Modelling Information for Non-Registered Generators

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Purpose

Certain entities are exempt from the requirement to register with *AEMO* as a *Generator* in order to *connect* an *embedded generating system* to *Ergon Energy's* or *Energex's distribution system*. This means that they are not directly subject to the requirement to provide *Ergon Energy* or *Energex* with modelling information under *AEMO's Power System Model Guidelines*.

However, as *Ergon Energy* and *Energex* have obligations under the *NER* to maintain the security and stability of its *distribution system* and the broader *power system*, it frequently needs certain modelling information in order to assess the effect of connecting the *embedded generating system* to its *distribution network*.

This fact sheet is intended to clarify, for *Non-Registered Embedded Generators*, what modelling information may be required to be provided to *us*.

Modelling requirements based on class of generating system

Ergon Energy and Energex's "Standard for High Voltage EG Connections" (document reference STNW1175) classifies *generating systems* into a number of different classes depending on their *nameplate capacity*. This is shown below.

Generation Capacity[1]	Short Circuit Ratio	Connection Category	Default NER Process
≤ 1.5 MVA	All	Class A1	Chapter 5A of the *NER*
> 1.5 MVA but < 5 MVA	> 5	Class A2[2][3]	Chapter 5A of the *NER*
> 1.5 MVA but < 5 MVA	≤ 5	Class B	Chapter 5A of the *NER*
≥ 5 MVA	All	Class B	Chapter 5 of the *NER*

The relevant modelling requirements for a *generating system* depend upon the particular classification of the *generating system*, as shown below.

[1] Generation capacity is the combined nameplate maximum continuous AC rating of the EG system irrespective of any export control limitation.

[2] Rotating machine *embedded generating* systems over 1.5 MVA and under 5 MVA shall be categorised as Class A2 regardless of the *short circuit ratio*.

[3] *Embedded generating systems* comprising of LV Inverters not complying to AS/NZS 4777.2 shall be assessed as Class B EG Systems.

Generation Capacity	Connection Type	Modelling Requirement
Class A1, ≤ 1.5 MVA	Chapter 5A of the *NER*	*PSCAD™/EMTDC™* model generally not required.
Class A2 > 1.5 MVA but < 5 MVA	Chapter 5A of the *NER*	Site-specific *PSCAD™/EMTDC™* model required.[4][5]
Class B, > 1.5 MVA but < 5 MVA	Chapter 5A of the *NER*	Site-specific tuned *PSCAD™/EMTDC™* model required to be provided by the Proponent.
Class B, ≥ 5 MVA	Chapter 5 of the *NER*	Site-specific tuned *PSCAD™/EMTDC™* model required to be provided by the Proponent.

This Fact Sheet deals with:

- Class A2 systems; and
- those Class B systems that are < 5 MVA.

Requirements for Class A2 generating systems

For a Class A2 *generating system*, *you* will need to give *us* a pre-validated and current electromagnetic transient-type simulation model that is compatible with version 5 of *PSCAD™/EMTDC™* and compiled with Intel OneAPI Fortran Compiler: Classic 2021.x (32-bit & 64-bit). Models shall be delivered in a format that allows for maintenance for life of asset. (e.g. .dll, support files).

You must also ensure that *we* are given a *releasable user guide* for the *PSCAD™/EMTDC™* model, which should incorporate details on how to use the *PSCAD™/EMTDC™* model. This *releasable user guide* must contain sufficient information to allow entities with no prior knowledge of the particular *embedded generating system* to perform system studies.

The modelling parameters must be consistent with the *releasable user guide*.

This simulation model must:

a) fully and accurately represent the particular *embedded generating system*, that is, it must:

   i. be based on data specific to the particular manufacturer, make and model of the *embedded generating system*;

   ii. incorporate *OEM*-specific simulation models where available (which may be black-box encrypted simulation models);

[4] Synchronous Rotating Machines are exempt from this requirement, and instead shall supply model block diagrams of the control system with all settings

[5] The EMT Model shall be supplied with supporting documentation including site-specific settings.

iii. incorporate the particular auxiliary or supporting electrical equipment (including *instrument transformers* and any power plant controllers) that will be installed (as opposed to generic data or assumptions);

iv. reflect the particular physical arrangement of the *embedded generating system* and its connection to our *distribution system*;

v. include the *inverter* and power plant control systems complete with the controller block diagrams (so as to explain the operation of the model without compromising the model veracity); and

vi. include the settings which are to be implemented on site (note that where any conversions are required between the actual *generating system* parameters and those implemented in the model, a mapping table of those conversions should also be provided);

b) be based on (as appropriate), the most recent preliminary design and, once commissioned, include any applicable updates;

c) be capable of reflecting the actual performance of the *embedded generating system* under all expected or potential operating conditions;

d) be suitable for *us* to assess the impact of connecting the *embedded generating system* to *our distribution system* at the *connection point* (including, without limitation, relevant security and stability impacts and to prove control system performance at low *distribution system short circuit ratios*), without compromising the veracity of those simulation models; and

e) meet the modelling requirements detailed in *AEMO's Power System Model Guidelines*.

Requirements for Class B generating systems

For a Class B *generating system* that is less than 5 MVA, *you* will need to give *us* a pre-validated and current electromagnetic transient-type simulation model that is compatible with version 5 of *PSCAD™/EMTDC™* and compiled with Intel OneAPI Fortran Compiler: Classic 2021.x (32-bit & 64-bit). Models shall be delivered in a format that allows for maintenance for life of asset. (e.g. .dll, support files).

You must also ensure that *we* are given a *releasable user guide* for the *PSCAD™/EMTDC™* model, which should incorporate details on how to use the *PSCAD™/EMTDC™* model. This *releasable user guide* must contain sufficient information to allow entities with no prior knowledge of the particular *embedded generating system* to perform system studies.

The modelling parameters must be consistent with the *releasable user guide*.

This simulation model must:

a) fully and accurately represent the particular *embedded generating system*, that is, it must:

i. be based on data specific to the particular manufacturer, make and model of the *embedded generating system*;

ii. incorporate *OEM*-specific simulation models where available (which may be black-box encrypted simulation models);

iii. incorporate the particular auxiliary or supporting electrical equipment (including *instrument transformers* and any power plant controllers) that will be installed (as opposed to generic data or assumptions);

iv. reflect the particular physical arrangement of the *embedded generating system* and its connection to our distribution system;

v. be appropriately tuned for the minimum *short circuit ratio* expected at the site;

vi. include the *inverter* and power plant control systems complete with the controller block diagrams (so as to explain the operation of the model without compromising the model veracity); and

vii. include the settings which are to be implemented on site (note that where any conversions are required between the actual *generating system* parameters and those implemented in the model, a mapping table of those conversions should also be provided);

b) be based on (as appropriate), the most recent preliminary design and, once commissioned, include any applicable updates;

c) be capable of reflecting the actual performance of the *embedded generating system* under all expected or potential operating conditions;

d) be suitable for *us* to assess the impact of connecting the *embedded generating system* to *our distribution system* at the *connection point* (including, without limitation, relevant security and stability impacts and to prove control system performance at low *distribution system short circuit ratios*), without compromising the veracity of those simulation models; and

e) meet the modelling requirements detailed in *AEMO's Power System Model Guidelines*.

Certifications

We also require *you* and the *OEM* to certify:

a) that the *PSCAD™/EMTDC™* simulation models are valid for the *embedded generating system*;

b) the minimum fault level (synchronous and sub-transient) and *short circuit ratio* at which the *embedded generating system* can reliably operate, and what margins of operation are recommended; and

c) whether the *embedded generating system* is capable of operating down to a minimum *short circuit ratio* of 3.0 at the *connection point*.

Measurement results

For a Class B *generating system*, *we* may also ask *you* to give *us* measurement results (from an equivalent facility and plant performance from other installations with similar network fault level and *X/R ratio* characteristics, laboratory tests, *HiL*, etc.) confirming:

a) the validity of the *PSCAD™/EMTDC™* simulation model vs the *HiL* simulation model; and

b) where no other equivalent installation or laboratory test measurement results are available to assess system performance at the proposed fault levels, *X/R ratio* and *system strength* characteristics experienced in the relevant part of the *distribution system*, then *HiL* testing must be undertaken.

These tests must, where requested by *us* or any other relevant *Network Service Provider*, include the following:

a) **(test set 1)** three phase, two phase to ground and phase to ground faults close to the *connection point* simulated with a low fault impedance (approx. 5 ohms) and clearing time of 430 ms;

b) **(test set 2)** three phase, two phase to ground and phase to ground faults close to the *connection point* simulated with a high fault impedance (approx. 50 ohms) and clearing time of 430 ms;

c) undertaking test sets 1-2 at P_{max} and P_{min} respectively and Q_{max} (lagging) and Q_{min} (leading) respectively;

d) a check of the response by changing P_{ref} from approximately 10-20% to approximately 80-90%;

e) a check of the response by changing V_{ref} by ±5% at P_{max} and P_{min} respectively;

f) a check of the high voltage ride through (HVRT) response as per S5.2.5.4 of the *NER* for Q_{max} (lagging) and Q_{min} (leading) at 100% P_{max};

g) injection of different rates of change of *frequency* or angle jump to assess the phase lock loop sensitivity (±4 Hz/sec. for 0.25 s, ±1 Hz/s for the remainder of the time until the *frequency* reaches 52 Hz or 47 Hz); and

h) testing to demonstrate the capability of the *embedded generating system* to remain *connected* in accordance with S5.2.5.6 of the *NER* (that is, during times when the harmonic *voltage* distortion, *voltage* fluctuation and *voltage* unbalance conditions reach levels specified by the compatibility levels in S5.1a.5, S5.1a.6 and S5.1a.7 of the *NER*.

Further Information[6]

The following reference documents may provide additional helpful information:

- STNW1175 Standard for High Voltage EG Connections
- Under 5MVA Application Checklist Class A2

[6] The documents referenced in this section can be found by searching STNW1175, checklist class A2, or checklist class B at https://www.ergon.com.au or https://www.energex.com.au

- Under 5MVA Application Checklist Class B

Prospective *Non-Registered Embedded Generators* may contact their *Project Sponsor* to obtain further specific information.

Glossary

Any terms that are used, but not defined, in this Fact Sheet have the meaning given to them in the *NER*.

AEMO or Australian Energy Market Operator: The agency responsible for the day to day management of wholesale and retail energy market operations and emergency management protocols for the *NEM*, on-going *NEM* development required to incorporate new rules, infrastructure and participants, and long-term *NEM* planning through demand forecasting data and scenario analysis.

asynchronous plant includes asynchronous *generating units* and dynamic *reactive power* support plant that uses phase-locked loops (for example, *static VAR compensators* and *STATCOMs*);

connection point: The physical point at which the *embedded generating system* will be *connected* to *Ergon Energy's* or *Energex's distribution system*;

detailed response means the relevant "detailed response" (as that term is defined in rule 5.3A.2(a) of the *NER*);

distribution system: The distribution system (as that term is defined in the *NER*) owned and operated by *Ergon Energy*.

embedded generating system: The *generating system* to be *connected* to the *distribution system*.

Ergon Energy: In this Fact Sheet, refers to Ergon Energy Corporation Limited as a *Local Network Service Provider*.

Energex: In this Fact Sheet, refers to Energex Limited as a *Local Network Service Provider*.

GPS Compliance Assessment and R2 Model Validation Test Plan means *AEMO's* document entitled: "GPS Compliance Assessment and R2 Model Validation Test Plan Template for power electronic interfaced non-synchronous generation technologies", published to facilitate the processes referred to in rules 5.8.4 and S5.2.4(d) of the *NER*;

HiL means hardware-in-the-loop simulation;

inverter means a device that uses semiconductor devices to transfer power between a direct current (DC) source or load and an alternating current (AC) source or load;

LNSP or Local Network Service Provider: A *Network Service Provider* within a local geographical area, which has the relevant jurisdictional authority (such as *Ergon Energy* or *Energex*).

NEM: National Electricity Market: The wholesale electricity market operating in relation to the interconnected electricity network in Queensland, NSW, ACT, Tasmania, Victoria and South Australia.

NER: National Electricity Rules: The rules under which the *National Electricity Market* operates.

Network Service Provider: Has the meaning given to that term in the *NER*.

OEM means original equipment manufacturer;

Power System Model Guidelines: The guidelines of that name promulgated by *AEMO*;

Powerlink Queensland means Queensland Electricity Transmission Corporation Limited ABN 82 078 849 233, being the relevant *Transmission Network Service Provider*;

Project Sponsor: An *Ergon Energy* representative who has been allocated to the prospective *Generator* to facilitate the *connection*;

PSCAD™/EMTDC™ means a software package developed by the Manitoba-HVDC Research Centre that comprises a power systems computer-aided design package which includes an electromagnetic transients (including DC) simulation engine, and which is used to carry out electromagnetic transient type studies;

PSS®E means Power Systems Simulator for Engineering, being a software package used to carry out root mean square studies;

R1 data has the meaning given to that term in S5.5.2 of the *NER* (essentially, a category of Registered data (as referred to in S5.5.2(b) of the *NER*) that encapsulates the measured performance and behaviour of an *embedded generating system* and which confirms and validates the modelled system across a range of potential study conditions and is supported by a long term monitoring program particularly for particular system fault conditions, events and fault ride through conditions);

R2 data has the meaning given to that term in S5.5.2 of the *NER* (essentially, a category of Registered data (as referred to in S5.5.2(a) of the *NER*) that is derived from manufacturers' data, detailed design calculations, off-site tests (i.e. other *generating system* sites), factory tests or site tests);

short circuit ratio is an analytical metric that normalises the *system strength* in MVA using synchronous fault levels at the *connection point* to the aggregate *nameplate rating* of any *embedded generating systems*;

system strength broadly refers to the stability of the *distribution system* and broader *power system*. It:

is typically measured by the available short circuit current or characterised by an analytical metric such as the *short circuit ratio* at any given location; and

relates to the size of the change in *voltage* for a change to the generation (or load) at a *connection point* (which can be affected by adjacent *asynchronous plant*).

System strength can be impacted where there is *asynchronous plant* in the area. Strong *distribution systems* exhibit better *voltage* control in response to small and large *power system* disturbances during both normal and contingency events, whilst weak *distribution systems* are more susceptible to *voltage* instability or collapse and the incorrect operation of protection systems; and

X/R ratio is the ratio of system inductive to resistive impedance.