INTERIM POWER SYSTEM MODELLING PROCEDURE

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compliance monitoring program not included in this document, will it be included here or in future documents?

1. Introduction

1.1 Purpose and scope

1.1.1 This Interim Power System Modelling Procedure (Procedure) is made in accordance with the functions of the Pilbara ISO (the ISO) under Subchapter 4.4 and Sub-appendix 4.14 of the Pilbara Networks Rules (the Rules).

1.1.2 This Procedure outlines the power system modelling requirements and associated documentation required for computer models representing the network upgrades and/or projects connecting to the NWIS as required in Rule 108.

1.1.3 This Procedure also provides a guideline to prepare and package complete and representative computer models of various network elements to enable ISO to effectively undertake its functions in line with Rules.

1.1.4 The requirement for the Registered NSPs to provide a power system model are described in subchapter 4.4 of the Rules while the definitions, operating protocols, connection, and testing requirements of various network elements are defined in the Harmonised Technical Rules (HTR). The HTR should be consulted for defining limits as required while developing the power systems models.

1.1.5 This procedure covers the Registered NSPs requirements to provide a both the full unencrypted power system models and the reduced order power system model.

1.2 Definitions and interpretation

1.2.1 Terms defined in the *Electricity Industry Act 2004* (WA), the Electricity Industry (Pilbara Networks) Regulations 2021, the Pilbara Networks Access Code and the Rules have the same meaning in this Procedure unless the context requires otherwise.

1.2.2 The following principles of interpretation apply in this Procedure unless the context requires otherwise.

(a) Subchapter 1.2 of the Rules apply to this Procedure.

(b) References to time are references to Australian Western Standard Time.

(c) A reference to the Rules or Procedures made under the Rules, have the meaning given to them in the Rules.

(d) Words expressed in the singular include the plural and vice versa.

(e) A reference to a paragraph refers to a paragraph in the Procedure.

(f) A reference to a rule, subchapter or chapter refers to the relevant section in the Rules.

(g) References to the Rules in this Procedure is bold and square brackets e.g. **"See Rule [XXX]"**, are included for convenience only, and do not form part of this Procedure.

(h) Explanatory notes are included for context and explanation and do not form part of this Procedure.

(i) Text located in boxes in this Procedure is included by way of explanation only and does not form part of this Procedure. This excludes tables marked with a caption.

1.2.3 Appendix A of this Procedure outlines the head of power rule(s) that this Procedure is made under, as well as other obligations in the Rules covered by the Procedure.

1.2.4 The acronyms in Table 1 are used throughout this procedure.

Table 1: Glossary of Acronyms

Acronym	Term
AGC	Automatic Generation Control
AVR	Automatic Voltage Regulator
BESS	Battery Energy Storage System
BOP	Balance of Plant
DC	Direct Current
EMT	Electromagnetic Transients
HPS	Hedland Power Station
IBR	Inverter Based Resources
IEC	International Electrotechnical Commission
ISO	Independent System Operator
NEM	National Electricity Market
OEL	Over Excitation Limiter
PNR	Pilbara Network Rules
PPC	Power Plant Controller
PSS	Power System Stabiliser
RMS	Root Mean Square
ROCOF	Rate of Change of Frequency
SCR	Short Circuit Ratio
SLD	Single Line Diagram
SMIB	Single Machine Infinite Bus Model
STATCOM	Static Synchronous Compensator
SYNCON	Synchronous Condenser
SVC	Static VAr Compensator
UEL	Under Excitation Limiter
VSD	Variable Speed Drives

1.3 Preservation of Records

See Rule [293(2)]

1.3.1 In accordance with Rule 293(2), a rules participant must preserve any records it is required to make under this procedure for at least 7 years, or such longer period as may be required by law.

1.4 References

1.4.1 The following Procedures and Guides are linked and must be consulted in conjunction with this Procedure:

(a) Interim Access and Connection Procedure

(b) Guide to Confidentiality – Access and Connection

(c) Interim Registration and Standing Data Procedure

(d) Harmonised Technical Rules

2. Procedure Overview

2.1 Overview

See Rule [108; 117; 121]

2.1.1 This Procedure covers the following matters for the full unencrypted and reduced order power system models:

(a) sets out a criteria for identifying which facilities must be included in the power system model to enable ISO to perform the functions set out in rule 108(2);

(b) outlines uniform standards, formats and assumptions to be used in network models, sufficient to ensure that all models integrate effectively and operate together efficiently;

(c) outlines the model functional requirements, performance, accuracy, and acceptance requirements to meet Rule 117;

(d) communicates general requirements for the power system models of facilities which are connected, being amended, or proposed to be connected to the NWIS;

(e) outlines the model assessment requirements and associated documentation requirements; and

(f) outlines model validation requirements.

3. Roles and Responsibilities

3.1 Access Seekers

3.1.1 The following provides the power system modelling activities, roles and responsibilities of access seekers when seeking access to the NWIS:

(a) Coordinate any data requirements with the Registered NSP to facilitate power system modelling.

(b) Obtain the reduced order NWIS model from the Registered NSP and/or ISO to undertake connection assessment.

(c) Where required, develop the Single Machine Infinite Bus Model (SMIB) power system models to undertake compliance assessment in line with the HTR and GEIP.

(d) Where required, using the reduced order NWIS model, assess impact and/or connection assessment in line with this procedure.

(e) Where required, undertake power system model validation for inclusion in the overall full NWIS model in line with this procedure.

(f) Respond to any direction from the Registered NSP and/or the ISO to provide power system models as and when required.

(g) Provide a copy of the validated power system model and user guide to the Registered NSP in line with this Procedure.

3.2 Registered NSPs

See Rule [109; 110; 116]

3.2.1 The following provides the power system modelling activities, roles and responsibilities of Registered NSPs required by the Rules and the Procedure:

(a) Serve as the point of contact for the access seeker requesting network power system models and related information for undertaking impact and/or connection assessment.

(b) Develop the power system models to undertake impact and/or connection assessment in line with this procedure.

(c) Incorporates the equipment limits and security limits in the model as set out in the standing data (Rule 116), the frequency operating standards and the other parameters for remaining inside the technical envelope applicable to the network to enable studies to be carried out and as required by Rule 109.

(d) Ensures that for all registered facilities (in the Registered NSP's network), and each other facility which meets the threshold as specified in the Access and Connection Procedure, the Registered NSP includes a mathematical model of the facility, including the impact of its control systems and protection systems on security and reliability within the network.

(e) Each Registered NSP will undertake power system model validation for their own network for inclusion in the overall NWIS model in line with this Procedure.

(f) Undertake a review of the power system models provided by the access seeker in line with this Procedure and to enable the purposes of the study to be met which shall be agreed with ISO in line with the Access and Connection Procedure. Reduced order models received from ISO may be used for access and connection studies, where it is agreed that the reduced model is not sufficient, the ISO will undertake the studies using the full model on behalf of the registered NSP.

(g) Consider the issues registered published by the ISO for the reduced order model for likely study impacts.

(h) Provide a copy of the validated power system model and user guide to ISO in line with this procedure.

(i) Over and above the power system and model sharing modelling requirements specified in the Access and Connection Procedure and irrespective of the threshold specified, Registered NSPs should share their network wide power system model (updated as per clause (j) below) with ISO once a year.

(j) The Registered NSP network wide model shall be updated in line with this procedure covering all elements in the Registered NSPs network before sharing with the ISO.

(k) The Registered NSP model should include parameters such as, but not limited to the following **see Rule [116]**. The list provided below is illustrative only. Standing data required in the full and reduced order model is provided in Appendix B:

  i. positive, negative and zero sequence network impedances for the network elements;

  ii. generator controllers including power park controllers, automatic voltage regulators, power system stabilisers, governors;

  iii. network topology changes across the Registered NSP network;

  iv. constraints information on transmission circuit limits, limit advice, overload ratings, including, where applicable, details of how long an overload rating can be maintained;

  v. short circuit capability of network elements and facility equipment and any other information reasonably specified in HTR, PNR and following GEIP.

(l) When ISO and/or the designated controller notifies a Registered NSP of a change to a generation facility or consumer facility, and/or when the Registered NSP changes a network element, the Registered NSP must determine whether to update its own network model and if it does so, inform the ISO of the modifications together with such of the information as the ISO may require updating the power system model.

3.3 Pilbara ISO

See Rule [108; 114; 116; 118; 119]

3.3.1 The following provides the power system modelling activities, roles and responsibilities of Pilbara ISO required by the Rules and this Procedure:

(a) Develops and maintain a full NWIS power system software model in accordance with this Procedure as per Subchapter 4.4.

(b) Checks that the models received from the Registered NSPs cover the equipment limits set out in the standing data, alignment with the security limits, frequency operating standards and the other parameters for remaining inside the technical envelope for both full and reduced order model.

(c) Checks that for all registered facilities (across the NWIS system), and each other facility which meets the threshold as specified in the Access and Connection Procedure, the Registered NSP's have included a mathematical model of the facility, including the impact of its control philosophy and protection settings on security and reliability across the NWIS system.

(d) Where requested by the access seeker or the Registered NSP under Rule 114 (1), undertake power system modelling and other analyses, and engage in reasonable consultation, to support or supplement the Registered NSP's analyses.

(e) In the event where ISO determines that any information provided to it by a Registered NSP under is incorrect, or does not comply with this procedure, the ISO (after first consulting with the Registered NSP) may direct the Registered NSP to correct the information.

(f) In accordance with Rule 118 and 119, ISO will notify Registered NSPs each time it makes a material change to the power system model and disclose power system modelling results where applicable and non-confidential in nature.

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Number: 1 Author: H186965 Subject: Comment on Text Date: 19/10/2023 12:03:15 PM

Does this clause require protection systems to be modelled on NSPs circuits? (i.e. VTs, CTs, relays, CBs)

4. Modelling Requirements

4.1 Purpose

4.1.1 This section identifies the modelling requirements associated with power system modelling in the NWIS. A phased modelling approach is adopted to avoid any unnecessary delay to a project and enable the access seeker, Registered NSP and/or the ISO to undertake the various power system studies that may be required and according to project phasing.

4.2 Power system modelling stages

4.2.1 This approach is aligned with the Interim Access and Connection Procedure which allows the access seeker and/or the Registered NSP projects to progress so long as the necessary information is available at each stage, with a view to achieving a final validated model at project completion. This Procedure applies to all stages of a project listed below and outlines the computer model and documentation requirements:

Stage 1 – Feasibility stage model which correlates to the project inception phase of a project where the model is developed considering typical, standard and/or preliminary data available at this early stage of the project, however, the development and provision of a power system model is not mandatory to be provided to ISO provision this stage.

Stage 2 – Application stage model (typically referred to as R0 model) which correlates to the phase where the model includes identified network interfaces and high-level design. The Application assessment stage is a mandatory "gate" where the Registered NSPs need to provide the model to ISO for due diligence prior to progressing to the Connection Application stage.

Stage 3 – Connection stage models (typically referred to as R1 & R2 models in NEM[1]). This correlates to as built models (R1 models) which include as built design data, followed by a site validated (R2 model). The validated model is a pre-requisite of project energisation enabling normal dispatch to the grid.

4.2.2 Power system modelling data and studies corresponding to each stage are covered in the Access and Connection Procedure.

4.3 Power system modelling software

4.3.1 ISO uses DIgSILENT PowerFactory software for performing NWIS network security, access and connection, and impact assessment studies. This software is considered as a standard power system study tool by ISO.

[1] This correlation is drawn for illustration and ease of reference purposes only. The Registered NSP shall follow the HTR, PNR and GEIP for assessing the scope of these preliminary studies. Appendix B of the Access and Connection Procedure provides a guideline of a sample set of studies expected at each stage of the access and connection procedure.

Number: 1 Author: h188118 Subject: Highlight Date: 12/10/2023 9:44:54 AM

NSP's may requests for a model from access seekers to perform studies. Can this be changed to 'the provision of a power...'

4.3.2 A requirement for an EMT model may be specified by ISO on a per project basis. A requirement to provide an EMT model will depend on the proposed technology, SCR at the point of connection, overall impact of the new connection on the system strength, and operation of other generating units. ISO currently uses the PowerFactory software for these studies, however other modelling software packages (e.g., PSCAD) can be used following consultation with the ISO. This will depend on the availability of OEM models and the complexity of assessment needed to assess network impact.

4.4 Power system modelling requirements

4.4.1 When developing a computer model there are general requirements that apply to all models, irrespective of the type of facility, as well as specific requirements that apply depending on whether the facility is a generating system, load, or any other type of equipment, such as a dynamic reactive device (STATCOM, SVC, or other).

4.4.2 As part of the Access and Connection Procedure, this assessment shall be undertaken by the Registered NSP using the reduced order NWIS model which is issued as part of Phase 1 or Phase 2 of the power system modelling stages. The standing data requirements are provided in Appendix B of this Procedure.

Steady state model requirements

4.4.3 The following requirements apply to steady state modelling focussing on model functionality, versioning, and its associated data and parameters which are key for undertaking steady state assessment:

(a) Consistency between Single Line Diagram (SLD) layouts and other schematics provided to the Registered NSP and/or ISO.

(b) Consistency between relevant network data provided including all network impedances and ratings, voltage levels, transformer specifics (location, rating, vector groups, winding configuration, tap changer specifics etc), auxiliary loads and reactive devices etc.

(c) Consistency between generating system or load specifications provided, such as the maximum capability and loading, active and reactive power ranges, generator impedances, etc. Loads (including generator auxiliary loads) must be modelled such that the load power factor is representative of the facility's actual performance under typical operating conditions.

(d) The models must initialise themselves in a steady state environment consistent with the system conditions in the network load flow model. When these preconfigured system conditions are beyond plant operational limits or otherwise not consistent with valid operating conditions for the plant, the model must warn the user by way of a message to the progress output device.

(e) Updates to existing models must be performed on the latest version of the model.

(f) The model must be suitable for balanced and unbalanced power flow studies, and calculation of balanced and unbalanced short-circuit currents using 'Complete' and 'IEC' methods.

Number: 1 Author: H186965 Subject: Comment on Text Date: 19/10/2023 12:28:02 PM

"...When these preconfigured system conditions are beyond plant operational limits or otherwise not consistent with valid operating conditions for the plant, the model must warn the user by way of a message to the progress output device.".

Is this referring to sending a warning to the PowerFactory output window's Warning messages?

Would like to understand how this warning is intended to be signalled for steady-state studies.

Number: 2 Author: H186965 Subject: Comment on Text Date: 19/10/2023 12:31:55 PM

There are multiple IEC standards i.e. IEC 60909, 61363, for avoidance of doubt we can clarify here that the intention is to be able to use the IEC 60909 method.

(g) New computer models must be in developed in DIgSILENT PowerFactory format and match the version of PowerFactory currently used by ISO and suitable for integration into the ISO PowerFactory database.

Dynamic model requirements

4.4.4 The following requirements apply to dynamic controller models, including Network Participant control desks, dynamic reactive control devices, generator control systems and inverter control systems, etc which are key for undertaking dynamic assessment:

(a) The model must include all functional controllers and ancillary equipment that materially affect the performance of the equipment over the typical timeframes of a dynamic simulation (up to several minutes), and accurately represent the performance for all possible conditions where the equipment would be in operation.

(b) The model must support a minimum step size of 1 msec for PowerFactory RMS simulations. A step size of 2 msec or larger is desirable subject to sufficient accuracy being achieved.

(c) The dynamic model must be able to be initialised from the Load Flow solution without any requirement to manually modify any parameter settings and without any error messages.

(d) Where initialising an RMS simulation from a Load Flow solution causes an unsteady response, the time to settle to a steady result should be no longer than 2 sec (simulation time).

(e) Dynamic model initialisation must be invariant to the simulation start time (i.e., the simulation must not be required to be initialised at a particular time).

(f) A model accuracy of ±10% should be demonstrated when validating the model performance against the commissioning tests.

(g) The dynamic model must be suitable for RMS studies at the project specific short circuit levels at the point of connection and should accurately represent the equipment response during and after a system event. This includes active and reactive current injection during a system fault or system frequency excursion. This performance must be achieved under a balanced and unbalanced system condition.

(h) The model must be numerically stable for all possible ranges of system strength (short-circuit ratio and X/R ratio) at its planned point of connection.

(i) The model may include non-convergence warnings for some simulation events, this may indicate issues with the dynamic model and have an adverse impact on simulation performance and/or cause the simulation to collapse. Care should be taken, and unnecessary warnings avoided when developing the model.

(j) For protection events (e.g., Wind Farm controller operation) the simulation events, including initial detection, operation, and time-out, should be reported to the PowerFactory output window during the simulation.

(k) The PowerFactory DSL model must compile to C code without warnings or errors.

(l) The dynamic model must accurately represent the performance of equipment for a minimum duration of 30 sec following an event.

EMT model requirements

4.4.5 The following modelling requirements are key for undertaking EMT assessment:

(a) The model must support a minimum step size of 10 µsec. A step size of 50 µsec is desirable subject to sufficient accuracy being achieved.

(b) The model should accurately represent the plant behaviour under all system conditions and fault levels.

(c) The EMT model must accurately represent the behaviour of the generating system under balanced and unbalanced simulations.

(d) The model must show accurate current injection during events including reactive current rise time/settling time, negative sequence reactive current injection and active power recovery time.

(e) The model should include all control loops implemented on the device. Where response time of a control function is outside the EMT simulation range of up to 10 sec, that control function may be excluded from the model following discussion and agreement with ISO.

(f) The model must include all input filters, limiters and protection equipment (such as current limiting devices, over current protection, over/under voltage protection, over/under frequency devices, etc).

(g) The model should be suitable for assessing the capability of the system to ride through a series of events, where required. This includes a sequency of balanced and unbalanced faults.

(h) For an inverter based generating facility, the EMT model should include source and system side converters including switches, filters, smoothing reactors and linking capacitors. For source side machines and PV arrays the model must be able to represent transients occurring at the DC link.

4.5 Model configuration requirements

4.5.1 This section details the modelling requirements for key equipment like generators, loads, transmission lines and the balance of plant:

Synchronous generating systems

4.5.2 A power station model comprising of Synchronous Generating units must include:

(a) A project specific load flow model based on the best information available (R0, R1 or R2). This model shall include the BoP primary equipment such as transformers, cables, generating units, auxiliary loads, earthing transformers, reactive power components (such as capacitor banks, reactor banks or harmonic filters).

(b) The generating units load flow model, including the MVA rating and the power capability curve. Any operational limitation on the active and reactive power must be implemented in the model.

(c) Primary element parameters shall be consistent with manufacturer's datasheet.

Number: 1 Author: H186965 Subject: Comment on Text Date: 19/10/2023 12:41:30 PM

Typo?

Number: 2 Author: H186965 Subject: Comment on Text Date: 19/10/2023 1:09:46 PM

How does ISO intend to capture the modelling of generators which have motoring capability (i.e. to support low-load conditions)?

Is it preferred to have an explicitly modelled representation of the generator in motoring mode, separate to the representation of the generator?

Number: 3 Author: H186965 Subject: Comment on Text Date: 19/10/2023 1:10:15 PM

How does ISO intend to capture the operational limitations of STGs based on the number / output of coupled CCGTs online?

[1]

(d) Generator data should be entered for [2]5°C ambient temperature. Temperature dependency of the generator output up to the site maximum ambient temperature to be provided.

(e) Details of all station controllers for coordination of the generating units active and reactive power, where applicable.

(f) The voltage control strategy shall be modelled including the relevant components such as transformer AVRs, shunt element switching strategies and generating unit voltage control modes.

(g) The dynamic model should adequately represent the performance of the equipment over its power capability range and over the system voltage and frequency operating range at the point of connection.

(h) Dynamic model of the power station voltage and frequency control system including the relevant components such as measurement devices, communication delays, shunt element, generating unit voltage control system, extended ramp rate and any other component necessary to implement the voltage/frequency control strategy shall be modelled.

(i) Synchronous machine control system components including: Excitation system and load drop compensation, turbine-governor (including speed droop and power control loops, turbine boiler dynamics, temperature and power control/limiting functions and other relevant control mode and protection functions), Power System Stabiliser, if available, Under-excitation limiter (UEL), Over-excitation limiter (OEL) and any other limiters (such as stator current limiter(s), volts per hertz limiter(s), over flux limiter(s)).

Inverter based generating systems

4.5.3 An Inverter based generating system (such as a wind farm or solar farm) must include:

(a) A project specific load flow model on best information available (R0, R1 or R2). Inverters may be modelled as static generator elements with project specific ratings, voltage dependent capability curves and short circuit current contribution included.

(b) BoP primary equipment (such as transformers, cables, auxiliary loads), reactive power components (such as STATCOMs, capacitor banks, reactor banks or harmonic filters).

(c) The flicker and harmonic spectrums for each inverter element.

(d) Primary equipment data, consistent with the manufacturer's datasheet.

(e) Generator data entered for the maximum site ambient temperature. Information on the temperature dependency of the generator output is to be provided.

(f) Load flow model should include details of any overall control system (Power Plant Controller (PPC)) where applicable. The standard "External secondary controller" and "External station controller" shall be used for modelling of this controller. All modes of operation (e.g., voltage control, Q(V), Power Factor or reactive power control modes) must be defined and all control and measurement points must be specified and be consistent with the proposed voltage control strategy.

(g) In the absence of a power plant controller, the load flow model should include the control methodology modelled on individual inverter elements. This can be done using the

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Number: 1 Author: H180237 Subject: Sticky Note Date: 18/10/2023 1:53:02 PM

Can more clarity be provided for the "site maximum"? Eg. the site maximum as specified by the NSP (or a default max value where not provided)?

Additionally, temperature dependency may be any piece of equipment imposing a technical limit on the generating unit, not just the generator itself.

Number: 2 Author: H186965 Subject: Comment on Text Date: 19/10/2023 1:10:54 PM

Just want to clarify the 35°C specification for synchronous generators while IBR are to be modelled at site maximum ambient (typically ~50°C in the Pilbara).

standard control functionality available within the static generator element of PowerFactory and may include frequency response, volt-Watt or volt- VAr response.

(h) The RMS model of the facility's voltage control system should be modelled by including the relevant components such as communication delays, power plant controller, transformer AVRs, shunt elements switching strategies, dynamic reactive support equipment, and any other component necessary to implement the voltage control strategy.

(i) Control mode and droop settings configured for usual operation, and consistent between both steady-state and dynamic simulations.

(j) All functional controllers and ancillary equipment that may materially affect the performance of the generator over the typical timeframe of a dynamic simulation (no less than 30 sec). The model(s) must accurately represent performance for all possible conditions where the equipment would be in operation.

(k) All controller components required to model any controlled response of the generating system. This includes those needed to implement current control, fault ride through, current limiting, frequency control, over/under voltage protection, over/under frequency protection, Rate of Change of Frequency (RoCoF) response. Any other components affecting the response of the inverter to a system event within a 30 sec time frame shall be included.

(l) Project specific control system parameter settings. These settings should be included in block definitions with no need to create parameter events for a correct model setup.

Battery energy storage systems

4.5.4 A battery energy storage system must include:

(a) A project specific load flow model shall be provided on best information available (R0, R1 or R2). The inverters can be modelled as static generator or rectified elements including the DC link to the battery storage element. The inverter components shall include project specific ratings, capability curves and short circuit current contributions.

(b) The flicker and harmonic spectrums for each inverter element shall be modelled.

(c) The overloading capability of the BESS inverter in the sub-transient fault contribution of the load flow element shall be included when modelled as a full-size converter.

(d) An inverter capability curve capturing the four-quadrant operation during charge and discharge should be included.

(e) Primary equipment data shall be provided in line with manufacturer’s datasheets.

(f) Generator data shall be modelled for the maximum site ambient temperature and the information on the temperature dependency of the BESS system output shall be provided.

(g) Detail of any primary and secondary control systems shall be provided where applicable. The standard “External secondary controller” and “External station controller” shall be used for modelling of this controller. All modes of operation (e.g., voltage control, Q(V), Power Factor or reactive power control modes) must be defined and all control and measurement points must be specified and be consistent with the proposed voltage control strategy.

(h) The control methodology (in the absence of a secondary controller) modelled on individual inverters using the standard control functionality available within the static generator element of PowerFactory shall be provided. This may include frequency response, volt-Watt or volt-VAr response.

(i) The RMS BESS model shall clearly define modes of operation for the BESS (e.g., grid forming/grid following and switching between different modes). The RMS model should accurately represent all modes of operations appliable to the project and the relevant settings.

(j) Any additional functionalities of the BESS system such as synthetic inertia, frequency response and black starting if they are proposed to be utilised in the project shall be included.

(k) If an active power overloading is available in the inverter and energy storage element, it should be clearly mentioned in the documentation. It is preferrable in this case if the energy storage DC components are included in the model.

(l) Control system components representing AVR and frequency Governor functionalities where the BESS includes virtual synchronous machine technology shall be included.

(m) Control mode and droop settings configured for usual operation shall be consistent between both steady-state and dynamic simulations.

(n) All functional controllers and ancillary equipment that may materially affect the performance of the generator over the typical timeframe of a dynamic simulation (up to 30 sec) shall be modelled. The model(s) must accurately represent performance for all possible conditions where the equipment would be in operation.

(o) The RMS model of all controller components required to model any controlled response of the generating unit (In the absence of the power plant controller) shall be modelled which includes those needed to implement current control, fault ride through, current limiting, frequency control, over/under voltage protection, over/under frequency protection, Rate of Change of Frequency (RoCoF) response.

(p) Project specific control system parameter settings shall be provided. These settings should be included in block definitions with no need to create parameter events for a correct model setup.

Static load and motor model requirements

4.5.5 The following requirements apply for static load and motor models. These requirements are intended as a guide and should be agreed with Registered NSP prior to model preparation. Static load or Motor models must include:

(a) Clearly identified lumped motor models where smaller motors have been lumped into equivalents. This should be clearly identified in the supporting documentation and the PowerFactory model.

(b) Detailed representation and an aggregated equivalent load shall be modelled where requested by the Registered NSP.

(c) Complex load parameters shall be modelled where a number of static loads are represented as a single lumped (static) load. These must be modelled based on the constituent loads (VSD's, induction machines and other loads), and with suitable voltage dependent parameters.

(d) The equipment fault level contributions shall be represented in the model. This will require simplification of load models to be consistent with GEIP.

(e) Converter controller model(s) for converter connected loads (such as hydrogen electrolysers or fuel cells) shall be included. These must include the voltage and frequency protection settings and harmonic spectrum. The load may be modelled as a static load with applicable voltage and frequency dependencies.

(f) Descriptions of any other special protection schemes shall be included.

4.6 Model user manual

4.6.1 A user manual is to be provided with the model with sufficient information to enable ISO to understand and use the model effectively. The user manual is to include:

(a) A description of the model components and parameters, and data category of each parameter.

(b) Information about how the model parameter values vary with the operating state or output level of the equipment or with the operating state or output level of any associated equipment (e.g., excitation system automatic and manual control, configuration of voltage and power factor control modes).

(c) Protection system settings and algorithms relevant to load flow or dynamic simulation studies (e.g., under- and over-voltage or frequency protection settings).

(d) Any special control or protection schemes that are relevant to load flow or dynamic simulation studies (e.g., runback schemes, low voltage ride-through schemes, active power reduction schemes).

(e) How the model is to be set up for power system analysis including, but not limited to:

i. Expected operational practice.

ii. Specific software simulation setup.

iii. Special setup for any associated auxiliary equipment or reactive compensation equipment.

iv. Special setup required to enable, disable and configure protection functions.

v. For a generating system, generating unit or load incorporating any power electronic devices, a description of how that device should be included in the short-circuit fault calculation.

(f) Any other information relevant to the performance of the equipment for the model's intended use or to achieve the relevant accuracy requirements.

5. Model Accuracy, Validation, Performance and Testing

5.1 Model accuracy

5.1.1 **See Rule [117]** The steady-state computer model accuracy requirements apply to both loads and generating systems, including dynamic reactive plant. The general requirements are as follows:

(a) The difference between the actual and simulated response of any measured quantity must not exceed 10%.

(b) The model must accurately represent the performance of the load, generating unit, or generating system at its terminals (or connection point for aggregated model) and not show any characteristics which are not present in the actual equipment response.

5.1.2 The dynamic model accuracy requirements apply performance measures to assess the alignment between simulated and measured responses of generators and dynamic reactive equipment (e.g., SVC, STATCOM, synchronous condenser). These requirements are as below:

(a) For any control system models, the overall linear response over a frequency bandwidth of at least 0.1-5 Hz must be within the following tolerances:

i. magnitude must be within 10% of the actual control system magnitude at any frequency.

ii. the phase must be within 5 degrees of the actual control system phase at any frequency.

(b) For time-domain responses that include non-linear responses or performance, as well as responses to switching or controlled sequence events (e.g., operation of fault ride-through schemes and converter mode changes), the key features of the response are within the following tolerances:

i. rapid slopes in the simulated response, compared with the actual equipment response must be within the less restrictive of 10% of the change; and from the start to finish of the slope, 20 msec.

ii. for rapid events caused by control sequences (such as some fault ride-through control schemes) or switching events, the sizes of peaks and troughs (measured over the total change for that peak or trough) must be within 10% of the change; i.e., oscillations in active power, reactive power, and voltage in the frequency range.

iii. 0.1 to 5 Hz must have damping and frequency of the oscillation within 10% of the actual response of the equipment.

(c) The deviation of the equipment model response from the actual equipment response for active power and reactive power must not exceed 10% of the total change in that quantity. During periods of oscillatory behaviour, this criterion applies to:

i. the first cycle of the oscillatory response after the transient period (i.e., if associated with a fault, then after clearance of the fault and the transient recovery from the fault).

ii. after the first cycle of the oscillatory response, to the upper and lower bounds of the envelope of the oscillatory response.

(d) The final active power or reactive power value at which the model settles is within the more restrictive of:

i. the final value at which the actual equipment response would settle ±2% of the equipment's nameplate rating; or

ii. the final value at which the actual equipment response would settle ±10% of the total change in the final value of the quantity.

5.1.3 Note that for convenience it is acceptable to apply accuracy tolerance bands to the simulated response rather than the measured response.

5.2 Model validation and performance

5.2.1 The HTR and the Access and Connection Procedure identifies that data associated with the relevant access application must be validated and submitted to the Registered NSP following tests.

5.2.2 The data to be validated includes, but is not limited to, the computer model, generator, and control system parameters.

5.2.3 The schedule of tests (test plan) for performance verification and model validation for generating units (synchronous and inverter based) should be discussed and agreed with the Registered NSP and ISO. The test plan should include details of the requirements for test equipment and measurement signals. Additional tests could be conducted to validate the model if necessary.

5.3 Test witnessing

5.3.1 In accordance with HTR, the Registered NSP should witness performance testing. Test procedures and test plans must be submitted to the Registered NSP and ISO for review and comment before witness testing. During test witnessing, the Registered NSP should assesses whether:

(a) Tests are conducted in accordance with the approved test procedure.

(b) Tests pose any risk to power system security or stability, safety or to other network users, in which case there may be a requirement to omit particular tests.

5.4 Connection Stage (R2 model) data and model validation

5.4.1 In line with the Access and Connection Procedure, the connection stage (R2 model) data, model validation, and performance report must include:

Number: 1 Author: H186965 Subject: Comment on Text Date: 19/10/2023 1:14:10 PM

If NSP witness testing is mandatory, I'd suggest changing this to "the NSP must" or "the NSP shall".

(a) Details of the tests undertaken.

(b) Details of any discrepancies between the tests conducted and the agreed test procedures.

(c) Results, measurements, analysis techniques used, and any relevant information to assist the Registered NSP and ISO with performing a due diligence assessment.

(d) Specific assessments of the performance against relevant clauses of the HTR should be documented and illustrated.

(e) Model validation assessment with respect to the requirements outlined in the HTR, including overlays of measured and simulated responses with accuracy bands.

(f) Final model and model documentation (computer model, block diagrams and settings, updated User/Vendor manual, etc).

(g) Updated access application studies with connection stage (R2) data.

5.5 Model Assessment

5.5.1 Registered NSPs and ISO undertake a due diligence assessment (model assessment) of the computer model to assess its performance against the requirements of the HTR. As part of the model assessment ISO will identify to what extent the computer model meets the relevant criteria defined in the HTR.

5.5.2 Before submission of the model to ISO, it is recommended the Registered NSP undertakes and assessment of the model tuning and compliance to the HTR requirements.

6. Access and Connection Data and System Study Requirements

6.1 Network data and project information required by the ISO

6.1.1 The Access and Connection Procedure provides the network data and project information which is expected by ISO in relation to the access and connection activities.

6.2 Relevant power system studies required by ISO

6.2.1 The Access and Connection Procedure presents a list of system studies which are proposed as a guideline for undertaking the impact assessment over and above the connection compliance requirements stated in Chapter 3 of the HTR. The list of studies is indicative only and subject to change depending on the connection type and complexity of the project. The Registered NSPs and access seekers shall refer to the study requirements presented in Appendix B of the Access and Connection Procedure.

7. Confidential Information

See Rule [Subchapter 11.2]

7.1.1 Rules Participants must comply with obligations to provide modelling information to the ISO whether or not the information is confidential, see Rule 120(2) of the Rules.

7.1.2 The confidentiality regime in Subchapter 11.2 of the Rules governs the process for preserving confidentiality, including the process for disclosure.

{Note – The ISO has published a "Guide to Confidentiality – Access and Connection" on the ISO's website.}

8. Special Circumstances

8.1.1 To be updated based on Registered NSP and ISO review annually.

Appendix A Relevant Rules

Table 1 details the Rules under which this *Procedure* has been developed and where an obligation, process or requirement has been documented in this *Procedure*.

Table 1 Relevant Rules

Pilbara Networks Rules
Subchapter 4.4 [108 – 121]
293
Subchapter 11.2
Sub-Appendix A4.14
Appendix 5 – Harmonised Technical Rules
HTR 1.2
HTR 2.2
HTR 2.3
HTR 2.4

Appendix B Power System Modelling – Equipment Standing Data Requirements

Equipment	Details	Description	Full and unencrypted NSP models	Reduced order encrypted NSP models	Access seeker equipment models
Generators including IBRs & BESS >10 MW	Steady state data	Equipment data sufficient to undertake power flow, power quality and fault level assessment	Required	Required	Required
Generators including IBRs & BESS >10 MW	Dynamic models	Equipment data sufficient to undertake network stability assessment – PSS, AVR, Governor, PCC, AGC and other forms of dynamic controls	Required	Required	Required
Generators including IBRs & BESS <10 MW	Steady state data	Equipment data sufficient to undertake power flow, power quality and fault level assessment	Required	Can be aggregated to represent at nearest aggregated 33 kV busbar	Required
Generators including IBRs & BESS <10 MW	Dynamic models	Equipment data sufficient to undertake network stability assessment – PSS, AVR, Governor, PCC, AGC and other forms of dynamic controls	Required	Can be aggregated to represent at nearest aggregated 33 kV busbar	Required
Load	Steady state data	Equipment data sufficient to undertake power flow, power quality and fault level assessment	Required	Can be aggregated at the bulk supply points	Required
Load	Dynamic models	Equipment data sufficient to undertake network stability assessment	Required	Can be aggregated at the bulk supply points, however loads above 1 MW shall be modelled individually	Required
Circuit Breaker	Equipment specifications	Circuit breaker status, breaker current withstand capability and associated arc flash rating where available	Required	Required for the aggregated network	Required

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Number: 1 Author: h188118 Subject: Highlight Date: 12/10/2023 10:13:07 AM

Clarity required.

System models load/gen is aggregated at the substation level. There is 22kV and 33kV for the NWIS. what is the expectation here?

Number: 2 Author: h188118 Subject: Highlight Date: 12/10/2023 10:14:13 AM

clarity required - the next column shows reduced order ? and in this is full and unencrypted?

Number: 3 Author: h188118 Subject: Highlight Date: 12/10/2023 10:14:32 AM

as above

Number: 4 Author: h188118 Subject: Highlight Date: 12/10/2023 9:55:45 AM

clarity required on the minimum and the connection type of generators. For example 60s bumpless? backup (not interconnected), parallel.

Number: 5 Author: h188118 Subject: Highlight Date: 12/10/2023 10:14:38 AM

as above

Equipment	Details	Description	Full and unencrypted NSP models	Reduced order encrypted NSP models	Access seeker equipment models
Isolators	Equipment specifications	Close/Open status and current withstand capability	Can be aggregated provided circuit breakers are modelled	Required for the aggregated network	Required
Transmission line	Geometric model	Transmission lines modelled with geometric parameters, length, and configuration	Required	Can be aggregated up to 33 kV. All transmission lines above 33 kV to be modelled	Required
Transformer	Transformer modelling with Vector grouping	Two winding and three winding transformers modelled	Required	Can be aggregated up to 33 kV. All transformers above 33 kV primary voltage to be modelled	Required
Reactor	Equipment specifications	Reactor details	Required	Can be aggregated up to 33 kV. All reactors connected above 33 kV primary voltage to be modelled	Required
Capacitor	Equipment specifications	Capacitor details	Required	Can be aggregated up to 33 kV. All capacitors connected above 33 kV primary voltage to be modelled	Required
SVC	Steady state data	Equipment data sufficient to undertake power flow, power quality and fault level assessment	Required	Required	Required
SVC	Dynamic models	Equipment data sufficient to undertake network stability assessment	Required	Required	Required
SynCon	Steady state data	Equipment data sufficient to undertake power flow, power quality and fault level assessment	Required	Required	Required
SynCon	Dynamic models	Equipment data sufficient to undertake network stability assessment	Required	Required	Required

Equipment	Details	Description	Full and unencrypted NSP models	Reduced order encrypted NSP models	Access seeker equipment models
Load feeders/Cables	Geometric model	Cables modelled with geometric parameters, length, and configuration	Required	Can be aggregated up to 33 kV. All cables/load feeders above 33 kV to be modelled	Required
Busbar	Equipment specifications	Busbar rating	Required	Can be aggregated up to 33 kV. All busbars above 33 kV to be modelled	Required