# Information Document
# Model Validation and Reactive Power Reporting Guidance
# ID #2017-013R

Information documents are not authoritative. Information documents are for information purposes only and are intended to provide guidance. If there is a discrepancy between an information document and any authoritative document[1] in effect, the authoritative document governs.

## 1 Purpose

This information document relates to the following authoritative documents:

- Section 502.6 of the ISO rules, *Generating Unit Operating Requirements* ("Section 502.6");
- Section 502.16 of the ISO rules, *Aggregated Generating Facilities Operating Requirements* ("Section 502.16"); and
- Section 502.14 of the ISO rules, *Battery Energy Storage Facility Operating Requirements* ("Section 502.14").

The purpose of this information document is to provide guidance to the legal owner of a generating unit, the legal owner of an aggregated generating facility and the legal owner of a battery energy storage facility on the content of a generating unit, aggregated generating facility and battery energy storage facility Model Validation and Reactive Power Verification Report, pursuant to subsections 10 through 13 of Sections 502.6, 502.16 and subsections 10 through 14 of Section 502.14.

### 1.1 Applicably of NERC Reliability Standards

The AESO reviewed NERC reliability standards MOD-025-2, *Verification and Data Reporting of Generator Real and Reactive Power Capability and Synchronous Condenser Reactive Power Capability* ("MOD-025-2"), and MOD-026-1, *Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions* ("MOD-026-1") and determined that the rules referenced above collectively adequately cover the requirements of MOD-025-2 and MOD-026-1. Subsequently, MOD-025-2 and MOD-026-1 were rejected for adoption for Alberta.

The AESO generally agrees with the information contained in the NERC technical reference documents[2] and recognizes that the documents may be a useful reference for the legal owner of a generating facility, the legal owner of an aggregated generating facility and the legal owner of a battery energy storage facility in the testing and reporting of subsections 10, 11, 12, and 13 of Sections 502.6, 502.16, and subsections 11,12,13 and 14 of Section 502.14.

## 2 Generating Unit Model Validation and Reactive Power Verification Report Content

The *Generating Unit Model Validation and Reactive Power Verification Report*, also known as *MVQ Report* described in subsection 13 of Sections 502.6, 502.16 and subsection 14 of 502.14. It serves to document the purpose of the tests, description of the generating unit at the time of the tests, test processes employed, model derivation process, resulting simulation models, and the limitation of these models.

If the legal owner of the generating unit includes more than one generating unit's test results in the report, the AESO suggests that the legal owner provide the items listed in 2.1 through 2.8 below for each generating unit.

---

[1] "Authoritative document" 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.

[2] NERC, *Reliability Guideline Power Plant Model Verification using PMUs*, dated September 2016 and *Reliability Guideline Power Plant Model Verification and Testing for Synchronous Machines*, dated July 2018, Available on www.nerc.com

Pursuant to section 13 of Sections 502.6, 502.16 and section 14 of 502.14, the A *Model Validation and Reactive Power Verification Repo*rt will include the following information unless identified as optional:

### 2.1 a cover page that contains:

(a) **the generating facility name and generating unit name or in the case of aggregated generating facility, the facility name;**

(b) **the name of the legal owner;**

(c) **the name, stamp and signature of the Professional Engineer licensed to practice engineering in the province of Alberta, who takes the engineering responsibility for the *Model Validation and Reactive Power Verification R*eport;**

(d) **the date on which the tests were performed;**

(e) **the report date;**

(f) **the revision number of report; and**

(g) **additional information may be provided in the report itself;**

### 2.2 for non-aggregated generating facilities, a detailed description of each generating unit that contains:

(a) **the generating unit name and ID;**

(b) **the name of the legal owner;**

(c) **the location of the generating facility including the station name;**

(d) **the generating unit maximum authorized real power;**

(e) **nameplate data of the components of the generating unit:**

(i) the generator nameplate data, including:

(A) manufacturer (optional);

(B) frame/model number (optional);

(C) serial number (optional);

(D) ratings including MVA, MW, RPM, kV, and P.F.;

(E) rated field current;

(F) rated field voltage;

(G) temperature rise;

(H) cooling;

(I) insulation class; and

(J) date of manufacture;

(ii) the excitation system nameplate, including:

(A) type of excitation system;

(B) manufacturer (optional);

(C) rotating exciter ratings including kV and A.;

(D) excitation transformer name plate data including kVA, kV, and impedance;

(E) rated and maximum voltage and current; and

(F) excitation control system including manufacturer, type, and model number;

(iii) the power system stabilizer nameplate data, if applicable, including:

(A) manufacturer (optional);

(B) type; and

(C) model number (optional);

(iv) the prime mover nameplate, including:

(A) manufacturer (optional);

(B) frame/model number (optional);

(C) ratings including MW, RPM, pressure, and temperature;

(D) model number (optional);

(E) fuel source; and

(F) turbine type;

(v) the turbine controller or governor nameplate, including:

(A) manufacturer (optional);

(B) type; and

(C) model number (optional);

(f) **if any item on the list is not applicable, the market participant must provide an explanation.**

**2.3 for aggregated generating facilities a detailed description of each generating unit that contains:**

(a) **the aggregated generating facility name and code;**

(b) **the name of the legal owner;**

(c) **the name and location of the connecting substation of the aggregated generating facility;**

(d) **the aggregated generating facility maximum authorized real power;**

(e) **the modeled single line diagram of the aggregated generating facility showing the reduced representation diagram of collector system or systems and aggregated machine modeled at each collector bus and their ID;**

(f) **equivalent impedance of the collector system; and**

(g) **nameplate data of each type of generator or converter if there is more than one type in the aggregated generating facility:**

(h) **the generator/converter nameplate data, including:**

(i) **generator or converter type;**

(i) number of generating units with the aggregated generating facility;

(ii) manufacturer;

(iii) frame/model number (optional);

(iv) ratings including MVA, RPM, kV, P.F., maximum and minimum real power, and reactive power;

(v) rated field current (if applicable);

(vi) rated field voltage (if applicable);

(vii) temperature rise (if applicable); and

(viii) cooling if applicable (optional);

(j) **the excitation system nameplate (if applicable), including:**

(i) type of excitation system;

(ii) manufacturer (optional);

(iii) rotating exciter ratings including kV, and A;

(iv) excitation transformer name plate data including kV, impedance, and A;

(v) rated and maximum voltage, including current; and

(vi) excitation control system including manufacturer, type, and model number;

(k) **the power system stabilizer nameplate data (if applicable) , including:**

(i) manufacturer (optional);

(ii) type; and

(iii) model number (optional);

(l) **the prime mover including photo voltaic module nameplate, including:**

(i) manufacturer (optional);

(ii) frame or model number (optional);

(iii) ratings including MW, RPM, pressure, and temperature;

(iv) fuel source; and

(v) turbine type;

(m) **the turbine controller (governor) or plant controller nameplate (if applicable), including:**

(i) manufacturer (optional);

(ii) type; and

(iii) model number (optional);

(n) **reactive compensation devices (if applicable), including**:

(i) manufacturer;

(ii) type such as mechanically switched capacitor banks, TCR, TSC, or STATCOM; and

(iii) ratings including MVAr and kV;

(o) **If any item on the list is not applicable, the market participant is expected to provide an explanation**.

**2.4 a description for each of the transmission system step-up transformers in the generating facility that contains**:

(a) **the nameplate information including the MVA, kV, impedance, and tap positions;**

(b) **the transformer type, three 1-phase or one 3-phase, and also an indication of whether the transformer is an auto-transformer; and**

(c) **the number of windings, 2 or 3;**

**2.5 a description of the testing and model validation process used to determine or validate the model parameters that contains:**

(a) **a summary paragraph identifying how any test meets the AESO's testing requirements as stated in**

(i) subsections 10 to 12 of Section 502.6;

(ii) subsections 10 to 12 of Section 502.16; and

(iii) subsections 11 to 13 of Section 502.14;

(b) **a plot of the performance of each model, overlaid on the test result for the same conditions;**

(c) **the actual test data recorded during the test, in electronic tabular form;**

(d) **in the case of a re-test report, the model parameters and model plot submitted may be taken directly from a prior test report, provided that the test data matches the test data from the prior test report;**

(e) **a description of the deficiencies and or limitations of each model when compared to the test data, including an assessment of the quality of fit between the test data and modelled data;**

(f) **discussion on any limitations encountered during the test and their effect on the model validation and reactive power testing; and**

(g) **stating the reason for testing in accordance with subsection 10(2) of Sections 502.6, 502.16 and subsection 11(2) of Section 502.14 assists the AESO's review process.**

**2.6 simulation models for each generating unit that contains:**

(a) **the exact model being submitted to produce the performance plot;**

(b) **block diagrams representing:**

(i) a standard PSS/E model, run with quarter-cycle time step; and

(ii) a standard PSLF model, run with a quarter-cycle time step;

(c) **a tabular listing of the parameters for each block diagram, including the validated values for all parameters for each PSS/E and PSLF model, with no parameters left blank;**

(d) **the model as provided by the manufacturer or prior test reports. If a parameter chosen for the block diagram conflicts with manufacturer's datum or prior report for that parameter, provide an explanation for the difference; and**

(e) **any limitation of the models due to the generating unit operation modes. For example applicability of a turbine governor for steam turbines operating in sliding pressure mode;**

Models are expected to cover a wide range of operations, including maximum authorized real power.

No specific software package is mandated for performing the simulation and plot. Regardless of the software used to plot the model performance, the AESO expects the models to comply with the applicable PSS/E or PSLF model data as stated in the *List of Electrical and Physical Parameters* referred to in Section 502.15 of the ISO rules, *Reporting Facility Modelling Data*. This includes the usage of the WECC's list of accepted standard PSS/E and PSLF library models.[3]

The AESO may validate the test results using the provided data in DYR and DYD files accompanied with the test report as follows:

### 2.6.1 for each synchronous generating unit:

(a) **the generator's MVA and kV used for per-unit calculations;**

(b) **the generator's winding resistance, reactance (unsaturated) and time constants including Xd, Xq, X'd, X'q, X"d, X"q, Xl, T'do, T'qo, T"do, T"qo, Ta, and saturation factors;**

(c) **the inertia of the generating unit including generator, turbine, rotating exciter and gearbox, if applicable;**

(d) **the open circuit saturation curve with air-gap line;**

(e) **the generator's reactive power capability curve; and**

(f) **the saturated positive, negative, and zero-sequence impedances from manufacturer's data;**

This data can be found on generator name plates and manufacturer's data sheets. The market participant is expected to include the units of measure for each data point including per-unit base value.

### 2.6.2 the generator capability curve (D Curve) at rated voltage is expected to be superimposed with control limiter and protection curves:

(a) **generator capability curve;**

(b) **the generating unit's defined operating reactive power capability;**

(c) **the generating unit's maximum authorized real power line;**

(d) **the AESO's reactive power requirements limits in accordance with subsection 5(3) of Section 502.5, 502.16 and subsection 6(3) of Section 502.14 of the ISO rules, *Generating Unit Technical Requirements*;**

(e) **the generating unit's under-excitation limiter and over-excitation limiter setting curves; and**

(f) **the effects of relays that encroach into the generating unit capability curve, for example loss of excitation relay curves;**

[3] WECC, *Approved Dynamic Model*, Version April 2021, Dated May 4, 2021, as amended from time to time, Available on www.wecc.org

**2.6.3 control systems are the major components of the generating unit directly controlling its terminal outputs. The AESO may validate provided data in DYR and DYD files for the following components of the generating unit's control systems:**

(a) **the turbine and controller, for example a governor or governor system;**

(b) **the excitation system and automatic voltage regulator;**

(c) **the power system stabilizer;**

(d) **the compensators; and**

(e) **other important control functions such as limiters**.

The type and settings of the over-excitation limit, under-excitation limit, stator current limiter and load compensator within automatic voltage regulator are also expected to be provided if applicable.

Where manufacturer's data is not available, the AESO expects the report to explain the circumstances resulting in the omission and the assumptions made to compensate for the missing data.

A power system stabilizer validation report that contains plots of:

(i) system performance measured response without power system stabilizer in service overlaid on system performance measured response with power system stabilizer in service, showing effective damping;

(ii) system simulated response without power system stabilizer in service overlaid on system performance measured response without power system stabilizer in service; and

(iii) system simulated response with power system stabilizer in service overlaid on system performance measured response with power system stabilizer in service.

A positive effect on system stability is expected from power system stabilizer validation reporting.

**2.6.4 for converter based generating units:**

(a) **for solar photo voltaic plants [4]:**

(i) the power flow single line diagram as shown in Figure 1;

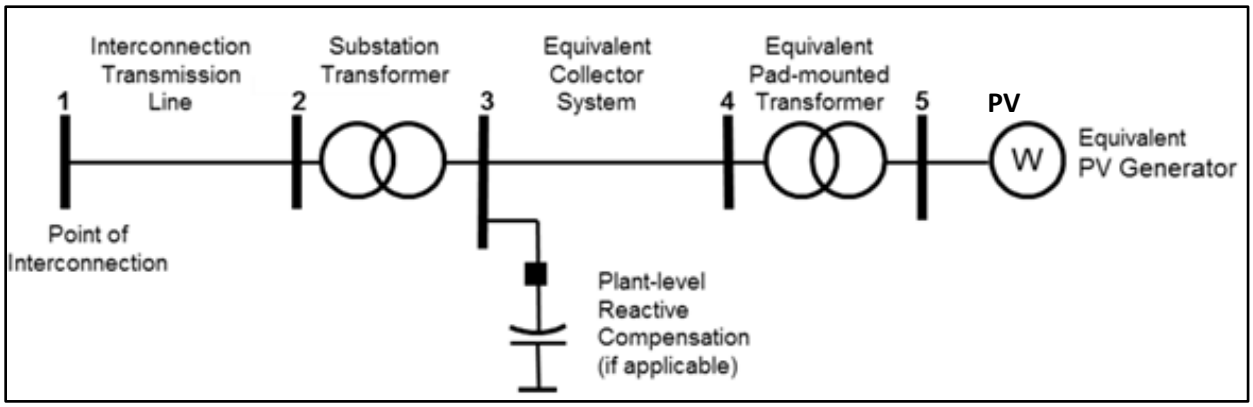


**Figure 1- Single-Generator Equivalent Power Flow Representation for a PV Power Plant (from WECC Guideline)**

(ii) the equivalent collector system parameters;

(iii) the reactive power compensator type, model, capabilities, and dynamics model and data;

(iv) in addition to the transmission system step-up transformers in the aggregated generating facility, the equivalent pad montoued transformer model; and

(v) the photo voltaic plant's renewable energy control modules dynamics data as listed in Table 1;

**Table 1- Renewable Energy Control Modules for solar and wind power plants implemented in the PSLF™, PSS®E, and PowerWorld platforms (from WECC Guideline)**

| Module | PSLF™modules | PSS®E modules | PowerWorld |
|---|---|---|---|
| Grid interface | regc_a | REGCAU1 | regc_a |
| Electrical controls | reec_b | REECBU1 | reec_b |
| Plant controller (if applicable) | repc_a | REPCAU1 | repc_a |

[4] There are two generic dynamic models for photo voltaic plants approved by WECC to be used in planning studies:
1) model consisting of plant controller, electrical controls, and grid interface modules, intended for large-scale photo voltaic plants, and
2) simplified model intended for distribution-connected, aggregated photo voltaic plants.
This information document intends to provide guidance for large-scale photo voltaic plants connected to the transmission system only. As described in *WECC Solar Plant Dynamic Modeling Guidelines* dynamic representation of large-scale photo voltaic plants requires the use of 3 renewable energy control modules as explained in this WECC guideline. Version April 2014, Dated April 2014, as amended from time to time, available at www.wecc.org

(b) **for wind power plants [5]:**

(i) the power flow single line diagram as shown in Figure 2;

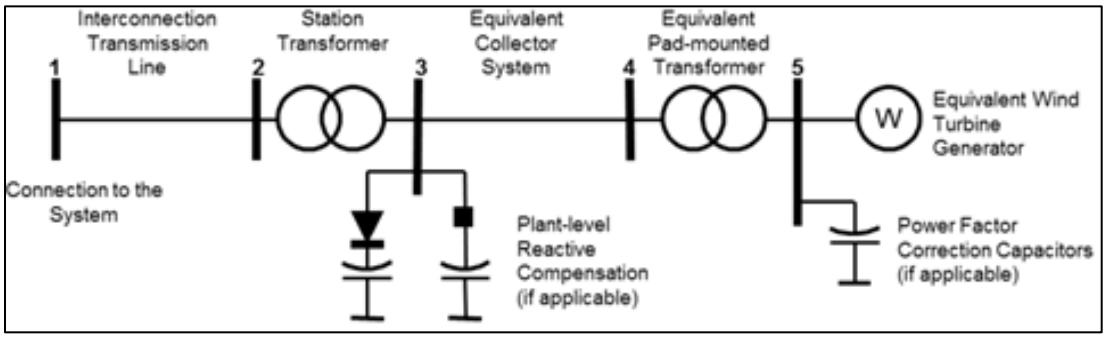


**Figure 2- Single-Generator Equivalent Power Flow Representation for a Wind Power Plant**

(ii) type of wind turbine technology;

(iii) the equivalent collector system parameters;

(iv) the reactive power compensator type, model, capabilities, dynamics model, and data;

(v) the equivalent pad montoued transformer model;

(vi) the wind plant's renewable energy control modules dynamics data as listed in Table 1; and

(vii) the power factor correction capacitor capacity;

### 2.7 all plots, raw data from test and simulation of the report:

(a) **detailed and precise labels for the axes and traces;**

(b) **traces distinguishable in a black-and-white printed copy;**

(c) **clear titles for each graph indicating the test that was performed;**

(d) **appropriate scales for both axes; and**

(e) **the measured response of the test over an adequate period to confirm the modelled results;**

[5] This information document provides guidance fore commercial wind power plants which use one of the 4 types wind turbine-generator technologies. For more information about the wind power plant power flow or dynamics modeling, please refer to the following WECC documents:

WECC, *Wind Plant Dynamic Modeling Guidelines*, Version April 2014, Date May 8, 2014, as amended from time to time, Available on www.wecc.org

WECC, *Wind Power Plant Power Flow Modeling Guide*, Version May 19, 2010, Date May 2008, as amended from time to time, Available on www.wecc.org

**2.8 include an accompanying data-file containing all test data and model simulation data in machine-readable tabular form such as a comma-separated-variable text file and .DYR or .DYD files.**

## 3 Model Revalidation and Partial Baseline Testing Reports

Model revalidation and partial baseline testing for conditions listed in subsections 10(2)(b) to (g) of Section 502.6; subsections 10(2) of Section 502.16; and also in subsections of 11(2)(b) to (c) of Section 502.14 may refer to the previously submitted *Model Validation and Reactive Power Verification Report* if the data source is appropriately referenced.

## 4 Contact Information

The legal owner may email the *Model Validation and Reactive Power Verification Reports* and associated data electronically to the AESO at psmm@aeso.ca in accordance with subsection 13 of Sections 502.6, 502.16 and subsection 14 of Section 502.14. For *Model Validation and Reactive Power Verification Reports* conducted as part of an AESO connection project, the legal owner may submit the *Model Validation and Reactive Power Verification Report* and associated data to the AESO Project Manager.

## Revision History

| Posting Date | Description of Changes |
|---|---|
| 2022-01-14 | Clarified content that is optional for legal owners to provide in subsections 2.2 and 2.3 of this information document.<br>Administrative amendment to align with current AESO drafting principles, update references to ISO rules. |
| 2018-09-04 | Aggregated generation facilities included. |
| 2017-11-21 | Initial release. |