ISO Rules
Part 500 Facilities
Division 502 Technical Requirements
Section 502.1 Aggregated Generating Facilities Technical Requirements

Expedited Filing Draft
September 7, 2017

Applicability

1(1) Section 502.1 applies to ~~the **ISO**, and subject to the provisions of subsections 1(2), (3) and (4) to any~~:

(a) ~~a new wind~~the **legal owner** of an **aggregated generating facility** ~~to be~~directly connected to the **transmission system**~~, and to their **legal owner**; and~~ or to a **transmission facility** within the service area of the City of Medicine Hat, including an **aggregated generating facility** situated within an industrial complex that is directly connected to the **transmission system** or to a **transmission facility** within the service area of the City of Medicine Hat, except as described in subsection 1(2);

(b) ~~a wind **aggregated generating facility** in existence and connected to the **transmission system** as of December 1, 2011, and to their **legal owner**, if such facilities were connected to the **transmission system** under the *Wind Power Facility Technical Requirements* dated November 15, 2004.~~the **legal owner** of a **transmission facility**; and

(c) the **ISO**.

(2) Subject to subsection 1(3), the provisions of this section 502.1 do not apply to the **legal owner** of an **aggregated generating facility** that was energized and commissioned prior to April 7, 2017 in accordance with a previous technical requirement, technical standard, **ISO rule** or functional specification, but the **legal owner** of such an existing **aggregated generating facility** must remain compliant with all the standards and requirements set out in that previous technical requirement, technical standard, **ISO rule** or functional specification, and must also meet the applicable requirements set out in section 304.9 of the ISO rules, *Wind and Solar Aggregated Generating Facility Forecasting* and section 502.16 of the ISO rules, *Aggregated Generating Facilities Operating Requirements*~~The **legal owner** of any existing wind **aggregated generating facilities**, who executed a *Construction Commitment Agreement* and completed the **ISO**'s approval process for connection to the **transmission system** under the *Technical Requirements for connecting generators (1999)*, is exempt from this section 502.1 but must remain in compliance with those 1999 requirements~~.

(3) Where an **aggregated generating facility** directly connected to the **transmission system** or a **transmission facility** within the service area of the City of Medicine Hat described in subsection 1(2) undergoes one or more~~If any existing wind **aggregated generating facilities** undergo any~~:

(a) ~~facilities~~ facility additions after April 7, 2017 ~~such that the~~ resulting in an increase in the cumulative **gross real power** capability of the **aggregated generating facility** ~~accumulative **real power** capability is increased~~ by an amount equal to or greater than ~~five (~~5~~)~~ MW; or

(b) ~~facilities'~~ equipment replacements after April 7, 2017 where the equipment replaced has a **gross real power** capability equal to or greater than ~~of five (~~5~~)~~ MW irrespective of whether the cumulative **gross real power** capability of the **aggregated generating facility** is increased,~~or more;~~

this section 502.1 applies in respect of the facility addition(s) or equipment replacement(s) as if the addition(s) or replacement(s) is a new **aggregated generating facility**;~~then the facilities addition or equipment replacement and associated **real power** will be subject to and must comply with the provisions of this section 502.1 in its entirety.~~

(4) Notwithstanding subsection 1(2) and (3)~~above~~, the **ISO** may require the **legal owner** of an **aggregated generating facility** or a **transmission facility** to comply with any specific provision or all of the provisions of this section 502.1, if the **ISO** determines that such compliance is necessary for the safe and reliable operation of the **interconnected electric system**~~all new and existing wind **aggregated generating facilities** with a **maximum authorized real power** of five (5) MW or more must comply with the meteorological collection tower and measurement devices provisions contained in subsection 25 below and the historical data and records requirements contained in subsection 29 below~~.

Requirements

Functional Specification

2(1) The **ISO** may~~, in accordance and consistent with this section 502.1 and any other applicable **ISO rules**, approve of~~ issue a written functional specification containing ~~further~~ details, ~~direction and discrete~~ work requirements and specifications for the design, construction and operation of ~~any wind~~an **aggregated generating ~~facilities~~facility** and associated **transmission ~~system~~facility** connection facilities.

(2) The functional specification referred to in subsection 2(1) must be generally consistent with the provisions of this section 502.1, but may contain material variances approved of by the **ISO** based upon its discrete analysis of any one or more of the technical, economic, safety, operational and ~~system~~ **reliability** requirements of the **interconnected electric system** related to the specific facility project.

~~**Successor to Prior Requirements**~~

~~**3** Subject to subsection 4(2), the provisions of this section 502.1 succeed the *Wind Power Facility Technical Requirements* dated November 15, 2004, and those requirements no longer will be in force and effect as of December 1, 2011.~~

Maximum Authorized Real Power ~~for Wind Aggregated Generating Facilities~~

~~**4**~~**3(1)** The **legal owner** of ~~any new wind~~an **aggregated generating ~~facilities~~facility** must ~~submit to~~, upon receiving a request from the **ISO**, determine the **maximum authorized real power** for ~~those wind~~the **aggregated generating ~~facilities~~facility~~,~~** and ~~once the **ISO** approves the~~provide this value to the **ISO**~~, it will form part of the functional specification for the project~~.

(2) The ~~**maximum authorized real power** for any existing wind~~**legal owner** of an **aggregated generating ~~facilities~~facility** must consider the **aggregated generating facility** capability and limitations under optimal conditions when determining the **maximum authorized real power** for the **aggregated generating facility**~~will be the "WPF Aggregated MW Capacity" as provided to the **ISO** under the requirements of section 5.1 set out in the *Wind Power Facility Technical Requirements* dated November 15, 2004~~.

~~**(3)** In accordance with the illustration set out in Appendix 2, the **ISO** will determine the **reactive power** capability requirements for any wind **aggregated generating facilities**, based on the **maximum authorized real power aggregated generating** determined under this subsection 4.~~

~~**Operating Voltage Requirements**~~

~~**5(1)** The **legal owner** of any wind **aggregated generating facilities** must submit to the **ISO** the value to be used for rated root mean square phase-to-phase voltage at:~~

~~(a) the **point** of **connection** to the **transmission system**, based on the normal operating voltage levels at the specific location of the wind **aggregated generating facilities**; and~~

~~(b) all **collector busses**.~~

~~**(2)** Once that value is approved by the **ISO**, it will form part of the functional specification for the project.~~

~~**(3)** The rated root mean square phase-to-phase voltage will be used in the application of this section 502.1 to determine and apply:~~

~~(a) the voltage ride-through requirements;~~

~~(b) voltage regulation; and~~
~~(c) the**reactive power** capability;~~

~~of the wind **aggregated generating** facilities.~~

Reactive Power Requirements

4(1) For the purposes of determining the dynamic **reactive power** requirements of this section 502.1, the **legal owner** of an **aggregated generating facility** must determine the root mean square phase-to-phase voltage value at the **collector bus** of the **aggregated generating facility**, to be used as the 1.00 per unit voltage value.

(2) An **aggregated generating facility** and any external dynamic **reactive power** resources approved under subsection 4(6) must have the capability to operate by both:

(a) manual control of the set point of the **voltage regulating system** of the **aggregated generating facility**; and

(b) automated action of the **voltage regulating system** of the **aggregated generating facility**.

(3) Subject to subsection 4(5), the dynamic **reactive power** capability of the **aggregated generating facility** must be in compliance with the following minimum requirements:

(a) 0.90 **power factor**, supplying dynamic **reactive power**; and

(b) 0.95 **power factor**, absorbing dynamic **reactive power**;

based on the **maximum authorized real power** of the **aggregated generating facility** over the entire **real power** operating range, down to the applicable minimum **gross real power**.

(4) Subject to subsection 4(5), an **aggregated generating facility** must not have limiters set to reduce the dynamic **reactive power** capability set out in subsection 4(3).

(5) The **legal owner** of an **aggregated generating facility** that has the capability to meet the dynamic **reactive power** requirements of this subsection 4 but that has stability concerns must submit in writing to the **ISO**:

(a) a request for a variance allowing for the reduction in the dynamic **reactive power** capability requirement set out in subsection 4(3)(b) due to **aggregated generating facility** stability concerns; and

(b) a detailed study in support of the request, which is specific to the **aggregated generating facility** at its location and completed by a qualified professional engineer, demonstrating that the dynamic **reactive power** capability set out in subsection 4(3)(b) should be reduced by a limiter because that dynamic **reactive power** capability will cause the **aggregated generating facility** to become unstable.

(6) The **legal owner** of an **aggregated generating facility** without the capability to meet the dynamic **reactive power** capability set out in subsection 4(3) must submit to the **ISO** in writing a request for a

variance allowing for the use of an external dynamic **reactive power** resource to compensate for the lack of capability, such that the combined capability of the **aggregated generating facility** and the external dynamic **reactive power** resource meets the requirements of subsection 4(3).

Voltage Ride-Through Requirements

65(1) Wind **aggregated generating facilities** with a **maximum authorized real power** amount equal to or greater than five (5) MW must meet For the purposes of determining the voltage ride-through requirements of this section 502.1, the **legal owner** of an **aggregated generating facility** must determine the root mean square phase-to-phase voltage value at the high voltage side of the **transmission system** step-up transformer of the **aggregated generating facility**, to be used as the 1.00 per unit voltage valuespecified in this subsection 6.

(2) Each The **legal owner** of an wind **aggregated generating facilitiesfacility** must ensure they are capable of the **aggregated generating facility** is designed to meet all of the following voltage ride-through requirements:

(a) continuous operation between greater than or equal to ninety percent (0.90%) and less than or equal to one hundred and ten percent (110%)1.10 per unit of the root mean squared rated phase-to-phase voltage at the **point of connection**.value determined under subsection 5(1);

(3) Subject to subsection 6(4), wind **aggregated generating facilities** must (b) not triptripping or going off-line any **wind turbine generator** that is producing **real power** due to voltage dips, as a result of a voltage dip or a post-transient voltage rises described in Appendix 1, deviation resulting from normally cleareda **disturbance** on **transmission systemfacilities** faults, on any phase or combination of phases at or beyond the **point of connection**., in accordance with the timing requirements of Appendix 1; and

(c) the amount of time that the voltage of the **aggregated generating facility** remains at 0.0 per unit must be at least the **normal clearing** time for a three (3) phase fault at the specific location where the **aggregated generating facility** is connected to the **transmission system** or to a **transmission facility** within the service area of the City of Medicine Hat.

(43) Notwithstanding any other provision of this subsection 6, wind5, an **aggregated generating facilities** are**facility** is not required to ride-through a fault on **transmission system** faults**facilities** that:

(a) cause an **automatic** a forced outage of a radial transmission line toconnecting the wind **aggregated generating facilities**; **facility** to the **transmission system** or a **transmission facility** within the service area of the City of Medicine Hat;

(b) occurs on the wind **aggregated generating facilitiesfacility** side of the **point of connection**, including the lowerlow voltage network and the substation; or

(c) results in the activation of a transfer trip or anti-islanding protection scheme to activate at the wind at the **aggregated generating facilitiesfacility** which causes the **aggregated generating facility** to be disconnected from the **transmission system** or a **transmission facility** within the service area of the City of Medicine Hat.

Voltage Regulation

76(1) The **ISO** will assess voltage regulation performance of windAn **aggregated generating facilitiesfacility** at the **collector busses** in accordance with this subsection 7.

(2) Wind **aggregated generating facilities** must be able to regulate voltage at the **voltage regulation system** or **automatic voltage regulator** point of control and as documented in the functional

~~specification for the project~~, under both non-disturbance and disturbance conditions.

(2) An **aggregated generating facility** must be designed so that the point of control for the **voltage regulation system** or **automatic voltage regulator** is not at the high voltage side of the **transmission facility** step-up transformer.

(3) ~~Wind~~The **aggregated generating ~~facilities~~facility** must have ~~a~~at least one (1) continuously variable, continuously acting, closed loop, centralized control **voltage ~~regulation~~regulating system** or **automatic voltage regulator** that measures voltage compared to a set point, and will control reactive devices including **~~wind turbine generators~~generating units**, dynamic **reactive power** resources, capacitor and reactor banks.

(4) The **voltage ~~regulation~~regulating system** ~~must be continuously in service and controlling while the wind **aggregated generating facilities** are connected to the **transmission system** and regardless of the quantity of actual **real power** output from the wind **aggregated generating facilities**.~~

~~**(5)** The~~or **automatic voltage ~~regulation system~~regulator** set point must be adjustable by the **operator** of the ~~wind~~ **aggregated generating ~~facilities~~facility** to a percentage between ~~ninety five percent (~~95%~~)~~ and ~~one hundred and five percent (~~105%~~)~~ of ~~rated~~nominal voltage at the point of control for the **voltage regulating system** or **automatic voltage regulator**.

(~~6~~5) The **voltage ~~regulation~~regulating system** or **automatic voltage regulator** must operate in a voltage set point control mode to the exclusion of any other modes.

(~~7~~6) The **voltage ~~regulation~~regulating system** or **automatic voltage regulator** must measure voltage that represents the overall voltage response of the ~~wind~~ **aggregated generating ~~facilities~~facility**.

(~~8~~7) The **voltage regulating system** or **automatic voltage regulator** must be capable of:

(a) adjustable gain, or reactive droop compensation adjustable from ~~zero to ten percent (~~0% to 10%~~)~~; and

(b) reactive current compensation to compensate for any step-up transformers connected to the **transmission system** or a **transmission facility** within the service area of the City of Medicine Hat.

(~~9~~8) The combined settings of the **voltage ~~regulation~~regulating system** or **automatic voltage regulator** must be able to achieve a steady state voltage regulation of ~~plus or minus zero point five percent (~~+/- 0.5%~~)~~ of the voltage controlled by the **voltage ~~regulation~~regulating system** or **automatic voltage regulator**.

(~~10~~9) The **ISO** ~~will~~must specify in the functional specification for the **aggregated generating facility** whether the reactive current compensation in the **voltage ~~regulation~~regulating system** or **automatic voltage regulator** must be implemented~~, which will form part of the functional specification for the project~~.

~~**(11)** The **ISO** may, upon no less than ninety (90) **days**' notice in writing to the **legal owner** of any commissioned wind **aggregated generating facilities**, require a change to the setting of the reactive droop compensation gain or the reactive current compensation settings for those commissioned wind **aggregated generating facilities**.~~

(~~12~~10) The **voltage ~~regulation~~regulating system** or **automatic voltage regulator** must be calibrated such that a change in **reactive power** will achieve ~~ninety five percent (~~95%~~)~~ of its final value, no sooner than zero point one (0.1) seconds and no later than one (1) second following a step change in voltage.

(~~13~~11) When the **voltage regulation system** or **automatic voltage regulator** requires the switching of a shunt reactive device, the switching operation must be delayed by ten (10) seconds.

External Voltage Regulation

8 No wind **aggregated generating facilities** may use or rely upon any **voltage regulation system** or **reactive power** resources that are external to the wind **aggregated generating facilities** without the approval of the **ISO**, which approval will form part of the functional specification for the project.

Wind Aggregated Generating Facilities Reactive Power Capability

9(1) Dynamic and non-dynamic **reactive power** requirements must be based on the rated voltage at the **collector busses**.

(2) As illustrated in Appendix 2, the minimum continuous **reactive power** capability of any wind **aggregated generating facilities** to supply **reactive power** must meet or exceed plus zero point nine (+0.9) **power factor**, based on the **gross real power** up to and including the **maximum authorized real power** of the wind **aggregated generating facilities**.

(3) As illustrated in Appendix 2, the minimum continuous **reactive power** capability of any wind **aggregated generating facilities** to absorb **reactive power** must meet or exceed minus zero point nine five (-0.95) power factor, based on the **gross real power** up to and including the **maximum authorized real power** of the wind **aggregated generating facilities**.

(4) Continuous **reactive power** capability referred to in subsections 10 and 11 may be aggregated to meet the requirements set out in subsections 9(2) and (3).

(5) All **reactive power** resources used to vary the **reactive power** output of the wind **aggregated generating facilities** within the requirements set out in subsections 9(2) and (3) must be under control of the **voltage regulation system**.

(6) The **operator** must not intentionally, and the control systems of wind **aggregated generating facilities** must not be designed to, reduce the **reactive power** capability from the dynamic reactive devices described in subsection 10, or the non-dynamic reactive resources described in subsection 11.

Dynamic Reactive Power Capability

10(1) As illustrated in Appendix 2, the minimum dynamic **reactive power** capability of any wind **aggregated generating facilities** must meet or exceed plus zero point nine five (+0.95) **power factor** based on the **gross real power** up to and including the **maximum authorized real power** of the wind **aggregated generating facilities**.

(2) As illustrated in Appendix 2, the minimum dynamic **reactive power** capability of any wind **aggregated generating facilities** must meet or exceed minus zero point nine eight five (-0.985) **power factor** based on the **gross real power** up to and including the **maximum authorized real power** of the wind **aggregated generating facilities**.

(3) Wind **aggregated generating facilities** must have **reactive power** resources that are continuously acting and continuously variable under control of the **voltage regulation system**, and be able to respond to **transmission system** voltage fluctuations.

(4) For the purposes of subsections 10(1) and (2), a short term **reactive power** capability for a

~~period of up to one (1) second will be deemed to meet the dynamic **reactive power** capability set out in those subsections.~~

~~**(5)** The short term **reactive power** capability referred to in subsection 10 (4) does not qualify for continuous **reactive power** described in subsection 9.~~

~~**Non-Dynamic Reactive Power Capability**~~

~~**11(1)** For any wind **aggregated generating facilities**, the MVAr size of the individual shunt **reactive power** resources under control of the **voltage regulation system** must not be larger than the total range of the continuous capability of dynamic **reactive power** set forth in subsection 10.~~

~~**(2)** Any shunt **reactive power** resources installed in any wind **aggregated generating facilities** must be capable of being switched on no later than five (5) minutes after having been switched off.~~

~~**Operator Availability**~~

~~**12** The **legal owner** of any wind **aggregated generating facilities** must have a designated and qualified **operator** available twenty four (24) hours a **day** every **day** for contact and communication with the **ISO**, in accordance with **ISO rules** and other communication policies and protocols.~~

Frequency and Speed Governing Requirements

7(1) An **aggregated generating facility** must have a continuously acting **governor system**, which must be designed:

(a) to be continuously in service, free to respond to frequency changes and controlling the response to frequency changes while the **aggregated generating facility** is connected to the **transmission system** or a **transmission facility** within the service area of the City of Medicine Hat and is producing any **real power** as measured at the **collector bus**;

(b) with a droop setting equal to or greater than 3% but less than or equal to 5%;

(c) with a deadband, intentional plus unintentional, not exceeding plus or minus 0.036 Hz;

(d) not to have an intentional time delay added to the control system;

(e) with the capability of manual setpoint adjustments within a range of 59.4 Hz and 60.6 Hz;

(f) to continuously monitor the frequency of the electric system or the speed of a synchronous **generating unit** at a sample rate of at least twenty (20) samples per second; and

(g) with a resolution of at least 0.004 Hz.

(2) The **governor system** must override any power limits in effect at the time of the frequency excursion but only while the frequency remains outside of the deadband.

(3) An **aggregated generating facility** must be designed not to trip for under-frequency and over-frequency deviations for the minimum time frames as set out in Appendix 2.

(4) Notwithstanding subsection 7(3), an **aggregated generating facility** that trips off in a shorter period than the minimum time set forth in Appendix 2 must have binding and firm arrangements to automatically and simultaneously trip off an amount of load in MW on the **interconnected electric system** equal to the anticipated generation loss in MW, at comparable frequency levels.

WECC Stability Control Requirements for an Aggregated Generating Facility Consisting of Directly Coupled Asynchronous Generating Units or Decoupled Generating Units

~~13~~**8** ~~After December 1, 2011, if~~If any **WECC** standards or policies specify the use of a power system stabilizer or similar functionality for ~~wind~~an **aggregated generating** ~~**facilities**~~**facility** ~~using a synchronous wind turbine generator~~consisting of directly coupled asynchronous **generating units** or decoupled **generating units**, then based on those standards or policies the **ISO** may, by written notice~~,~~ to the **legal owner** ~~may,~~ require ~~the wind~~an **aggregated generating** ~~**facilities**~~**facility** consisting of directly coupled asynchronous **generating units** or decoupled **generating units** to use such a power system stabilizer.

WECC Stability Control Requirements for an Aggregated Generating Facility Consisting of Directly Coupled Synchronous Generating Units

9(1) The **legal owner** of an **aggregated generating facility** consisting of directly coupled synchronous **generating units** and with a **maximum authorized real power** greater than 67.5 MW must install power system stabilizers.

(2) Notwithstanding subsection 9(1), a power system stabilizer is not required to be installed on an **aggregated generating facility** consisting of directly coupled synchronous **generating units** if the closed loop phase lag between the **aggregated generating facility** voltage at the **collector bus** and the **automatic voltage regulator** reference input is greater than 135 degrees.

(3) Any pumped storage **aggregated generating facility** consisting of directly coupled synchronous **generating units** must be equipped with a power system stabilizer and be capable of operating in the pump mode while connected to the **transmission system** or a **transmission facility** in the service area of the City of Medicine Hat, and if the power system stabilizer does not produce negative damping, then the power system stabilizer must be designed to be in service in the pump mode.

(4) A power system stabilizer must:

(a) be designed to be in continuous operation while the **aggregated generating facility** consisting of directly coupled synchronous **generating units** is on-line, except for when the **aggregated generating facility** consisting of directly coupled synchronous **generating units** is producing less **real power** than its design limit for effective power system stabilizer operation;

(b) be reviewed and retuned if any **automatic voltage regulator** response parameters for the **aggregated generating facility** consisting of directly coupled synchronous **generating units** are modified;

(c) be either:

(i) a dual input integral of accelerating **real power** type; or

(ii) a single input speed or frequency type;

(d) provide a compensated frequency response of the excitation system and the **aggregated generating facility** consisting of directly coupled synchronous **generating units** such that, through the frequency range from 0.1 Hz to 1.0 Hz, the phase shift will not exceed plus or minus 30 degrees;

(e) be capable of output limits between plus or minus 5% of the operating voltage value submitted under subsection 4(1);

(f) have the gain set to provide a gain margin of no less than 6 dB and no more than 10 dB; and

(g) have the washout time constant set as low as possible while maintaining the compensated phase criteria.

(5) A power system stabilizer of the **real power** type is prohibited for an **aggregated generating facility** consisting of directly coupled synchronous **generating units**.

(6) The use of a single power system stabilizer for an **aggregated generating facility** consisting of directly coupled synchronous **generating units** must be approved by the **ISO** and detailed in the functional specification for the **aggregated generating facility**.

Transmission ~~System~~Facility Step-Up Transformer

~~14~~10**(1)** The voltage ratio, tap changer type, range and step size specifications for ~~any~~the transmission step-up transformer of ~~any wind~~an **aggregated generating ~~facilities~~facility** must be such that the **maximum authorized real power** and **reactive power** requirements specified in subsection~~s 9~~3 and 4 are fully available throughout the operating voltage range documented in the functional specification for the ~~project~~**aggregated generating facility**.

(2) The connection of ~~the **wind turbine generator**~~a **generating unit** step-up transformer, **transmission ~~system~~facility** step-up transformer or any combination of the two (2) transformers for ~~any wind~~an **aggregated generating ~~facilities~~facility** must be designed to provide:

(a) a favorable circuit to block the transmission of harmonic currents; and

(b) isolation of **transmission ~~system~~facilities** and **~~wind turbine generator~~generating unit** side ground fault current contributions.

(3) ~~The wind~~An **aggregated generating ~~facilities~~facility** must utilize an effectively grounded wye connection on the high side of the **transmission ~~system~~facility** step up transformer.

Fault Interrupting Devices

~~Off Nominal Frequency Requirements~~

~~15~~11**(1)** ~~For wind~~An **aggregated generating facility** must be designed to:

(a) account for the fault contributions from both the **transmission facilities** and the **aggregated generating facility**; and

(b) **have** fault interrupting and momentary withstand ratings that are adequate to meet the maximum expected fault levels, with a margin for future anticipated fault levels as approved by the **ISO** in the functional specification for the **aggregated generating facility**~~have a requirement to protect equipment for off-nominal frequency operation, the **legal owner** must install protective relays so as to accommodate operation for the specified time frames shown in the Table set out in Appendix 3~~.

(2) An **aggregated generating facility** connecting to a **transmission facility** must provide the functionality and remote control capabilities to enable the **operator** of the **transmission facility** to open or trip any connecting breaker either at the **point of connection** or any **collector bus** feeder breakers, as applicable.~~The trip setting of the protective relays must either:~~

(a) be set to the requirements set out in Appendix 3 with respect to the frequency versus time setting; or

(b) automatically trip load to match the anticipated generation loss and at comparable frequency levels.

(3) Any frequency relays installed to protect equipment for off-nominal frequency operation must:

(a) be solid state or microprocessor based;

(b) use a definite time characteristic; and

(c) not be disabled for **transmission system** voltages that are below eighty percent (80%) of the rated voltage without the approval of the **ISO**, which approval will form part of the functional specification for the project.

Over Frequency Control System Requirements

16(1) Any wind **aggregated generating facilities** must have an over frequency control system that continuously monitors the frequency of the **transmission system** at a sample rate of at least thirty (30) per second and a resolution of at least zero point zero zero four (0.004) Hertz, and the over frequency control system must automatically control the **gross real power** output of the wind **aggregated generating facilities** at all times.

(2) The over frequency control system may have an intentional deadband of up to zero point zero three six (0.036) Hertz.

(3) The over frequency control system must be designed and calibrated to reduce the **gross real power** output at the **collector bus** based on the capability of all on-line **wind turbine generators** producing **real power** during an over frequency excursion, and such reductions must be:

(a) proportional to the frequency increase by a factor of thirty three percent (33%) per Hertz of the **gross real power** output;

(b) at a rate of five percent (5%) of the **gross real power** output per second; and

(c) with no intentional time delay added to the control system.

(4) In accordance with subsection 15, for **transmission system** over frequency events greater than sixty-one point seven (61.7) Hertz, wind **aggregated generating facilities** may trip due to the over frequency, but if the wind **aggregated generating facilities** remain connected to the **transmission system** then the over frequency control system must continue to ramp down the **gross real power** output in accordance with the requirements of this subsection 16.

(5) The over frequency control system requirements of this subsection 16 must have control priority over the power limiting control function and must reduce the **gross real power** output for an over frequency condition even when the requirements of subsection 18 are in effect.

Wind Aggregated Generating FacilitiesFacility Disconnection

1712(1) WindAn **aggregated generating facilitiesfacility** must have systems, controls and related procedures to electrically disconnect the wind **aggregated generating facilitiesfacility** from the **transmission system** or a **transmission facility** within the service area of the City of Medicine Hat either at:

(a) the **point of connection**; or

(b) the **collector bus** feeder breakers; or

(c) both ~~of them~~ ;

as documented in the functional specification, after consultation ~~among the **ISO**~~,between the **legal owner** of the ~~wind~~ **aggregated generating** ~~**facilities**~~**facility** and the **legal owner** of the applicable **transmission facility**.

(2) ~~Wind~~An **aggregated generating** ~~**facilities**~~**facility** connecting to a **transmission facility** must provide the functionality and remote control capabilities to enable the **operator** of the **transmission facility** to open or trip any connecting breaker either at the **point of connection** or any **collector bus** feeder breakers, as applicable.

Isolating Devices

13(1)~~**(3)** Once a connecting breaker or feeder breaker of any wind~~An **aggregated generating** ~~**facilities**~~**facility** ~~has been opened or tripped, then~~ must be designed with manually operable isolation switches at all points of isolation, as documented in the ~~**operator** may only electrically reconnect to~~functional specification, after consultation between the **legal owner** of the **aggregated generating facility** and the **legal owner** of the applicable **transmission facility** ~~after receiving approval from the **ISO**~~.

(2) The isolation switches must permit visual verification of electrical isolation and have the capability of being locked open with multiple locks.

~~Wind~~ Aggregated Generating ~~Facilities Real~~Facility Power ~~and Ramp Rate Limitations~~Quality

~~18~~14(1) ~~Wind~~An **aggregated generating** ~~**facilities**~~**facility** must ~~have~~be designed to meet the ~~control capability to limit the **real**~~following power ~~output~~quality requirements at the **point of connection** ~~in accordance with any limits or instructions contained in any **directive,** and in any event the **real power output** ~~:

(a) the voltage must ~~not exceed the tolerances described in this subsection 18.~~:

~~**(2)** The **real power** control limit referred to in subsection 18(1) must be adjustable from the minimum operating output to the **maximum authorized real power**, at an average resolution of one (1) MW.~~
~~**(3)** When a **real power** control limit is in effect in accordance with a **directive** and wind speed conditions at the wind **aggregated generating facilities** are increasing, then subject to subsection 18(4), the **real power** limiting controls of the wind **aggregated generating facilities** must be capable of keeping the one (1) minute average **real power** output from exceeding the wind **aggregated generating facilities** limit specified in the **directive** by two percent (2%) of the **maximum authorized real power**.~~
~~**(4)** If a wind gust results in the **real power** control limit set out in the **directive** being instantaneously exceeded, then the wind **aggregated generating facilities** will remain in compliance if the **real power** output at the **point of connection** does not exceed the **real power** control limit by more than five percent (5%) of the **maximum authorized real power**.~~

~~**(5)** Wind **aggregated generating facilities** must be equipped with **ramp rate** limiting controls.~~

~~**(6)** The **ramp rate** limiting controls must be capable of limiting the ramp up of the **real power** of the wind **aggregated generating facilities**, and must be adjustable such that the **ramp rate** does not exceed, in MW per minute, a range equal to five percent (5%) of the **maximum authorized real power** to twenty percent (20%) of the **maximum authorized real power**.~~

~~**(7)** The default setting for the **ramp rate** limiting controls must be set at ten percent (10%), unless otherwise approved by the **ISO**, which approval will form part of the functional specification for the project.~~

~~**(8)** Any difference in the **real power** at the **point of connection** and any **collector busses** must be compensated for in the **real power** limiting and **ramp rate** limiting controls.~~

~~**Wind Aggregated Generating Facilities Power Quality**~~

~~**19(1)** Wind **aggregated generating facilities** must be designed and operated to meet or exceed the minimum power quality standards set out in this subsection 19.~~

~~**(2)** With regard to voltage flicker as measured at the **point of connection**, the **legal owner** of any wind **aggregated generating facilities** must comply~~(i) be in compliance with the specifications set out in the version of the *International Electrotechnical Commission 61000-3-7, Electromagnetic compatibility (EMC) – Part 3-7: Limits - Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems* that is in effect as of the date ~~of~~ the **ISO** first ~~**ISO** approved revision of~~approves the functional specification for the **aggregated generating facility** connection project~~.~~; and

~~**(3)** Upon request from~~(ii) be in compliance with the ~~**legal owner**~~short and long term flicker limits as set out in the following Table 1:

Table 1
Short and Long Term Flicker Limits

	Planning Levels
Pst	0.8
Plt	0.6

where:

Pst is the magnitude of ~~any new wind~~the resulting short term flicker level for the considered aggregation of flicker sources (probabilistic value); and

Plt is the magnitude of the resulting long term flicker level for the considered aggregation of flicker sources (probabilistic value);

and

(iii) meet the:

(A) 99% probability weekly value for Pst; and

(B) 95% probability weekly value for Plt

based on a measurement period of one (1) calendar week of normal operation of the **aggregated generating ~~facilities~~facility**~~, the **ISO** must provide a written description of the specific harmonic impedance envelope at a proposed **point of connection** for those wind~~;

(b) the **aggregated generating ~~facilities~~facility** must be in compliance with the specifications set out in~~.~~

~~**(4)** With regard to harmonics as measured at the **point of connection**, the **legal owner** of any wind **aggregated generating facilities** must comply with~~ the version of the *IEEE Standard 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems – Section 11* that is in effect as of the date ~~of~~ the **ISO** first ~~**ISO** approved revision~~

ofapproves the functional specification for the **aggregated generating facility** connection project.; and

(5) Any wind(c) the **aggregated generating facilitiesfacility** must include systems and components designed to avoid introducingnot introduce any resonance into the **transmission system**, with such design specifications to apply to**facility**, including self-excitation of induction machines, transformer ferroresonance, resonant effects of capacitor additions and the capacitance of collectorthe cables of the **aggregated generating facility**.

(6) Wind **aggregated generating facilities** must not cause any voltage unbalance on the **transmission system**, as measured at the **point of connection**, in excess of the value specified by the **ISO**, which will form part of the functional specification for the project.

Grounding

2015 Any windAn **aggregated generating facilitiesfacility** must be designed and constructed to take in to account that the operate within a **transmission system** that operates as an effectively grounded system.

Lightning and Other Surge Protection

2116(1) The lightning An **aggregated generating facility** must be equipped with surge protection for any associated substation equipmentfacilities associated with any wind **aggregated generating facilities**.

(2) The surge protection referred to in this subsection 16(1) must operate under the following conditionsbe designed to take into account:

(a) lightning, including the average isokeraunicground flash density level for the site **aggregated generating facility** location of the wind **aggregated generating facilities**,;

(b) switching surges;

(c) neutral shifts;

(d) **electrical islands**; and to

(e) temporary over-voltages.

(3) The surge protection referred to in subsection 16(1) must be compatible with the connecting **transmission facility** connected to the **aggregated generating facility** to ensure coordination of insulation levels.

Fault Interrupting Devices

22(1) Any wind **aggregated generating facilities** must be designed to:

account for the fault contributions from both the **transmission system** and the wind

(a) **aggregated generating facilities**; and

(b) have fault interrupting and momentary withstand ratings that are adequate to meet the maximum expected fault levels, with a margin for future anticipated fault levels as approved by the **ISO** which approval will form part of the functional specification for the project.

(2) The wind **aggregated generating facilities** must not use high voltage fuses at sixty (60) kilovolts or higher.

Isolating Devices

23(1) Any wind **aggregated generating facilities** must be designed with manually operable isolation switches at all points of isolation as documented in the functional specification, after consultation among the **ISO**, the **legal owner** of the wind **aggregated generating facilities** and the **legal owner** of the applicable **transmission facility**.

(2) The isolation switches must permit visual verification of electrical isolation and have the capability of being locked open with multiple locks.

Supervisory Control and Data Acquisition Additional Requirements

24 Deleted – see Revision History.

Meteorological Collection Tower and Measurement Devices and Availability Requirements

25(1) Any wind **aggregated generating facilities** must have a meteorological collection tower and related devices installed in accordance with the provisions of this subsection 25.

(2) The tower must be equipped with two (2) sets of weather measurement devices in accordance with the following:

(a) for any new wind **aggregated generating facilities**:

(i) one device must take measurements at the **wind turbine generator** hub height; and

(ii) the second device must take measurements at a height that the **ISO** specifies in the functional specification; and

(b) for any existing wind **aggregated generating facilities**, the measurements must be taken at heights specified by the **ISO** in writing after consultation with the **legal owner**.

(3) The measurement devices must measure, on a ten (10) minute average value;

(a) wind speed in meters per second (m/s), with a precision for instantaneous measurements to the nearest zero point one (0.1) meters per second;

(b) wind direction in degrees from true north, with a precision for instantaneous measurements to the nearest one (1) degree;

(c) barometric pressure in HectoPascals (HPa), with a precision for instantaneous measurements to the nearest six (6) Pa; and

(d) ambient temperature in degrees Celsius (°C), with a precision for instantaneous measurements to the nearest zero point one (0.1) degrees Celsius.

(4) Any wind **aggregated generating facility** must provide to the **ISO** the current and planned **available capability** down to the **real power** equivalent of one (1) **wind turbine generator**.

(5) When the current or planned **available capability** that was provided to the **ISO** in accordance with subsection 25(4) changes, the wind **aggregated generating facility** must provide to the **ISO** the new current or planned **available capability** as soon as practicable.

(6) The **legal owner** must submit to the **ISO** the data specified in this subsection 25 in the method and format the **ISO** specifies:

(a) in the functional specification for any new wind **aggregated generating facilities**; or

(b) in writing to the **legal owner** for any existing wind **aggregated generating facilities**.

~~**Wind Aggregated Generating Facilities Synchrophasor Measurement**~~

~~**26(1)** Any wind **aggregated generating facilities** must have equipment installed for synchrophasor measurements that complies with the specifications referenced in the functional specification for the project~~

Aggregated Generating Facility Synchrophasor Measurement

17(1) The **legal owner** of an **aggregated generating facility** must install a synchrophasor measurement system on the **aggregated generating facility** in accordance with this subsection 17.

(2) Synchrophasor measurements must take place at the following points:

(a) all three (3) phase-to-ground voltages at each **collector bus** of the ~~wind~~ **aggregated generating** ~~**facilities**~~**facility**;

(b) all three (3) phase currents for each **transmission facility** step-up transformer on the low voltage side of the ~~transformer~~**aggregated generating facility**; and

(c) all three (3) phase-to-ground voltages and currents at each **point of connection** of the ~~wind~~ **aggregated generating** ~~**facilities**~~**facility**.

~~**Wind Aggregated Generating Facilities Testing Post Connection**~~

~~27(1) **Following the connection of any wind aggregated generating** facilities **to the** transmission system, **the**~~

(3) The legal owner ~~must test the wind~~of an **aggregated generating facility**~~**facilities**~~ in accordance with the provisions of subsection 27(2), must design a synchrophasor measurement system that is capable of downloading and ~~must provide the test results and report as per the **ISO** document *"Requirements*~~retaining a record of the measurements set out in subsection 17(2) for *Model Validation"* ~~no later~~ a period of not less than ~~sixty (60) **days** following~~ one (1) calendar year from the date of the initial recording unless the ISO indicates otherwise in the functional specification for the **aggregated generating facility**~~upon which wind speed conditions reasonably will allow for the tests to be conducted~~.

~~**(2)** The following specific tests must be completed:~~

~~(a) a **voltage regulation system** and **reactive power** response test, which demonstrates the ability of the wind **aggregated generating facilities** to control the **collector bus** and **transmission system** voltage in a stable manner, and which test consists of injecting a test signal to the voltage reference point of the **voltage regulation system**;~~

~~(b) a **reactive power** capability test, which demonstrates the ability of the wind **aggregated generating facilities** to provide continuous **reactive power** in accordance with subsection 9; and~~

~~(c) a voltage set-point capability test, which demonstrates the ability of the wind **aggregated generating facilities** to adjust the voltage set-point of the **voltage regulation system** to any applicable provisions of the **ISO rules**.~~

~~**(3)** The **ISO** may specify the additional following tests in the functional specification for the project:~~

~~(a) a harmonic test which must demonstrate that harmonic levels for the wind **aggregated generating facilities** are within the specifications set out in subsection 19(4); and~~

~~(b) a voltage flicker test, which must demonstrate that the flicker levels for the wind **aggregated**~~

generating facilities are within the specifications set out in subsection 19(2).

(4) The **ISO**, by written notice, may require the **legal owner** of any wind **aggregated generating facilities** to repeat any of the tests set out in this subsection 27 if:

(a) there is evidence that the results of the tests do not correlate with the actual response, except in instances where the lack of correlation was caused by equipment problems that were subsequently corrected; or

(b) there are changes in any applicable **NERC** or **WECC** policy or standards requirements which necessitate a repeat of any of the tests.

Provision of Modeling Information from Wind Aggregated Generating Facilities

28(1) The **legal owner** must provide the **ISO** with power system studies which demonstrate that the wind **aggregated generating facilities** are capable of meeting the voltage ride-through requirements specified in subsection 6.

(2) The **legal owner** must provide a **voltage regulation system** model with validated data demonstrated by a physical performance test of at least one (1) **voltage regulation system** device used at the wind **aggregated generating facilities.**

(3) The **legal owner** must re-validate all model data if the **ISO** provides written notice that there is evidence that the modeled response of the wind **aggregated generating facility** does not correlate with the actual response, except in instances where the lack of correlation was caused by equipment problems that were subsequently corrected.

Wind Aggregated Generating Facilities Data and Records Requirements

29(1) Subject to the provisions of this subsection 29, the **legal owner** of any wind **aggregated generating facilities** must retain historical data and records consisting of ten (10) minute averaged meteorological data, including wind speed, wind direction, temperature, barometric pressure, and details on the height of the measurements.

(2) The **legal owner** must provide the historical data and records referred to in this subsection 29 to the **ISO**.

(3) Upon the **ISO**'s written request**,** the **legal owner** must, subject to availability, provide such historical data and records for up to two (2) calendar years prior to the **commissioning** period for any new wind **aggregated generating facilities**, and the most recent two-year period for existing wind **aggregated generating facilities**.

(4) The **legal owner** in addition must provide the **ISO** with specific **wind turbine generator** data and records, including hub height, turbine land coordinates, turbine power curves, high wind speed cut-out and any applicable temperature cut-outs.

(5) The **legal owner** must provide to the **ISO** the data and records referred to in this subsection 29 in a method and format the **ISO** specifies, which for new wind **aggregated generating facilities** will be contained in the in the functional specification for the project.

Appendices

Appendix 1 – *Voltage Ride-Through Requirements for Aggregated Generating Facilities*

Appendix 2 – *Reactive Power Capability*

~~Appendix 3 -~~ *Trip Settings of Off-Nominal Frequency Protective Relays*

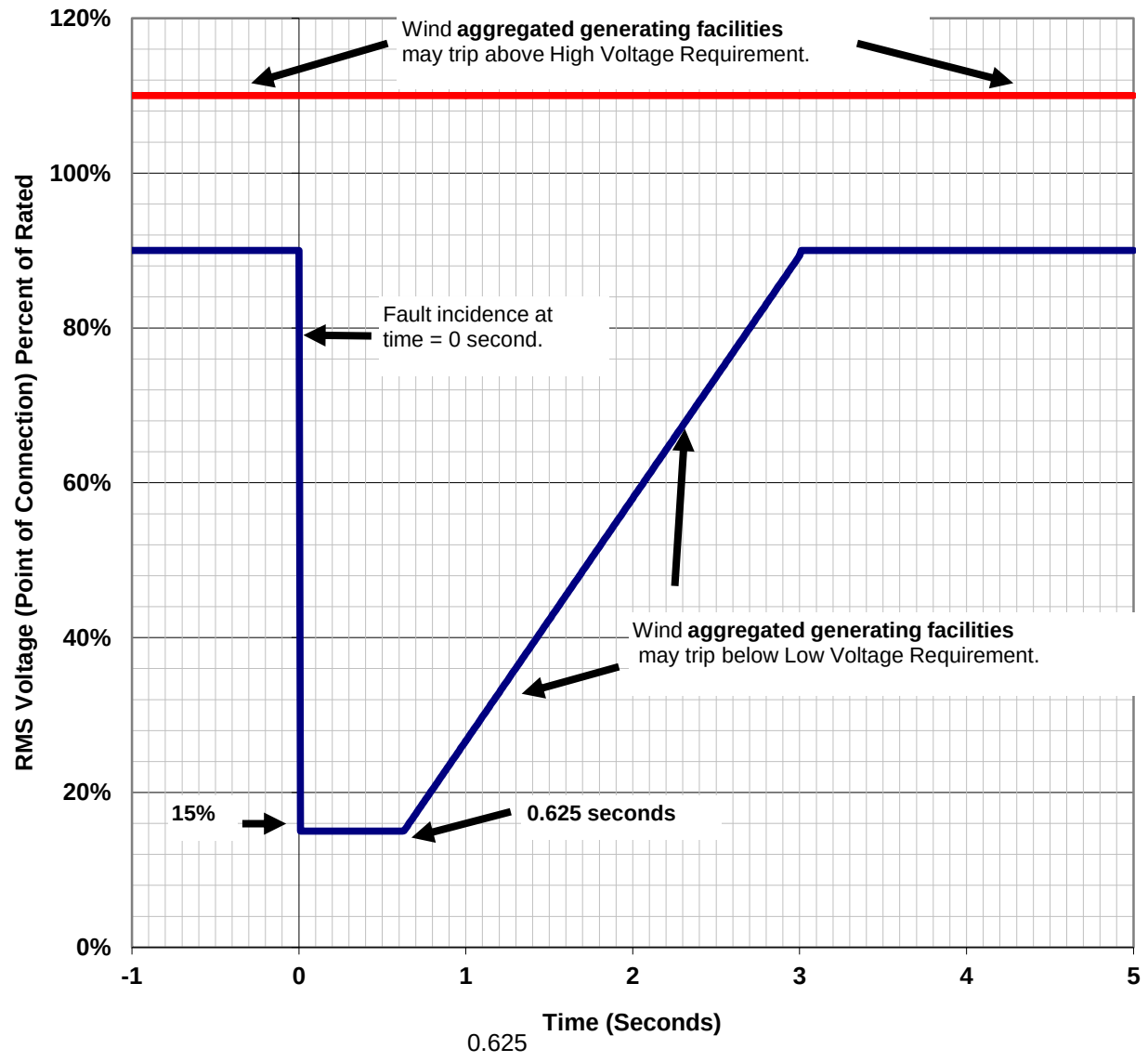
Revision History

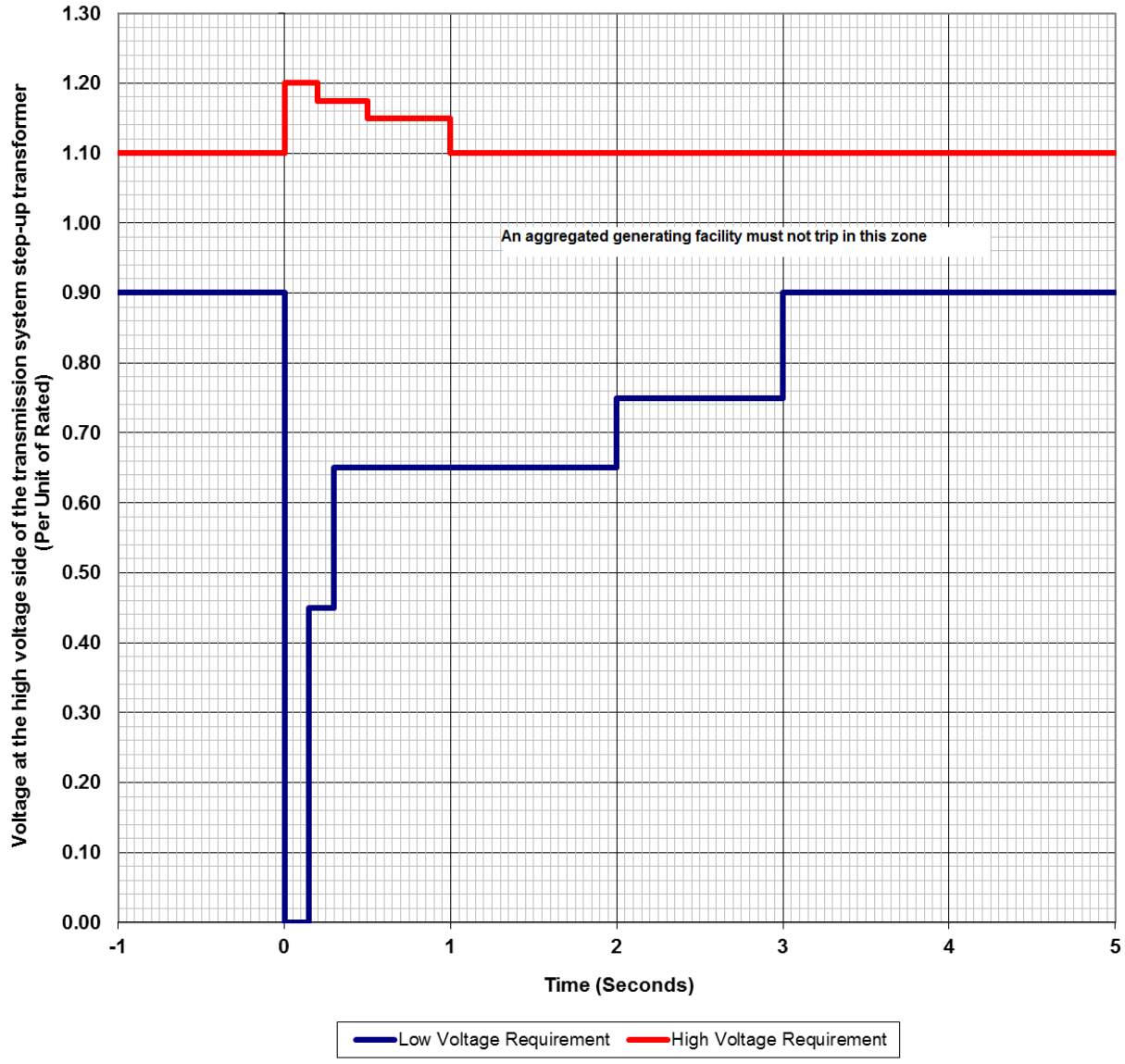
Date	Description
xxxx-xx-xx	Revised references to "wind aggregated generating facility" to "aggregated generating facility"; revised Applicability section; removed operating requirements, including testing post connection, modelling information, data and record requirements and operator availability; removed real power and ramp rate limitations and meteorological collection tower measurement devices and availability requirements; added frequency and speed governing and record retention period for synchrophasor measurement data requirements; revised reactive power, voltage ride through, voltage regulation, WECC stability control, disconnection, power quality and lightning surge protection requirements; clarified subsection 5(2)(a); revised Appendix 1 to apply to both wind and solar aggregated generating facilities and clarified voltage ride-through requirements for 1.10 per unit of the voltage value; removed Appendix 2, *Reactive Power Capability*; and revised Appendix 3, *Trip Settings of Off-Nominal Frequency Protective Relays* and moved to Appendix 2.
2015-04-01	Subsections 25(4) and (5) were added to increase the accuracy of the wind power forecast by requiring the current and planned available capability.
2015-03-27	Replaced "effective date" with the initial release date in sections 1(1)(b), 3 and 13; and replaced the word "Effective" in the Revision History to "Date".
2014-07-02	In subsection 7(11) deleted reference to "aggregated generation facilities" and replaced it with "aggregated generating facilities"; in subsection 25(2)(a)(ii) deleted the period at the end and replaced it with a semicolon and the word "and"; in subsection 29(3) deleted the words "two (2) year" and replaced it with "two-year"; and deleted references to "forced outage" and replaced it with "automatic forced outage".
2013-09-24	Updated to remove bolding on the term "power system stabilizer".
2011-12-01	Initial Release.

Appendix 1 – Voltage Ride-Through Requirements for Aggregated Generating Facilities

~~Voltage Ride Through Requirements~~

High Voltage Ride Through Duration		Low Voltage Ride Through Duration	
Voltage (per unit)	Time (seconds)	Voltage (per unit)	Time (seconds)
≥ 1.200	Instantaneous trip	< 0.45	0.15
≥ 1.175	0.20	< 0.65	0.30
≥ 1.15	0.50	< 0.75	2.00
> 1.10	1.00	< 0.90	3.00
≤ 1.10	Continuous operation	≥ 0.90	Continuous operation

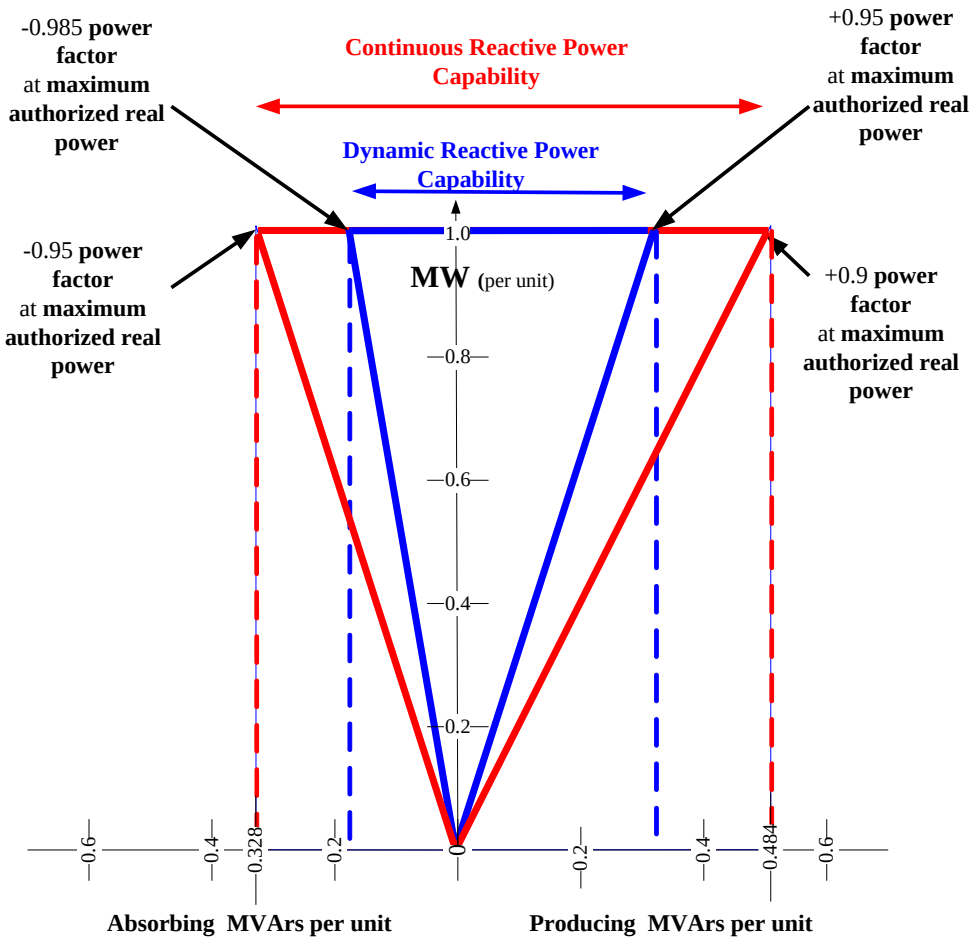


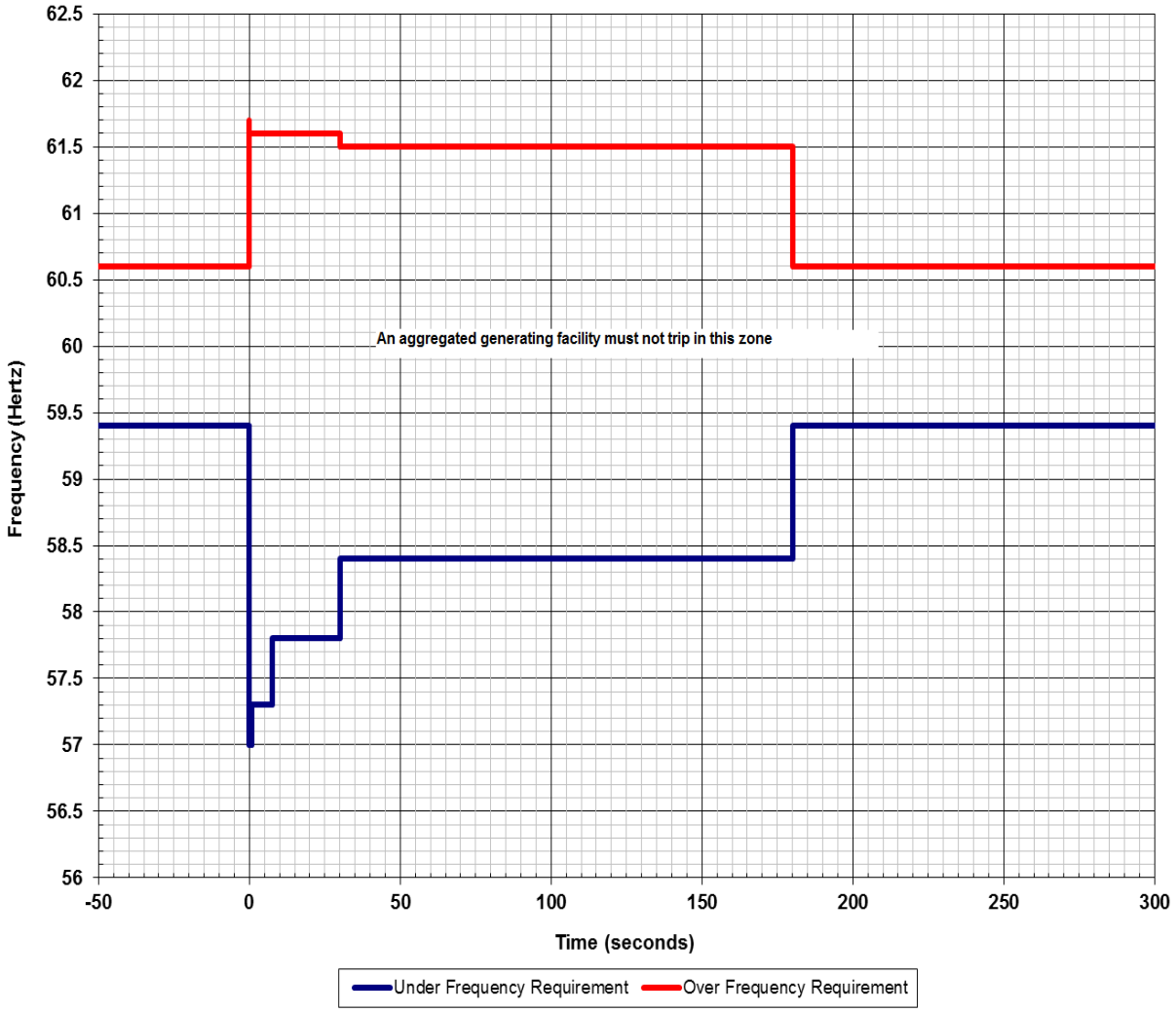

Voltage at the high voltage side of the transmission system step-up transformer (Per Unit of Rated)
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-1
0
1
2
3
4
5
Time (Seconds)
An aggregated generating facility must not trip in this zone
Low Voltage Requirement
High Voltage Requirement

Appendix 2 – Trip Settings of Off-Nominal Frequency Protective Relays

~~Reactive Power Capability~~

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Time (seconds)	Frequency (Hz)	Time (seconds)
≥ 61.7	Instantaneous trip	≤57.0	Instantaneous trip
≥61.6	30	≤57.3	0.75
≥60.6	180	≤ 57.8	7.5
<60.6	Continuous operation	≤ 58.4	30
		≤ 59.4	180
		> 59.4	Continuous operation




62.5
62
61.5
61
60.5
60
59.5
59
58.5
58
57.5
57
56.5
56
Frequency (Hertz)
An aggregated generating facility must not trip in this zone
-50
0
50
100
150
200
250
300
Time (seconds)
Under Frequency Requirement
Over Frequency Requirement