change where the voltage exceeds 1.20 per unit and the aggregated generating facility is allowed to trip off instantaneously. The under voltage example shows a swing behavior where the voltage behavior drops below a 0.75 per unit threshold and a 0.65 per unit threshold. The 0.75 per unit threshold has a 2.0 second duration and the 0.65 per unit threshold has a 0.30 second duration. The example shows where the voltage dips below the 0.65 per unit then rises above the 0.65 per unit threshold. The voltage then drops below the 0.65 per unit threshold and exceeds the 0.30 second duration, where the aggregated generating facility is allowed to trip off.

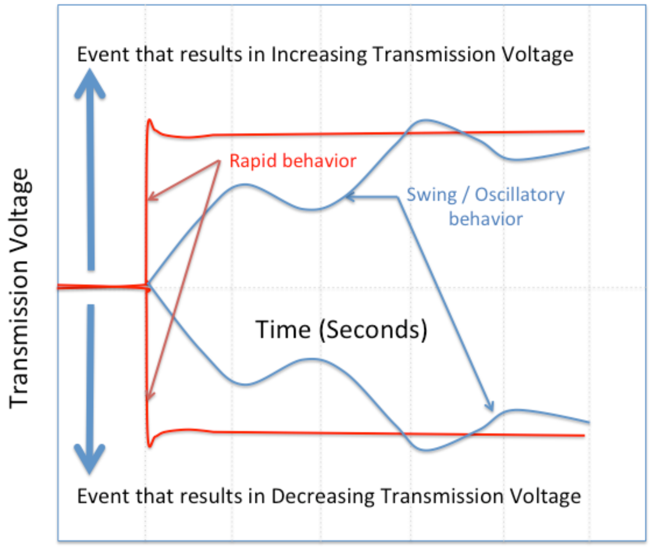

Figure 5

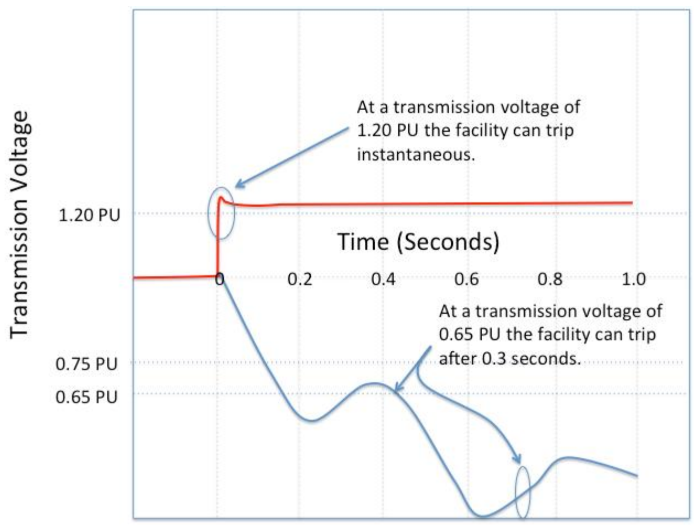

Figure 6

c. Frequency and Speed Governing Requirements

The frequency and speed requirements of subsection 7 of Section 502.1 are based on the frequency of the voltage at the aggregated generating facility. Subsection 7 describes 2 types of requirements. The first type of requirement is outlined in subsection 7(1)(b) and describes governor system requirements where an aggregated generating facilities' real power output is reduced when frequency exceeds 60 Hz. The second is outlined in subsection 7(3) and describes the scenarios of over- and under-frequency thresholds and durations where a facility is not permitted to trip, and where a facility is permitted to trip, if the threshold and duration is exceeded.

Frequency can increase or decrease and exhibit a swing or oscillatory type behavior. The rate of change of frequency is often slower than voltage changes as frequency is subject to the inertia of the system.

System frequency will always have some movement up and down, and the governor systems can have up to a 0.036 Hz deadband so that the controls are not reacting to small frequency changes. When frequency deviates, such as in the over-frequency example shown in Figure 7, the real power will reduce at a rate set by the governor system droop, which can be set between 3% and 5% as described in subsection 7. As frequency is restored, the real power will increase back to the real power capability or real power limit if a power limit was put into effect for the aggregated generating facility.

For an under-frequency event shown in Figure 8, it is likely that the aggregated generating facility would be operating at its maximum real power capability or at a real power limit, and the real power output would not increase for the under-frequency event. However, if the aggregated generating facility is providing ancillary services, where the real power output of the aggregated generating facility is less than the real power capability, then the real power output would increase subject to the deadband and droop requirements.

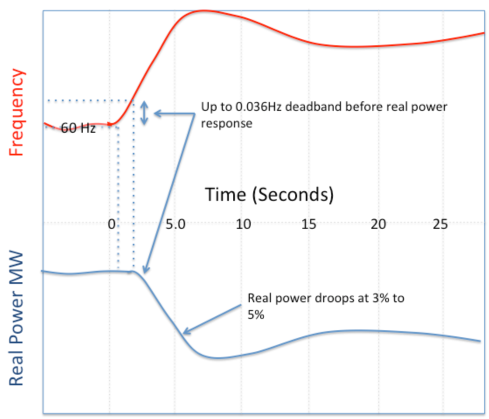

Figure 7

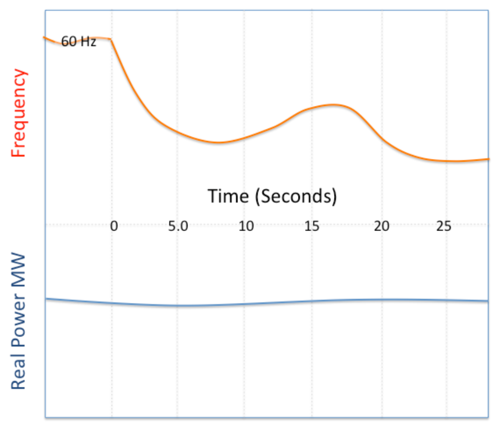

Figure 8

The second type of requirement is outlined in subsection 7(3) and describes the scenario where an aggregated generating facility is not permitted to trip within a specified frequency threshold and duration unless there is an equal amount of load tripped simultaneously that satisfies the requirements set out in subsection 7. Subsection 7 does not have requirements for an aggregated generating facility to trip, though an aggregated generating facility is allowed to trip outside the zone created between the blue and red lines in Appendix 2 of Section 502.1.

As set out in subsection 7(3) of Section 502.1, if the frequency rises above or drops below the frequency thresholds and period of time described in Appendix 2, an aggregated generating facility is allowed to trip.

Figure 9 illustrates 2 frequency behaviors where an aggregated generating facility is allowed to trip. The over-frequency example is where the frequency exceeds 61.7 Hz and the aggregated generating facility is allowed to trip off instantaneously. The under frequency example is where the frequency drops below 57.8 Hz threshold for more than 7.5 seconds at which point the aggregated generating facility is allowed to trip.

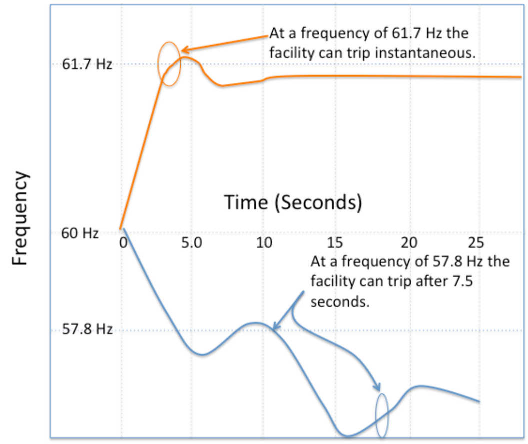

Figure 9

4 Synchrophasor Measurement System Requirements

Subsection 17 of Section 502.1 refers to synchrophasor technical requirements. The technical requirements for synchrophasor measurement systems are set out in Section 502.9 of the ISO rules, *Synchrophasor Measurement Unit Technical Requirements* ("Section 502.9"). Market participants are encouraged to review Section 502.9 in conjunction with Section 502.1. In addition, the AESO specifies the sample rate and other required configuration parameters for synchrophasor measurement systems in a project's functional specification document.

Revision History

Posting Date	Description of Changes
2020-06-22	Addition of subsection 4 regarding synchrophasor measurement system requirements. Administrative edits
2018-09-04	Initial release