Guidelines for the Connection of Embedded Generators of 5 MW or Greater

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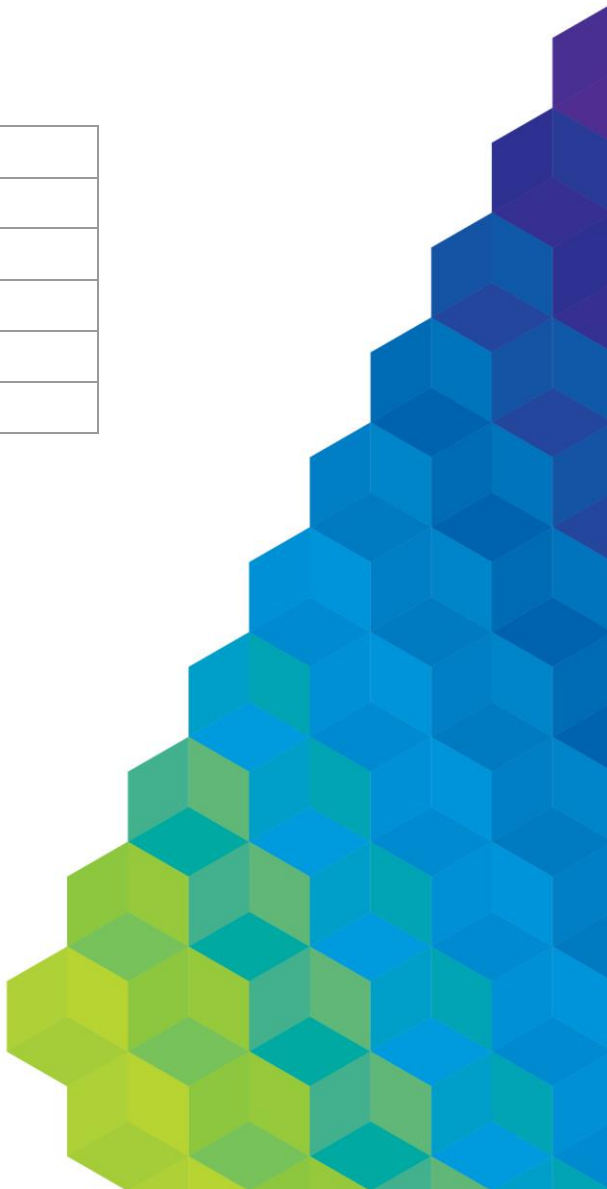

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1 INTRODUCTION AND PURPOSE

The intention of this guideline is to cover the connection of *Embedded Generators* that are registered by AEMO to the AusNet Services *distribution network*. It also applies to *Embedded Generators* that are required to, or intend to register with AEMO. These *Embedded Generators* typically have a capacity greater than AEMO's standing exemption from registration, which is currently less than 5 MW.

This guideline includes:

- the connection process;
- the steps a *Connection Applicant* will need to follow at each stage of the connection process;
- the information to be provided by the *Connection Applicant*;
- the type of information that will be made available to the *Connection Applicant* by AusNet Services;
- the technical requirements; and
- the factors taken into account by AusNet Services when assessing a *Connection Application*.

This guideline is to be treated as the information pack in accordance with clause 5.3A.3 of the National Electricity Rules.

2 ABBREVIATIONS AND DEFINITIONS

Italicised expressions in this guideline are defined in the glossary in Chapter 10 of the National Electricity Rules.

Term	Definition
Connection Agreement	the agreement entered into between the *Embedded Generator* and AusNet Services in accordance with the National Electricity Rules
DNSP	*Distribution Network Service Provider*
ESC	Essential Services Commission
NEM	The *National Electricity Market*
NER	National Electricity Rules (otherwise known as "The Rules). A copy of the current version of the National Electricity Rules (NER) is available here. Chapter 5 of the NER outlines the requirements for the connection of generators to a Network Service Provider's (NSP) network.
VEDC	Victorian Electricity Distribution Code

3 CONNECTION PROCESS

This section focuses on the minimum exchange of information that is required to progress the connection of *Embedded Generators* of 5 MW or greater on AusNet Services' *distribution network*. The minimum requirements and timeframe for responses are governed by the AEMC and the NER.

Figure 1 depicts the high level process for a new connection. Refer to specific sections for further details on each stage. The Distribution Connection Process Map on the AusNet Services website gives a more detailed explanation of the connection process.

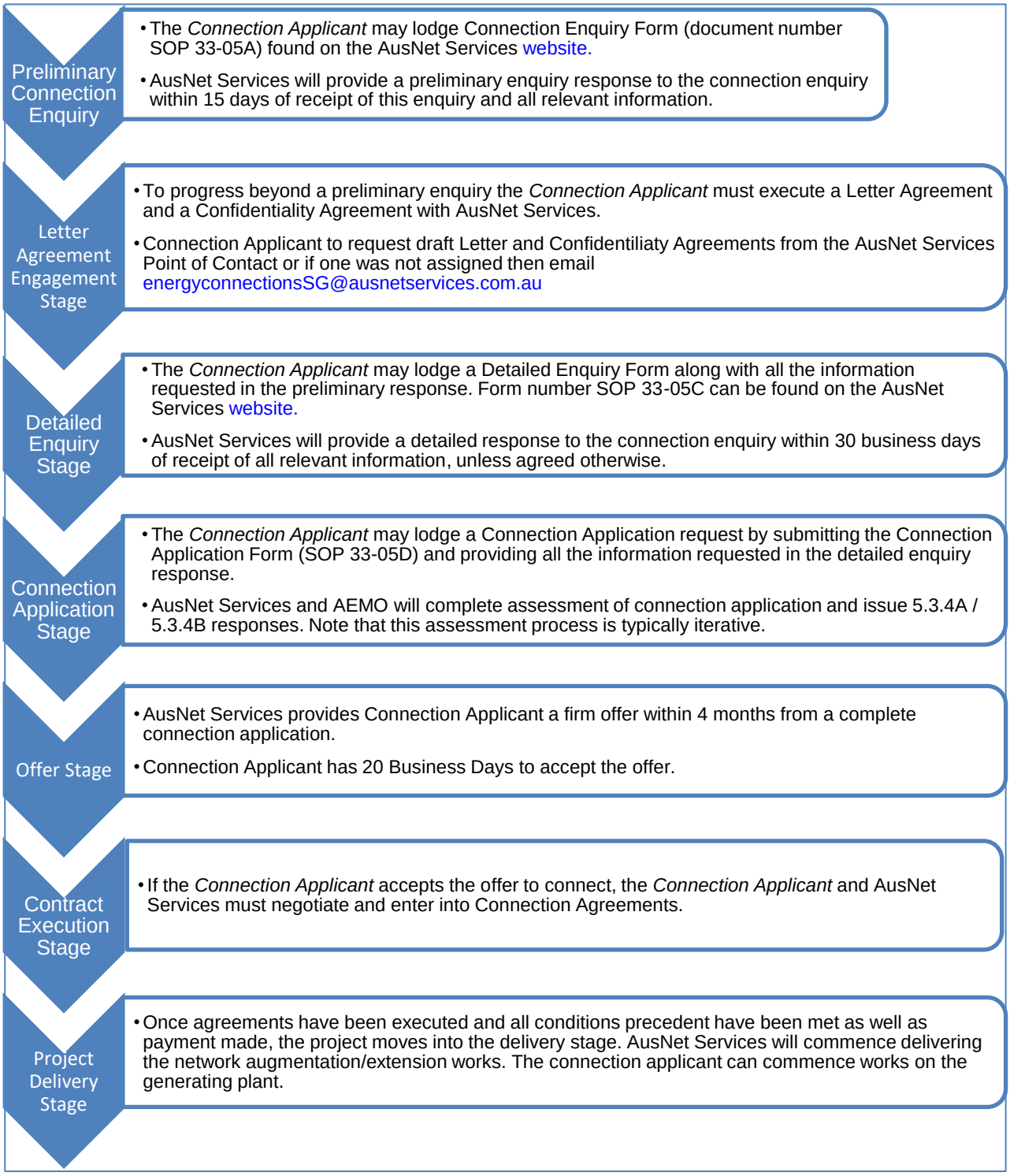


Figure 1: The high level connection process

3.1 PRELIMARY ENQUIRY STAGE

A Connection Applicant who wishes to make a Connection Enquiry must utilise the Connection Enquiry Form (SOP 33-05A) found on the connections page of the AusNet Services website. This form identifies the information that is required as part of a connection enquiry. AusNet Services will provide a written acknowledgment (in the form of an email) within 5 *Business Days* after receiving an enquiry. If the enquiry is incomplete in a material respect, AusNet Services will advise the *Connection Applicant* within 5 *Business Days* and will request further information to be provided.

A *Connection Applicant* may request to bypass the preliminary enquiry stage of the connection process and proceed directly to the detailed enquiry stage. AusNet Services will assess the request to bypass the preliminary enquiry stage within 5 *Business Days* of receipt of all necessary information; it will then advise the *Connection Applicant* if it agrees to the request.

3.1.1 PRELIMINARY ENQUIRY RESPONSE

AusNet Services will provide a preliminary response to the connection enquiry within 15 days of receipt of this enquiry and all relevant information. If AusNet Services requires an extension of time, it will provide a notice in writing specifying the reasons required for the extension. The *Connection Applicant* may not unreasonably withhold consent to that extension. An extension of time may also be required if another DNSP or *AEMO* needs to be consulted.

AusNet Services will provide the following information within a preliminary enquiry response as set out in the NER Schedule 5.4A. This includes:

- relevant technical information about the AusNet Services network, including guidance on how the *Connection Applicant* may meet those requirements if it were to proceed to prepare an *application to connect*;
- information relevant to each technical requirement of the proposed *plant* as relevant to applicable minimum, automatic and *plant* standards and normal voltage level;
- identity of other parties to be involved in connection;
- those services that are *contestable*;
- worked examples of connection charges;
- information regarding AusNet Services and its network, system limitations and other relevant constraints;
- an indication of whether network augmentation may be required and if required, what work the network augmentation may involve;
- link to AusNet Services' information pack (this guideline);
- contact details for the relevant point of contact within AusNet Services;
- AusNet Services response to objectives of connection sought;
- an overview of any available options for connection;
- description of the detailed enquiry process;
- further information requirements from the *Connection Applicant*;
- an estimate of the enquiry fee payable by the *Connection Applicant* for the detailed response and the component payable to request the detailed response;
- an estimate of the application fee which is payable on submitting an *Application to connect*; and
- any additional information relevant to the enquiry.

If AusNet Services agreed to the *Connection Applicant*'s request to bypass the preliminary response stage, AusNet Services will advise the *Connection Applicant* the following steps including the Letter Agreement Engagement Stage which requires the execution of a Letter Agreement and Confidentiality Agreement. A draft of these agreements will be provided to the connection applicant as a first step.

3.2 LETTER AGREEMENT ENGAGEMENT STAGE

To progress to detailed enquiry stage and beyond the connection applicant must first execute a Letter Agreement and Confidentiality Agreement with AusNet Services.

The letter agreement will define the services to be performed by AusNet Services for the Connection applicant.

The costs recognised under this letter agreement will cover the costs for the detailed enquiry stage, the connection application stage, the preparation of the offer as well as contract negotiations. Any input by AEMO or other DNSPs will be a cost pass through to the connection applicant.

An initial non-refundable advance payment of $20,000 is payable at execution of the letter agreement. All other costs will be charged on an hourly basis.

AusNet Services will pass all *AEMO* and other DNSP costs (if any) to the *Connection Applicant*. It is the *Connection Applicant*s responsibility to pay the relevant costs within the agreed timeframe.

3.3 DETAILED ENQUIRY STAGE

A *Connection Applicant* may lodge a request for a detailed enquiry response to AusNet Services by submitting a Detailed Enquiry Form found on the AusNet Services Connections website along with all other information requested in the preliminary response. AusNet Services, within 5 *Business Days* after receiving such request and relevant information, will provide a written acknowledgment (in the form of an email). If the further information provided (as requested in the preliminary enquiry response) is incomplete in a material respect, AusNet Services will advise the *Connection Applicant* within 10 *Business Days* of the deficiency and what is required to address it.

3.3.1 DETAILED ENQUIRY RESPONSE

AusNet Services will provide a detailed response to the connection enquiry within 30 *Business Days* of receipt of all of the following:

- any further information requested in the preliminary enquiry response; and
- any further information requested if and when further information provided (as requested in the preliminary enquiry response) is found incomplete in a material respect by AusNet Services.

AusNet Services will confirm once all the information required to provide a detailed response to the enquiry has been received. From experience, preparation of the detailed enquiry response is expected to be an iterative process to allow for clarification and consideration of options and alternatives.

If AusNet Services requires additional time, it will provide a written notice specifying the reasons required for the extension. The *Connection Applicant* may not unreasonably withhold consent to that extension.

AusNet Services will provide the following information within the detailed enquiry response as set out in the NER Schedule 5.4B. This includes:

- contact details for the relevant point of contact within AusNet Services;
- written details of each technical requirement of the proposed *plant* as relevant to applicable minimum, automatic and *plant* standards and normal voltage level;
- those services that are contestable;
- details of the connection requirements;
- details of the level and standard of service of power transfer capability;
- *negotiated access standards* requiring *AEMO* involvement;
- details of the minimum *three phase fault level* at the *connection point* and the results of the preliminary assessment of the impact of the new *connection* undertaken in accordance with

the *system strength impact assessment guidelines*[1] and clause 5.3.4B of the NER;

- list of technical data to be included with the *Application to connect*;
- commercial information to satisfy any prudential requirements;
- itemised estimate of connection costs;
- risks and obligations in respect of proposed connection associated with planning and environmental laws;
- draft connection agreement containing proposed terms and conditions for connection to the network;
- description of the process for lodging the *application to connect*;
- application fee payable when submitting an *application to connect*;
- validity period for the detailed connection enquiry response; and
- any other relevant information.

3.3.2 CONTESTABILITY OF CONNECTION AND AUGMENTATION

If connection of the *Embedded Generator* requires augmentation to the *distribution* network, a *Connection Applicant* may choose to engage AusNet Services approved and accredited designers and constructors to undertake network extensions and augmentations (including tendering).

There are certain tasks which only a DNSP can perform, such interface works, audits and reviews. All other works are considered contestable, but must be based on AusNet Services design and safety standards.

3.4 CONNECTION APPLICATION STAGE

Following receipt of a detailed enquiry response from AusNet Services, a *Connection Applicant* may make an *Application to connect* by submitting a Connection Application Form and providing all the information requested in the detailed response. If the further information provided (as requested in the detailed enquiry response) is incomplete in a material respect, AusNet Services will advise the *Connection Applicant* within 10 *Business Days* of the deficiency and what is required to address it.

AusNet Services will undertake a due-diligence assessment in consultation with AEMO. This is typically an iterative process. AusNet Services will support and assist the Connection Applicant to submit a complete Connection Application. Once AusNet Services deems a connection application as complete, it will then commence the offer preparation stage.

3.5 OFFER STAGE

AusNet Services will proceed to prepare an offer to connect in response to the Connection Application once all technical standards (automatic, minimum or negotiated) have been agreed. To maintain levels of service and quality of supply to existing *generators* in accordance with the NER, AusNet Services may need to consult with *AEMO* and other *generators* in the region.

If the *Embedded Generator* has a capacity of greater than 10 MW, AusNet Services will need to consult with the TNSP (AusNet Transmission Group for Victoria) regarding the impact of the connection on fault levels, line reclosure protocols and stability aspects. The TNSP's cost of addressing these technical matters will be included in the Offer to connect and AusNet Services will make it a condition of the offer to connect that the *Connection Applicant* must pay these costs.

AusNet Services will provide an Offer to connect within four months of receipt of a complete Connection Application (but with stop clock mechanisms for technical dispute), or unless otherwise agreed between the *Connection Applicant* and AusNet Services.

[1] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/System-Strength-Impact-Assessment-Guidelines

An offer to connect will remain open for acceptance for 20 *Business Days* from the date it is made and, if not accepted within that time period, lapses unless the *Connection Applicant* has sought an extension of the period of time from AusNet Services.

3.6 CONTRACT EXECUTION STAGE

If the *Connection Applicant* wishes to accept the Offer to connect, the *Connection Applicant* and AusNet Services must negotiate and enter into Connection Agreements.

The provision of connection by AusNet Services will be made subject to gaining environmental and planning approvals for any necessary augmentation or extension works to the network.

The Connection Agreement sets out:

- the terms and conditions under which AusNet Services will provide the connection;
- the rights and obligations of each party concerning the installation, use and operation of AusNet Services' network; and
- details of the connection charges to be paid.

3.7 PROJECT DELIVERY STAGE

The Project Delivery stage will commence once conditions precedent in the Connection Agreements have been met and payment has been made.
While AusNet Services is delivering the Network Augmentation / Extension works, the Applicant can commence construction of the Generating Plant in parallel.
The Applicant will not be able to generate until AusNet Services has achieved Practical Completion (PC) and energised the assets up to the agreed Point Of Connection (POC).

Once energised , the Applicant can commence commissioning of the Generating Plant. AusNet Services will assist the Connection Applicant to ensure the plant has been commissioned in accordance with the Commissioning Plan and all Generator Performance Standards (GPS) requirements have been met.

Finally AusNet Services will provide the Connection Applicant with a GPS Compliance Letter to mark the completion and satisfactory compliance of the Generating Plant.

4 TECHNICAL REQUIREMENTS FOR THE CONNECTION OF EMBEDDED GENERATION

The following technical requirements have been written to provide the *Embedded Generator* with details that must be considered in the processing of a connection enquiry or an *application to connect*.

4.1 EMBEDDED GENERATOR PERFORMANCE

4.1.1 ACCESS STANDARDS

As part of the connection application submission, the Connection Applicant is required to propose generator performance standards as outlined in Schedules S5.2.4, S5.2.6, S5.2.7 and S5.2.8 of the NER and summarised in Table below. For each standard, the NER defines an automatic, minimum and negotiated access standard (AAS, MAS and NAS). When submitting a proposal for a negotiated access standard, the connection applicant must propose a standard that is as close as practicable to the corresponding automatic access standard. The connection applicant is required to provide reasons and evidence as to why the proposed negotiated access standard is appropriate.

Upon receipt of proposed access standards, AusNet Services is required to consult with AEMO in relation to AEMO advisory matters. The proposed access standards will be assessed by both AusNet Services and AEMO to confirm that they are set at a level that will not affect power system security or quality of supply for

other Network Users. Detailed information on the assessment of Access Standards is provided in AEMO's Access Standard Assessment Guide[2].

Table 1: Generator Access Standards

NER CLAUSE	DESCRIPTION	AEMO ADVISORY MATTER (Y/N)
S5.2.5.1	Reactive power capability	Y
S5.2.5.2	Quality of electricity generated	N
S5.2.5.3	Generating system response to frequency disturbances	Y
S5.2.5.4	Generating system response to voltage disturbances	Y
S5.2.5.5	Generating system response to disturbances following contingency events	Y
S5.2.5.6	Quality of electricity generated and continuous uninterrupted operation	N
S5.2.5.7	Partial load rejection	Y
S5.2.5.8	Protection of generating systems from power system disturbances	Y
S5.2.5.9	Protection systems that impact on power system security	Y
S5.2.5.10	Protection to trip plant for unstable operation	Y
S5.2.5.11	Frequency control	Y
S5.2.5.12	Impact on network capability	Y
S5.2.5.13	Voltage and reactive power control	Y
S5.2.5.14	Active power control	Y
S5.2.6.1	Remote monitoring	Y
S5.2.6.2	Communications equipment	Y
S5.2.7	Power station auxiliary supplies	N
S5.2.8	Fault current	N

[2] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Access-Standard-Assessment-Guide-20190131.pdf

4.1.1.1 REACTIVE POWER CAPABILITY (S5.2.5.1) AND POWER FACTOR CORRECTION

Network voltage management in a typical DNSP's sub-transmission and *distribution network* is designed for power to flow through the network from the higher voltage levels to the *customers* connected at the lower levels.

In general if the *Embedded Generator* is supplying VARS to the network (i.e. effectively acting like a capacitor) the network voltage will rise and conversely if the *generator* is absorbing VARS from the network then the resulting voltages will be lower. Modern *generators* are capable of adjusting the network power factor and provision of reactive power may be required.

Hence, the ability of a *generator* to operate over a range of leading and lagging power factors is an important criterion when establishing its' suitability for installation in a particular part of the *distribution network*. The preferred operating range is 0.93 lag to 0.93 leading as specified in Clause S5.2.5.1 (a) in the NER.

Assessment of proposed performance standards requires steady state analysis to validate the reactive power capability at the *connection point* over a range of power system conditions.

Additionally, as the network may also experience a much wider variation in real and reactive power flows to and from the network, AusNet Services will require that under all conditions of real and reactive power transfer that the variation in voltage seen by the other *customers* remains within acceptable limits. In order to maintain voltage within acceptable limits at the connection point (i.e. point of common coupling), operating range of the *generator's* power factor will be specified as per Clause S5.2.5.1(c) of the NER. Power system simulation studies are required to determine the *generator's* operating power factor range and optimum voltage at the point of common coupling.

The allowable operating range of the *generator's* power factor must be specified in the *connection agreement* and associated instruments of agreement. In addition to operating range of the *generator's* power factor, connection point operating voltage range can also be specified in the agreement.

4.1.1.2 QUALITY OF SUPPLY (S5.2.5.2)

The NER in Schedule 5.1 specifies "Network Performance Requirements". This schedule places certain responsibilities on DNSPs for quality of supply. NER schedule S5.2.5.2 details the requirements for quality of electricity generated regarding voltage fluctuations, harmonics and voltage unbalance.

The VEDC stipulates quality of supply parameters that must be maintained by DNSPs to its *customers* in respect of:

- steady state voltage;
- voltage fluctuations (Flicker);
- harmonic voltages;
- negative sequence voltage;
- load unbalance; and
- inductive interference

The *generator* must not impact adversely on AusNet Services' ability to meet these requirements and mitigation actions may be included as part of the *connection agreement*.

Connection Applicants are required by the VEDC to control the following at their *connection point*;

- power factor;
- harmonic currents generated;
- load balance between phases; and
- voltage fluctuations caused by the *Connection Applicant*'s connection.

The *Embedded Generator* is required to provide detailed information about their plant and proposed connection arrangement. Based on the information, an acceptable harmonic and flicker emission level will be allocated to the *generator* on case by case basis. The *Embedded Generator* is required to install power quality monitoring for one week before and one week after the *generator* connection is made to prove

compliance. Any deviations from the allocation need to be rectified by the *generator* to meet DNSP's requirements.

The following standards and guidelines stipulate the assessment of emission limits for distorting loads:

- AS/NZS 61000.3.6:2001 "Electromagnetic compatibility (EMC) – Part 3.6: Limits – Assessment of emission limits for distorting loads in MV and HV power systems (IEC 61000-3-6:1996, MOD)"
- AS/NZS 61000.3.7:2001 "Electromagnetic compatibility (EMC) – Part 3.7: Limits – Assessment of emission limits for fluctuating loads in MV and HV power systems (IEC 61000-3-7:1996, MOD)"
- ENA Doc 033-2014
  Guideline for Power Quality: Harmonics. Recommendations for the application of the Joint Australian/New Zealand Technical Report TR IEC 61000.3.6:2012
- ENA Doc 034-2014
  Guideline for Power Quality: Flickr - Recommendations for the application of the Joint Australian/New Zealand Technical Report TR IEC 61000.3.7:2012
- Latest version of Victorian Electricity Distribution Code

4.1.1.3 RESPONSE TO FREQUENCY (S5.2.5.3) AND VOLTAGE DISTURBANCES (S5.2.5.4)

An *Embedded Generator* must ensure that the embedded generating unit is capable of continuous uninterrupted operation at the system frequency of 50 Hz and permitted variations in accordance with the NER.

An *Embedded Generator* must ensure that the embedded generating unit is capable of continuous uninterrupted operation for network voltage variations permitted in accordance with the NER. *Embedded Generators* must be equipped with controls that enable satisfactory operation over a variation in network voltage that could occur due to many reasons including, load rejection and power system faults. For power system faults the *generator* should remain in service provided that the event is not one that would disconnect the *generator* from the network.

The compliance to these two clauses will need to be demonstrated by network studies.

4.1.1.4 VOLTAGE AND REACTIVE POWER CONTROL (S5.2.5.13)

Network voltage management in a typical DNSP's sub-transmission and *distribution network* is designed for power to flow through the network from the higher voltage levels to *customers* connected at the lower levels.

The connection agreement must stipulate the allowable voltage variation at the point of common coupling in order to maintain other *customers'* voltage within acceptable limits as per the VEDC.

It is expected that all embedded generators greater than 5 MW will have a voltage control system which incorporates a voltage droop characteristic. The voltage set-point and droop values to be adopted will be determined by the detailed systems studies.

4.1.1.5 FAULT CURRENT (S5.2.8)

This standard considers the fault current contribution of the *Embedded Generator* to the connecting network and the fault current withstand of both the *generator* and those circuit breakers used to isolate it from the network.

The installation of an *Embedded Generator* may raise the fault level[3] of the network to which it is connected. It is important to ascertain that the resulting fault levels are not raised above the existing acceptable fault levels for circuit breakers, conductors, any auxiliary *plant* and fittings or design limits.

General rulings regarding fault levels are not provided as these are completely dependent upon unique variables such as the size of the *Embedded Generator*, the voltage at which it is connected and the fault

[3] Fault level has the same meaning as Short Circuit level

capacity of the local *distribution network*. Typical fault level management strategies to comply with the VEDC include reduction of *generator* size, installing a series reactor with the *generator*, connection to an alternate part of the network or at a higher voltage. These are discussed in detail with the *Connection Applicant* during assessment of *Connection Application.*

An *Embedded Generator* must design and operate its embedded generating units so that it does not cause fault levels in the distribution system to exceed the levels specified in the VEDC. These limits are given in Table 2.

Table 2: VEDC Fault Level Limits

Distribution System Fault Levels		
Voltage Level kV	**System Fault Level MVA**	**Short Circuit Level kA**
66	2500	21.9
22	500	13.1
11	350	18.4
6.6	250	21.9
<1	36	50.0

The generating unit(s) contribution to connection point fault level values and facility switchgear details must be provided with the application for connection. The amount of short circuit current an *Embedded Generator* is permitted to contribute shall be nominated by AusNet Services considering the limits specified in Table 2 and the expected organic growth in the area. The calculation of short circuit currents will be in accordance with the latest version of Australian Standard AS 3851.

The *Embedded Generator*'s switching devices and infrastructure must be designed to withstand the total short circuit current from AusNet Services' *distribution network* plus *Embedded Generator*'s installation.

Should the *Embedded Generator*'s installation raise fault levels in excess of Table 2, the *Embedded Generator* will be responsible for any augmentation required to reduce these to within the prescribed limits of Table 2. Any required augmentation must not limit AusNet Services network operation or efficiency.

4.1.1.6 OTHER ACCESS STANDARDS

Other Access Standards as per the NER Schedule 5 will be assessed on a case-by-case basis. If the proposed performance standard is below the *automatic access standard*, AusNet Services will assess the proposed Negotiated Standard based on the specific requirements for that connection. These requirements may vary according to the location of the connection point and various power system conditions.

4.1.2 MODELLING REQUIREMENTS

4.1.2.1 PROVISION OF NETWORK MODEL

AusNet Services uses the system modelling software PSS®E (Siemens) for 66 kV sub-transmission network analysis and PSS®SINCAL (Siemens) for distribution network analysis. Once a non-disclosure agreement is executed, AusNet Services will provide network information of the 66 kV network in the PSS®E format and the 22 kV network (if required) in PSS®SINCAL format, as raw data files.

It is likely the applicant will be required to integrate AusNet Service's sub-transmission network model with NEM snapshots also in PSS®E format. NEM snapshots are to be obtained directly from AEMO via a Data Provision Request[4].

[4] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Network-Data/Policy-on-provision-of-network-data

4.1.2.2 GENERATOR MODELS

The Connection Applicant is required to provide a modelling package including the following site specific models:

- Root Mean Square (RMS) model - compatible with PSS/E Versions 34.2 and 34.5
- Electromagnetic Transient (EMT) model – compatible with PSCAD / EMTDC Version 4.6 and Intel Visual FORTRAN Version 12.

The model package and associated documentation must comply with the requirements of AEMO's Power System Model Guidelines[5]. It should be revised periodically throughout the connection process as follows:

- Preliminary model package – based on preliminary design data and submitted with connection application;
- R1 model package – based on detailed design data and submitted at least three months prior to commissioning; and
- R2 model package - based on site validated data and submitted, along with an R2 model verification report, within three months of the final commissioning tests being completed.

4.1.3 CONNECTION STUDIES

The *generator* must be able to demonstrate compliance to the proposed GPS through network studies.

A connection studies report must be submitted with the connection application demonstrating compliance with the proposed access standards through network studies. It will include result from both steady state and dynamic studies as outlined below.

The *Connection Applicant*'s appointed engineer is expected to propose a set of contingencies and network scenarios for connection studies. AusNet Services will comment and approve the proposal and reserves the right to propose further contingencies and scenarios that need to be studied.

4.1.3.1 STEADY STATE STUDY

The steady state criteria defines the ability of the network to accept the connection of embedded generation within the component ratings, voltage limits and power quality limits defined in the NER and as per VEDC.

The main objectives of this study are:

- to identify any network thermal limitations which would lead to *Embedded Generator* operating constraints. This may in turn facilitate the need for network augmentation before connecting;
- to assess the impact of connecting the *Embedded Generator* on the voltage levels including voltage dips / rise and voltage fluctuations at the *connection point*, considering both normal and single contingency scenarios;
- to assess voltage harmonics and flicker emissions. (Note: The acceptable harmonics and flicker emission limits will be allocated prior to the system studies); and
- to determine the impact of the *Embedded Generator* on existing network fault levels in order to access if existing switchgear has the capability to accommodate increased fault levels.

The steady state studies are used to assess the *Embedded Generator*'s compliance with the relevant NER performance standards and VEDC.

4.1.3.2 DYNAMIC STUDY

The dynamic study assesses the ability of the *Embedded Generator* to remain connected and recover from the critical faults on the network; this phenomenon is also called 'fault ride-through'. This study also

[5] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/System-Security-Market-Frameworks-Review/2018/Power_Systems_Model_Guidelines_PUBLISHED.pdf

assesses the *Embedded Generator*'s response to voltage disturbances in the network and the network's stability with the presence of the *generator*.

The main objectives of this study are:

- to assess if the *generator* will be capable of continuous uninterrupted operation where a power system disturbance causes the voltage at the connection point to vary within pre-determined ranges;
- to assess that the *generator* has fault ride-through capability and will remain connected and will recover from major network disturbances; and
- to assess the stability of the network after the commissioning of the *generator*.

4.1.3.3 SYSTEM STRENGTH IMPACT ASSESSMENT

Unless the Preliminary Impact Assessment indicates that it is not needed, AusNet Services will undertake a Full Impact Assessment in accordance with the *system strength impact assessment guidelines* upon receipt of a connection application for an asynchronous generator. In this assessment, EMT-type studies will be used to determine whether the proposed generator connection will result in an *adverse system strength impact* including:

- Inability of existing generating systems to meet any aspect of their performance standards;
- Inability of proposed connection to meet its proposed performance standards;
- Network stability cannot be maintained in accordance with clause S5.1a.3 of the NER;
- Generating system unable to maintain stable operation following credible contingency event or protected event

If the connection is assessed as having an adverse system strength impact, remediation will be required. Possible remediation measures include (but are not limited to):

- Network augmentation (e.g. new or upgraded 66 kV lines or transformers);
- Reconfiguration of existing networks;
- Installation of synchronous condensers;
- Installation of harmonic filters;
- Tuning of inverter control schemes; or
- Post-contingency control schemes.

4.2 PROTECTION SYSTEMS AND PROTECTION SCHEMES

Generally AusNet Services does not state what protection is required to protect the *Embedded Generator*.

NOTE: The *generator* control and synchronisation must occur at the *generator* circuit breaker associated with the *generator* protection. *Generator* reconnection can only occur once the *distribution network* has maintained stable supply conditions for more than 1 minute. *Generator* protection is the responsibility of the *Embedded Generator*.

The following is the basis for AusNet Services protection requirements:

- CB at *connection point*;
- must disconnect from grid in <3 seconds of network loss;
- if protection is communication dependent then must disconnect from grid in <30 seconds of communication's failure; and
- AusNet Services must have remote capability to disconnect the *generator.*

4.2.1 CUSTOMER INSTALLATION PROTECTION

This document does not cover customer's obligations as required by the following standards and guidelines:

- Electricity Safety Act, Electricity Safety (Installations) Regulations and other Australian

Standards including AS 3000, NOTE: Under AS3000 the customer must also provide overcurrent protection and now for new circuit's earth fault via a RCD. AS 3000 does not specify unidirectional or bidirectional protection.

- Distribution Code – In particular Section 7
- Victorian Service and Installation Rules – Clause 6.8

It is *generator's* responsibility to meet the above requirements.

4.2.2 INTERCONNECTION PROTECTION

Interconnection protection is required to permit the *Embedded Generator* to be connected to the electricity grid to enable it to operate in a grid interactive mode. Interconnection protection must be located near the point of supply at the main switchboard and will control the operation of the main switch or *generator* circuit breaker (at the main switchboard).

Its function is to:

- Disconnect the *Embedded Generator* should the grid supply be interrupted for safety and operational needs.
    a. Anti-island protection,
    b. For larger HV installations the HV/LV interconnecting transformer must be delta/star with interconnection protection including Neutral Voltage displacement.
- Protect the electricity network and other network customers from damage caused by connection of the *Embedded Generator* for legal and quality of supply needs. (e.g. Machine Based generation, such as an induction *generator*, is capable of producing up to 2 times the rated voltage under certain fault conditions. Machine Based generation, such as an induction *generator*, is capable of producing up to several (6) times its rated current under certain fault conditions.

Any protection must disconnect the *generator* in the dead time of the AusNet Services reclose function so as to protect the *generator* from damage.

Besides safety considerations this is a compelling reason why the *Embedded Generator* must provide interconnection protection within their installation which must conform to AusNet Services' requirements. AusNet Services will provide Live Line blocking of the reclose function for *Embedded Generators*.

4.2.3 LOCATION OF MAIN SWITCHBOARD

Interconnection protection must be located on the main switchboard. AusNet Services must provide protection for the service line up to the generator's protective equipment as required by Electricity Safety (Installation) Regulations Clause 233 and as a result the main switchboard which incorporates the generator's protective equipment, for HV and LV installations must be located within 5m of the point of supply.

AusNet Services will not provide primary or backup protection beyond the generator's main switchboard.

4.2.4 AUSNET SERVICES DISCONNECTION

For *generators* with nameplate equal and larger than 5 MW, AusNet Services must have the independent ability to disconnect the *Embedded Generator* from the rest of the *distribution network*. This facility is provided by the *Embedded Generator* and controlled via normal control room to control room agreed operating procedures. In addition AusNet Services must be able to independently disconnect the *generator* under an emergency condition without reference; due to the advent of remote controlled enclosed switches a remote controlled bi-directional ACR set to a single trip (no reclose) is required. The *Embedded Generator* needs to provide coordination for faults internal and external of site.

The ACR provides:

- isolation point;
- additional protection – Capacity Control Device (in both directions) and a Service Protection Device;

- Ground Fault Neutraliser (GFN) may be implemented in AusNet Services. As such if the *generator* protection ignores operation it will result in additional *generator* protection operations.

4.3 PREFERRED CONNECTION ARRANGEMENTS

The following requirements define the minimum interconnection requirements. Typical Installations include single or grouped synchronous or power electronic controlled induction machines - wind farms, hydro, solar thermal, gas and diesel fuelled *plant*.

4.3.1 22 KV CONNECTIONS

The preliminary enquiry is undertaken prior to detailed studies being undertaken by approved AusNet Services consultants. If the Project proceeds additional design and other studies may need to be completed prior to a preparation of a firm offer. A typical 22 kV *Embedded Generator*'s installation is shown in Figure 2.

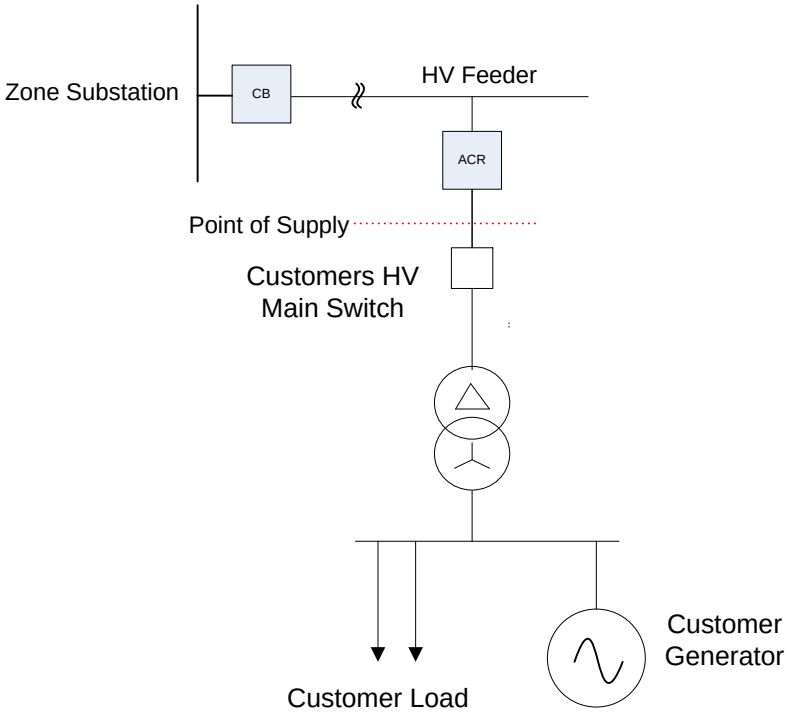


Figure 2: Typical HV Embedded Generator installation (22 kV Connection)

Meanwhile Figure 3 lists the minimal protection requirements for the interconnection of 22 kV only.

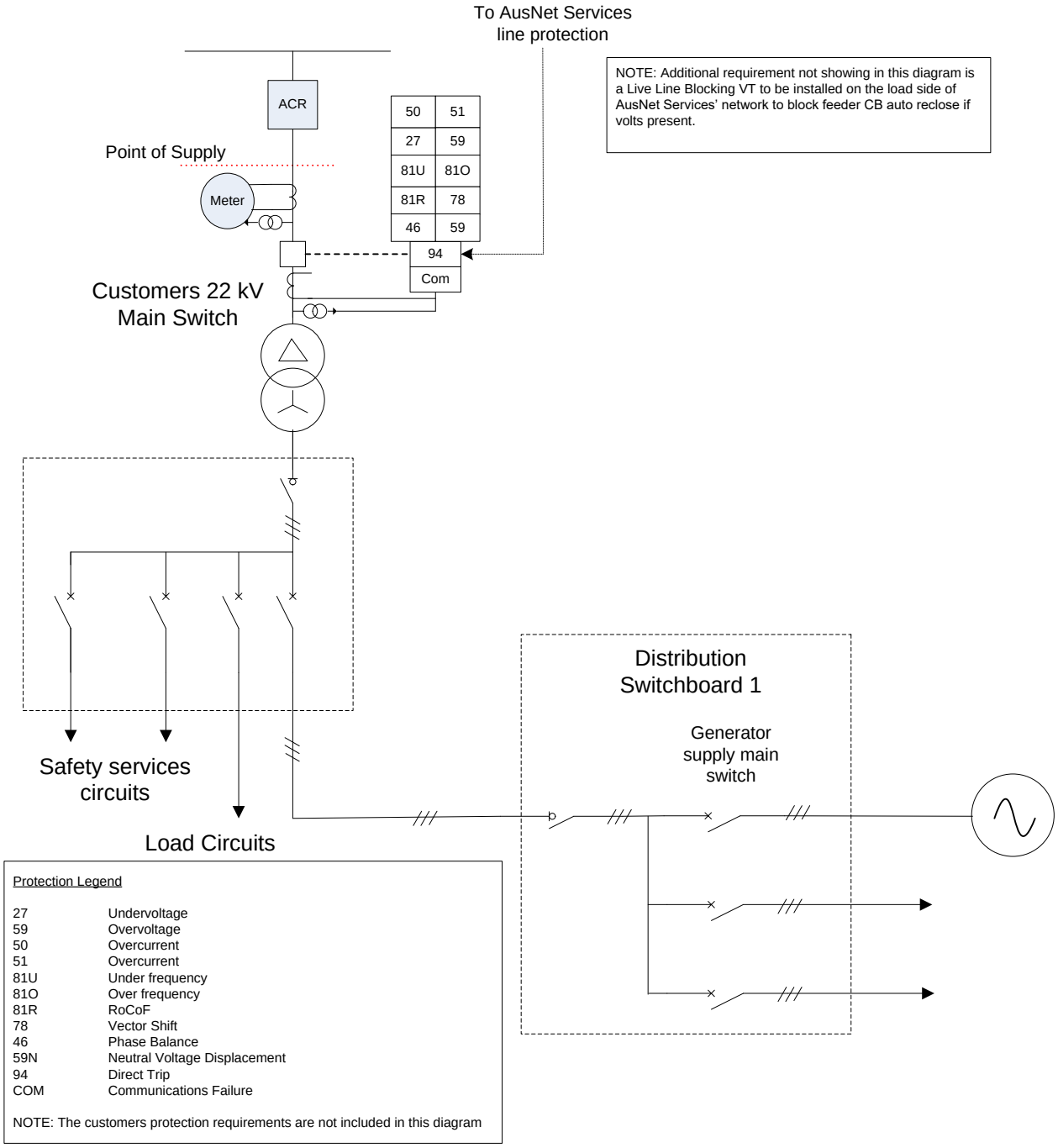


Figure 3: Minimum requirements for 22 kV generator connection

The protection relay MUST be located at the main switchboard and cannot be installed at the Distribution Switchboard. If the *Embedded Generator* is able to provide a communications path to trip the IES rather than the circuit breaker, staged tripping will be considered. Staged tripping if proposed would normally incorporate a loss of communication trip requirement. Staged tripping, which must incorporate tripping at the Main Switchboard, will be considered. The *Embedded Generator* is not permitted to provide an auto reclose function at the site to reconnect the *generator*.

4.3.2 66 KV CONNECTIONS

The proposed *Embedded Generator* may be connected to a new 66 kV switching station built by AusNet Services or the *Embedded Generator* for the proposed *connection*. The switching station will be located between two zone substations currently connected via a 66 kV line as shown in Figure 4 below.

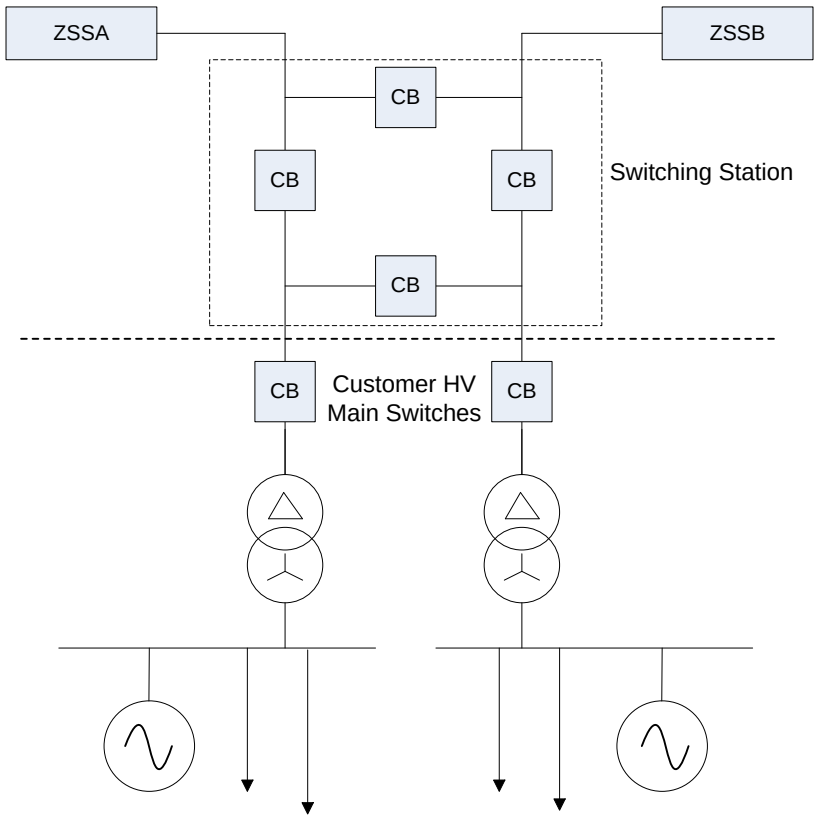
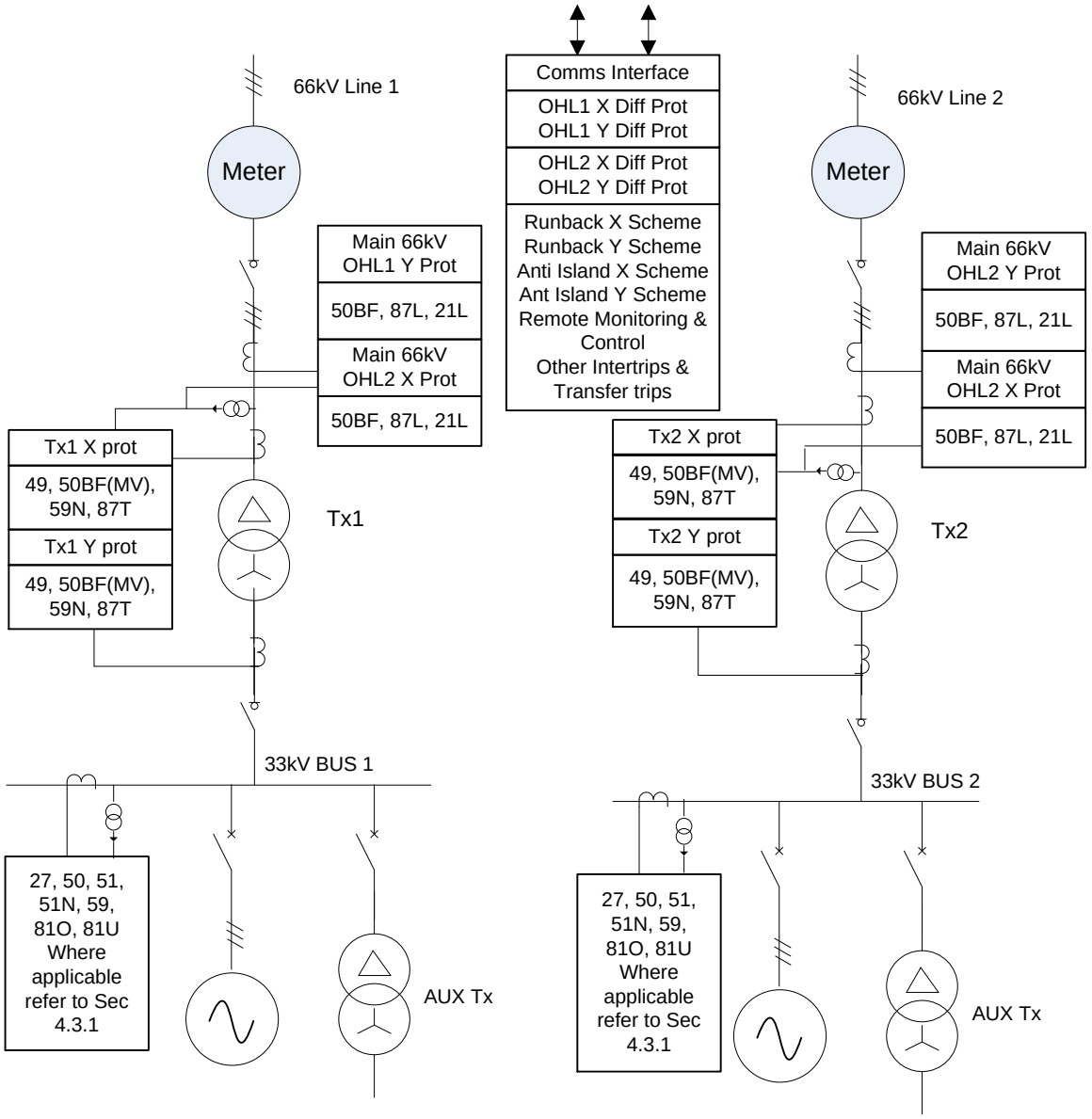


Figure 4: Typical HV Embedded Generator installation (66 kV Connection)



Protection Legend

21L	Line Dist prot
27	Undervoltage
49	Overload
50	Inst Overcurrent
50BF	Breaker Fail
51	Inverse Overcurrent
51N	Inst Earth Fault
87L	Line Diff
87T	Transformer Diff
81O	Over frequency
81U	Under frequency

NOTE: The customers protection requirements are not included in this diagram
Note: RoCoF and Vector shift protection is required at the main switchboard and must protect each circuit with any form of embedded generation.

Figure 5: Minimum requirements for 66 kV generator connection

The final type of connection arrangement to be applied shall be at the discretion of AusNet Services. In both cases, circuit breaker(s) must be provided at the *Embedded Generator's* installation for each connection point to switching stations for complete isolation of the *Embedded Generator* from the connection point.

Single line diagrams of the Embedded Generator's preferred connection arrangements and other possible connection arrangements if applicable, showing the connection point, the point of common coupling, the generating units(s), circuit breakers, isolators, earth switches and other primary equipment should be submitted.

For each preferred connection arrangement, a single line schematic diagram of the protection system, control system monitoring equipment and instrumentation/metering equipment relevant to the connection of a generating unit to the *distribution network* should be submitted. The protection schematic should indicate the protection system and control system to be applied, in their ANSI code where applicable. The protection schematic should indicate locations of all relevant current transformers, and voltage transformers and their connections to the relevant protection system, control systems, monitoring equipment and instrumentation/metering equipment.

4.3.2.1 CONNECTION TO A NEW 66 KV SWITCHING STATION

Consider a switching station with 66 kV lines to Zone Sub A and Zone Sub B; the following protection will be required at Zone Sub A as a minimum:

- X and Y current differential protection with built-in distance protection for 66 kV Lines between switching station and zone sub;
- X and Y CB failure protection with associated communications for remote trips between switching station and zone sub;
- duplicated anti islanding schemes with associated communications for remote trips; and
- duplicated runback schemes for the *Embedded Generator* with associated communications for remote trips.

Similar protection systems as in Zone Sub A shall be provided at Zone Sub B.

The following protection will be required at the Switching Station:

- X and Y current differential protection with build-in distance protection for 66 kV Lines between switching station and each zone sub;
- X and Y CB failure protection with associated communications for remote trips between switching station and each zone sub;
- duplicated anti islanding schemes with associated communications for remote trips between switching station and each zone sub;
- duplicated runback schemes for *Embedded Generator* with associated communications for remote trips between switching station and each zone sub;
- X and Y current differential protection with built-in distance protection for 66 kV Lines between switching station and *Embedded Generator*;
- X and Y CB failure protection with associated communications for remote trips between switching station and *Embedded Generator*;
- duplicated anti islanding schemes with associated communications for remote trips between switching station and the *Embedded Generator*; and
- duplicated runback schemes for the *Embedded Generator* with associated communications for remote trips between the switching station and the *Embedded Generator*.

For protection at the *Embedded Generator*, please refer to Section 4.3.2.2.

4.3.2.2 PROTECTION FOR CONNECTION TO 66 KV SWITCHING STATION

The following protection will be required for 66 kV lines connecting power station to zone sub or switching station:

- X and Y current differential protection with build-in distance protection for 66 kV Lines between switching station and each zone sub;
- X and Y CB failure protection with associated communications for remote trips between switching station and each zone sub;
- duplicated anti islanding schemes with associated communications (as receiving end of the scheme);
- duplicated runback schemes for *Embedded Generator* with associated communications (as receiving end of the scheme);
- duplicated directional power protection if limited power or no power is permitted to be exported by *Embedded Generator* to the grid;
- duplicated neutral voltage displacement for protection against earth fault when 66 kV side of *generator* transformer is not earthed;
- duplicated under and over-frequency protection, including rate of change of frequency;
- duplicated under and over-voltage protection;
- overcurrent protection; and
- duplicated direct intertrip function for intertrip received from zone sub or switching station.

4.4 COMMUNICATIONS AND REMOTE MONITORING AND CONTROL

There are two different types of existing functions between the *Embedded Generator* and AusNet Services that require the communication services are:

- *Embedded Generator* provided communications path from *generator* CB and Main Switch to the AusNet Services CB. Note: isolation of the two earthing systems is required either by the use of a fibre optic path or intermediate relay to provide isolation;
- *Embedded Generator* to provide communication path from Main Switch and (optional) *generator* CB to AusNet Services CB.

4.4.1 22 KV CONNECTIONS

The following data points are generally required for any *generator* connected at 22 kV or greater and embedded generation connected at low voltage but of 1.5 MW and above or incorporating a complex connection arrangement (dedicated or second methods of supply):

- MW (directional 3 phase);
- MVAr (directional 3 phase);
- 3 Phase Amps;
- 3 of Phase to Phase Voltages and 3 of Phase to Ground Voltages;
- open/Close status of incomer feeder (*Embedded Generator's* main switch);
- last trip Amp (R,W, B and N);
- *generator* Open/Close status;
- protection trip at main switch; and
- the *Embedded Generator* is to provide a suitable two paths of reliable communication one for SCADA and one for remote trip
- Remote trip of AusNet Services incomer switch (refer to "*Embedded Generator* Inter-Trip" for more details).

4.4.2 66 KV CONNECTIONS

Meanwhile for 66 kV connection the communication requires Duplicated digital communication channels should be provided between AusNet Services interconnecting Zone substation (or switching station) and the *generator* station. Optical fibre based communication links are preferred.

The communication channels will be used for the following applications:

- OHL No.1 X Line Differential Protection
- OHL No.1 Y Line Differential Protection
- OHL No.2 X Line Differential Protection
- OHL No.2 Y Line Differential Protection
- X Anti Islanding Scheme
- Y Anti Islanding Scheme
- X Runback Scheme
- Y Runback Scheme
- Remote Monitoring and Control
- Other X and Y intertrip and transfer trip signals

4.5 CONTROL SYSTEMS REQUIRED AT POWER STATIONS

4.5.1 SYNCHRONISM CHECK

Synchronisation to the grid system must occur at the *generator* circuit breaker or at the *Embedded Generator* owned circuit breaker at the *connection point*. *Generator* connection to the grid can only occur after the grid has been in a stable condition for more than 1 minute.

4.5.2 REMOTE MONITORING

The following data points are generally required to be communicated to AusNet Services:

- MW (directional 3 phase);
- MVar (directional 3 phase);
- 3 Phase Amps ;
- 3 of Phase to Phase Voltages and 3 of Phase to Ground Voltages;
- Open/Close status of *Embedded Generator* circuit breakers at the *connection point*;
- last trip Amp (R,W, B and N);
- *generator* CB Open/Close status;
- protection trip at *Embedded Generator; and*
- acknowledgement of Intertrip signals received from AusNet Services.

4.5.3 COMMUNICATION LINKS REQUIRED AT POWER STATIONS

If the protection and control requirements call for an X & Y or duplicated requirement, two separate and independent optical fibre cables with diverse routes should be installed between the *Embedded Generator* and the zone sub or switching station. Sufficient cores should be provided in each optical cable for protection, control and communication functions.

4.6 EARTHING REQUIREMENTS

The earthing system shall ensure the safety of personnel and the public, protect electrical installations, ensure correct system operations, and minimise interferences on other infrastructure. At a minimum the earthing system shall comply with all relevant Australian Standards, codes, and best industry practices. Potential earthing hazards shall be eliminated or adequately mitigated.

As embedded generation connections become an integral part of the *distribution network* once connected, they need to be designed such that any neutral earthing arrangements for the *generators* and any interconnection transformers suit the requirements of both the *distribution network* and the *Connection Applicant's* generation installation.

Where these requirements are unable to be met, the *Connection Applicant* shall consult AusNet Services.

4.6.1 HV GENERATOR EARTHING REQUIREMENTS

To meet the *automatic access standards* the zero sequence impedance of the *generator* observed from the network must be infinite. This is required to prevent earth fault current flowing between the network and the *generator* that can affect earth fault protection on the network.

Generator and transformer earthing will be reviewed and designed on a case by case basis by AusNet Services and the *Connection Applicant*.

4.6.2 LV GENERATOR EARTHING REQUIREMENTS

To comply with the *automatic access standards* the earthing system of an LV *generator* must provide satisfactory earthing independently of the AusNet Services network earthing system to prevent the *generator* from being a source for earth fault, limit any contribution to a network earth fault and inhibit the flow of harmonic currents through the neutral.

4.7 NETWORK AUGMENTATION

As a guide, a *generating plant* of capacity below 1.5 MW is not connected to the high voltage distribution system.

This limit is indicative only as it depends on many factors including the location, *generators* size, network short circuit rating, the nature of other loads and local factors. It is sometimes necessary to augment the network to accommodate the proposed generation to comply with the required quality of supply to other *customers*.

The connection process will identify the extent of network extension and augmentation that is required to facilitate a generation connection. The shared network augmentation will be undertaken according to AusNet Services' standards.

The circumstances in which network augmentation may be required to facilitate integration of the *generator* into the network are given below.

1) Increase thermal rating of plant and equipment (e.g. conductors) to enable *generator* connection
2) Maintain network fault levels (short circuit ratings) within VEDC
3) Maintain power quality within VEDC
4) Protection and coordination work required for safe operation of the *generator*
5) Any other safety related work.

5 COMMISSIONING AND TESTING REQUIREMENTS

5.1 PRINCIPLES

It is expected that the commissioning process will be directly managed by the *Embedded Generator* and AusNet Services. It should be noted that *AEMO* may have requirements over and above the requirements of AusNet Services.

As the first stage of the commissioning process, the *Embedded Generator* must develop a commissioning plan and submit the plan to AusNet Services.

The *Embedded Generator* is required to cooperate with AusNet Services to ensure that commissioning is undertaken in a manner that:

- does not adversely affect other *customers* connected to the network;
- does not affect quality of supply, particularly to *customers* connected to the same part of the network; and
- minimises the risk of damage to the equipment of the network or other *customer* connected to the network.

The *Embedded Generator* is responsible for specifying and undertaking commissioning tests and providing evidence to AusNet Services that demonstrates the performance of the *plant*. The commissioning tests of interest to AusNet Services are considered a part of the overall commissioning activities, with AusNet Services expecting that the *Embedded Generator* would have additional commissioning requirements.

General principles applied for the commissioning of generating systems connected to the AusNet Services network are:

- Commissioning tests are intended to provide evidence to AusNet Services at the time of commissioning that a generating system may remain safely connected to the power system, and the generating system meets the Registered Performance Standards and any other technical requirements specified in the connection agreement.
- AusNet Services requires the applicant to compare the actual recorded results with the results expected from design or modelling. Once a model is verified under one set of conditions, it is assumed to be verified for other sets of conditions in the model. This is known as R2 model validation testing.
- Independent equipment is to be installed to collect commissioning results separate from the device under test; and the resolution and accuracy of the test instruments, for both time and recorded value, are suitable to measure the response.

5.2 DEMONSTRATION OF PERFORMANCE STANDARDS

During commissioning, the applicant must demonstrate that its generating system meets or exceeds the Registered Performance Standards. Wherever practicable, the performance of the generating system must be demonstrated by test. Particular performance standards and the associated testing will be discussed on a case by case basis.

To robustly demonstrate the performance of the generating system against all performance standards, AusNet Services requires that commissioning tests demonstrate that the actual *plant* performance meets the expected *plant* performance within predefined and agreed tolerances. The requirements for how the test will be assessed will be agreed on a case by case basis.

Commissioning tests are undertaken under power system conditions at the time of commissioning; however, the comparison of actual results against the design or modelled results provides reasonable evidence that the *generator* may remain in service for the full range of power system conditions according to its design.

Appendix A and Appendix B outline a number of typical tests that have been conducted on generating systems in the past. These tests are not mandatory; however, the results from these tests have been used in the past to demonstrate generating system performance.

The *generator* must advise AusNet Services that the generating system is able to comply with each of the Registered Performance Standards.

If the results show a failure to meet a generating system's Registered Performance Standard or model, AusNet Services may halt or modify the commissioning process of the *generator* if there is a risk of damage to the power system or other safety concerns. Where the generating system is connected and acts inconsistently with its Registered Performance Standards at commissioning, AusNet Services may also constrain the output of the generating system to any output (including zero), or otherwise disconnect the *plant*.

5.3 HOLD POINTS

AusNet Services will nominate specific points in the commissioning plan on a case by case basis, at which the *generator* must submit results for AusNet Services to review prior to progressing further with commissioning. Broadly, AusNet Services may require the applicant to submit commissioning test results prior to energisation or synchronisation occurring and through a staged release of capacity. This process allows the demonstration of Registered Performance Standards through testing at various pre-agreed output levels. Typically, hold points will be established at minimum load, and 50% and 75% of maximum output of the generating system or generating unit.

5.4 DEVELOPING A COMMISSIONING PLAN

As the first stage of the commissioning process, the applicant must develop a commissioning plan and submit the plan to AusNet Services. The commissioning plan for an *Embedded Generator* must be submitted at least one month prior to when commissioning is expected to take, or as stipulated in the Connection Agreements.

The plan is then reviewed by AusNet Services in consultation with AEMO. AusNet Services may also request further information in relation to the proposed plan, including test procedures or data capture and storage methods.

If AusNet Services or AEMO identify any concerns, the parties will negotiate changes to the commissioning plan until a final plan is agreed.

AusNet Services must notify the *Embedded Generator* that they agree with the proposed commissioning plan, or require changes to it in the interest of maintaining power system security, safety of operation, and quality of supply.

5.5 COMMISSIONING PLAN REQUIREMENTS

The Rules do not detail any specific commissioning tests that must be undertaken by a *Embedded Generator*. Instead, as technologies, types and the specific installation (either in installed equipment or settings) may vary from site to site, it is expected that the tests will be tailored to the requirements of the installed equipment and settings. AEMO publishes GPS compliance assessment and R2 model validation test plan templates for both synchronous[6] and asynchronous[7] generators which can be used by the proponent as a basis for the preparation of a site specific commissioning plan.

The commissioning plan must include a list of commissioning tests to be undertaken, providing:

- a description of the purpose of the test, outlining:
- the equipment under test;
- which performance standard will be assessed;
- what comparison against the expected result;
- the proposed dates for test;

[6] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Transmission-and-Distribution/Generating-System-Test-Plan-Template-for-Conventional-Synchronous-Machines.pdf

[7] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Transmission-and-Distribution/Generating-System-Test-Template-for-Non-Synchronous-Generation.pdf

- the proposed duration of test;
- measurement equipment; and
- any specific network conditions.

The plan must allow for hold points and include a proposal for evidence to be provided at each hold point.

The commissioning plan may include other commissioning tests; however, it must show clearly which tests are intended to demonstrate the performance of the generating system against the Registered Performance Standards.

AusNet Services may request a specific commissioning test procedure for further clarity regarding a particular test.

5.6 UNDERTAKING COMMISSIONING

5.6.1 PRECONDITIONS TO ONLINE COMMISSIONING

Prior to commencing online commissioning of a generating system, the following must be completed:

- approval of commissioning plan for the generating system;
- registration of the generating system; and
- commissioning of SCADA systems relating to the generating system.

5.6.2 PROVISION OF COMMISSIONING STATUS ADVICE

As commissioning activities may be subject to rescheduling due to on-site works and issues, AusNet Services may request that the applicant provide regular updates regarding commissioning. These updates may be requested on a weekly or daily basis depending on the impact of the generating system on the local network. This status advice may also provide an opportunity to review and update the commissioning plan.

5.6.3 UNDERTAKING A COMMISSIONING TEST

As commissioning activities may impact on the network, specific actions may be required prior to undertaking online commissioning tests. For these tests, AusNet Services requires that the applicant:

- advise appropriate contact details in advance of commissioning;
- contact the AusNet Services commissioning engineer prior to commencing a commissioning test that:
  a. may impact the MW, MVAr, voltage or frequency of the generating system; or
  b. has the potential to impact the performance of the generating system as outlined in the Registered Performance Standards or any other network configuration; and
- follows all appropriate operational and market protocols – including reflecting its commissioning activities in its interaction with electricity market systems.

The AusNet Services control room may, at its sole discretion and to manage quality of supply to *customers*, require the delay or cancellation of a commissioning test due to system conditions at the time.

5.7 COMMISSIONING RESULTS

During the preparation of the commissioning plan AusNet Services will nominate any tests that need to be reviewed prior to undertaking further testing and any other test results that need to be submitted as they become available.

The output of the generating system will be restricted and testing will not be permitted at higher output levels until a review of the commissioning test results is completed. Once AusNet Services has reviewed the commissioning test results for each hold point, AusNet Services will allow the generating system to progress beyond that hold point.

5.8 COMMISSIONING REPORT

A draft commissioning report must be submitted to AusNet Services no more than two weeks after the completion of commissioning. This commissioning report must:

- outline the commissioning tests undertaken on-site;
- compare expected performance (modelled) with on-site performance; and
- outline the conclusions drawn regarding compliance with the NER, compliance with the design and consistency with the model.

The finalised R2 model package must be provided to AusNet Services within 3 months after completion of commissioning (refer Section 4.1.2.2).

6 CONNECTION FEES AND CHARGES

The following example fees and connection services charges are based on the preferred connection arrangements depicted in Figure 2 and Figure 4. It should be noted that these scopes of work are indicative only and hence the scope of works for other connections may vary in quantity and type of works and thus cost of those works may vary considerably from the examples provided below. As a result, fees and charges will be assessed on a case by case basis.

These examples are also based on the assumption that AusNet Services completes all capital works. These examples are also based on the assumption that AusNet Services will pass all *AEMO* and other DNSP costs (if any) to the *Connection Applicant.*

Example 1 – 66 kV Connection (30 MW Connection into sub-transmission network)

The following fees and charges are based on the scope of works and assumptions below and the connection arrangement depicted in Figure 4:

Scope of Work and Assumptions

Engineering, design, procurement and construction associated with the following scope:

- Reconductor 15 KM of existing 66 kV 6/1/0.186ACSR single circuit with 66 kV 19/4.75AAC;
- 5 KM of new 66 kV overhead, single CCT 19/4.75AAC;
- 20 KM of fibre optic link 20kM (ADSS);
- 3 circuit breakers;
- Civil works (fencing, earthing, buildings); and
- Bus works and isolators
- The following assumptions have been considered:
  a. The following activities are excluded from this estimate: Easement acquisition, land owner negotiations, planning permits, environmental investigations and potential offset works and procurement of land. These activities would be the responsibility of the *Connection Applicant*.
  b. Traffic management, vegetation clearing, access works and significant protection works occurring due to fault level increases are also excluded.

Preliminary Enquiry Fee

No Cost.

Letter Agreement Fees

Under the executed Letter Agreement Fees there is an initial non-refundable Advance Payment of $20,000. This allows for project set up and initial discussions as well as preliminary network data provision. All further costs after the initial $20K has been exhausted are charged on a time cost basis (per hour).

All costs for the detailed enquiry stage, the connection application stage, the offer preparation and contract negotiations are considered under the letter agreement hourly cost.

Based on the above scope of work and assumptions, the estimate of costs under the letter agreement would be approximately $300,000 (this includes the advance payment of $20K).

Please note consultation with AEMO and their review will be required during the connection application process, these costs are passed through to the connection applicant (at cost). These costs are additional to the overall Letter Agreement fees.

Connection Service Charges

Based on the above scope of work and assumptions, the charges would be as follows:

- an upfront payment of $12,500,000 to cover the costs of the capital works; and
- Any further external parties' costs (i.e. AEMO) associated with the connection after the execution of the project agreements will be passed through at cost.

Example 2 – 22 kV Connection (5 MW Connection)

The following fees and charges are based on the scope of works and assumptions below and the connection arrangement depicted in Figure 2:

Scope of Work and Assumptions

Engineering, design, procurement and construction associated with the following scope:

- Thermally upgrade 10 KM of line from 50˚C to 80 ˚C;
- Installation of appropriate switches as per AusNet Services Protection requirements;
- Review and upgrade the protection on the feeder;
- Review and change the distribution transformer taps on 60% of the subs on the feeder;
- Power quality measurement one week before and after the connection of the generator;
- The following assumptions have been considered:
  a. Generator location of 10 KM from the Zone Sub;
  b. Backbone Feeder length – 20 KM;
  c. The following activities are excluded from this estimate: Easement acquisition, land owner negotiations, planning permits, environmental investigations and potential offset works and procurement of land. These activities would be the responsibility of the *Connection Applicant*.
  d. Traffic management, vegetation clearing, access works and significant protection works occurring due to fault level increases are also excluded.

Preliminary Enquiry Fee

No Cost.

Letter Agreement Fees

Under the executed Letter Agreement Fees there is an initial non-refundable Advance Payment of $20,000. This allows for project set up and initial discussions as well as preliminary network data provision. All further costs after the initial $20K has been exhausted are charged on a time cost basis (per hour).

All costs for the detailed enquiry stage, the connection application stage, the offer preparation and contract negotiations are considered under the letter agreement hourly cost.

Based on the above scope of work and assumptions, the estimate of costs under the letter agreement would be approximately $300,000 (this includes the advance payment of $20K).

Please note consultation with AEMO and their review will be required during the connection application process, these costs are passed through to the connection applicant (at cost). These costs are additional to the overall Letter Agreement fees.

Connection Service Charges

Based on the above scope of work and assumptions, the charges would be as follows:

- an upfront payment of $2,990,000 to cover the costs of the capital works.

7 MODEL CONNECTION AGREEMENTS

A model connection agreement for embedded generators is available on the AusNet Services Distribution Connection website. This model agreement is typical for 5 MW or greater of embedded generation connections. Connection agreements will be negotiated on a case by case basis for embedded generators above 30 MW.

8 RESOURCE REFERENCES

All documents listed below can be found on the AusNet Services Distribution Connection Website.

Document ID	Document Title
SOP 33-05A	Embedded Generator Connection Enquiry Form
SOP 33-05B	Register of Completed Embedded Generation Projects
SOP 33-05C	Embedded Generator Detailed Enquiry Form
SOP 33-05D	Embedded Generator Connection Application Form

9 APPENDICES

Appendix A – Typical tests for synchronous machines

Appendix B – Typical tests for non-synchronous machines

10 SCHEDULE OF REVISIONS

Issue	Date	Author	Details of Change
01	29/09/2014	Joanne Soysa	First Issue
02	28/01/2015	Joanne Soysa	Second Issue – incorporated changes highlighted by ClimateWorks Australia, the Property Council of Australia and Seed Advisory compliance monitoring project
03	13/02/2015	Preeti Arora	Third Issue – incorporated changes highlighted by ClimateWorks Australia, the Property Council of Australia and Seed Advisory compliance monitoring project
04	23/01/202020	Maha Ismail / Erika Twining	Fourth issue – incorporated recent NER changes including system strength requirements.

APPENDIX A. TYPICAL TESTS FOR SYNCHRONOUS MACHINES

To assist the applicant with the preparation of a commissioning plan, Table A1 outlines a number of typical tests that have been conducted on synchronous machines in the past. These tests are not mandatory; however, the results from these tests have been used in the past to demonstrate Registered Performance Standards.

Table A1: Typical tests for synchronous machines

Performance Standard	Offline tests	Online tests
S5.2.5.1	Not applicable	Vee Curve Tests Capability Curve Tests Online step response tests (into limiters)
S5.2.5.2	Quality of supply monitoring	Quality of supply monitoring
S5.2.5.3	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.4	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.5	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.6	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.7	Not applicable	Online step response tests Full load rejection Partial load rejection
S5.2.5.8	Secondary injection testing, CT and VT tests, CB timing tests	On load protection tests
S5.2.5.9	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.10	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.11	Offline step response test	Online step response tests Partial/Full load rejection
S5.2.5.12	Model validation tests	Model validation tests Online step responses
S5.2.5.13	Offline step response tests Open circuit saturation curve V/f limiter tests	Online step response: under excited unity power factor over excited into limiters
S5.2.5.14	Not applicable	Online step response tests
S5.2.6	SCADA commissioning tests	SCADA commissioning tests
S5.2.7	Quality of supply Power factor tests	Quality of supply Power factor tests Online protection tests
S5.2.8	Not applicable	Not applicable

APPENDIX B. TYPICAL TESTS FOR NON-SYNCHRONOUS MACHINES

To assist the applicant with the preparation of a commissioning plan, Table B1 outlines a number of typical tests that have been historically conducted on devices other than synchronous machines. These tests are not mandatory; however, the results from the tests have been used in the past to demonstrate Registered Performance Standards.

Table B1: Typical tests for other than synchronous machines

Performance Standard	Offline tests	Online tests
S5.2.5.1	Not applicable	Operation at reactive power limits
S5.2.5.2	Quality of supply monitoring	Quality of supply monitoring
S5.2.5.3	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.4	Secondary injection testing , CT and VT tests	On load protection test
S5.2.5.5	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.6	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.7	Not applicable	Not applicable
S5.2.5.8	Secondary injection testing , CT and VT tests, CB timing tests	On load protection tests
S5.2.5.9	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.10	Secondary injection testing , CT and VT tests	On load protection tests
S5.2.5.11	Offline step response tests to determine frequency control Model validation tests	Online step response tests to determine damping performance Model validation tests
S5.2.5.12	Model validation tests	Model validation tests
S5.2.5.13	Model validation tests	Online step response tests at various generation and reactive power levels including into any limiters
S5.2.5.14	Not applicable	Online step response tests
S5.2.6	SCADA commissioning tests	SCADA commissioning tests
S5.2.7	Quality of supply Power factor tests	Quality of supply Power factor tests Online protection tests
S5.2.8	Not applicable	Not applicable