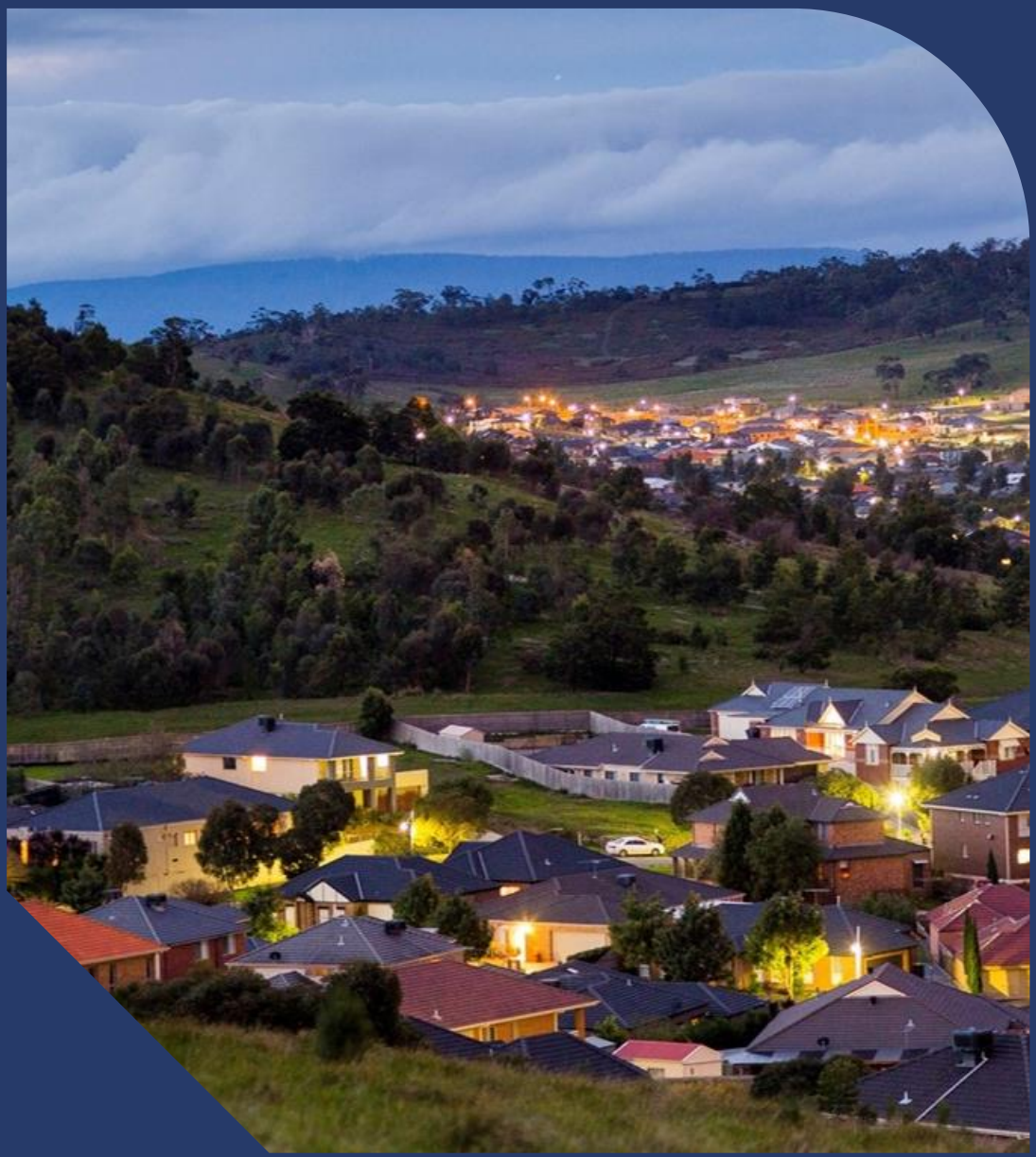
AusNet

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



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

AusNet

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1. 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 a part of 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
AEMO	Australian Energy Market Operator
AEMC	Australian Energy Market Commission
BESS	Battery Energy Storage System
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
FA	Full Assessment
GFN	Ground Fault Neutraliser
GPS	Generator Performance Standards
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.
PC	Practical Completion
PA	Preliminary Assessment
POC	Point of Connection
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, this detail can also be found below in the detailed descriptions.

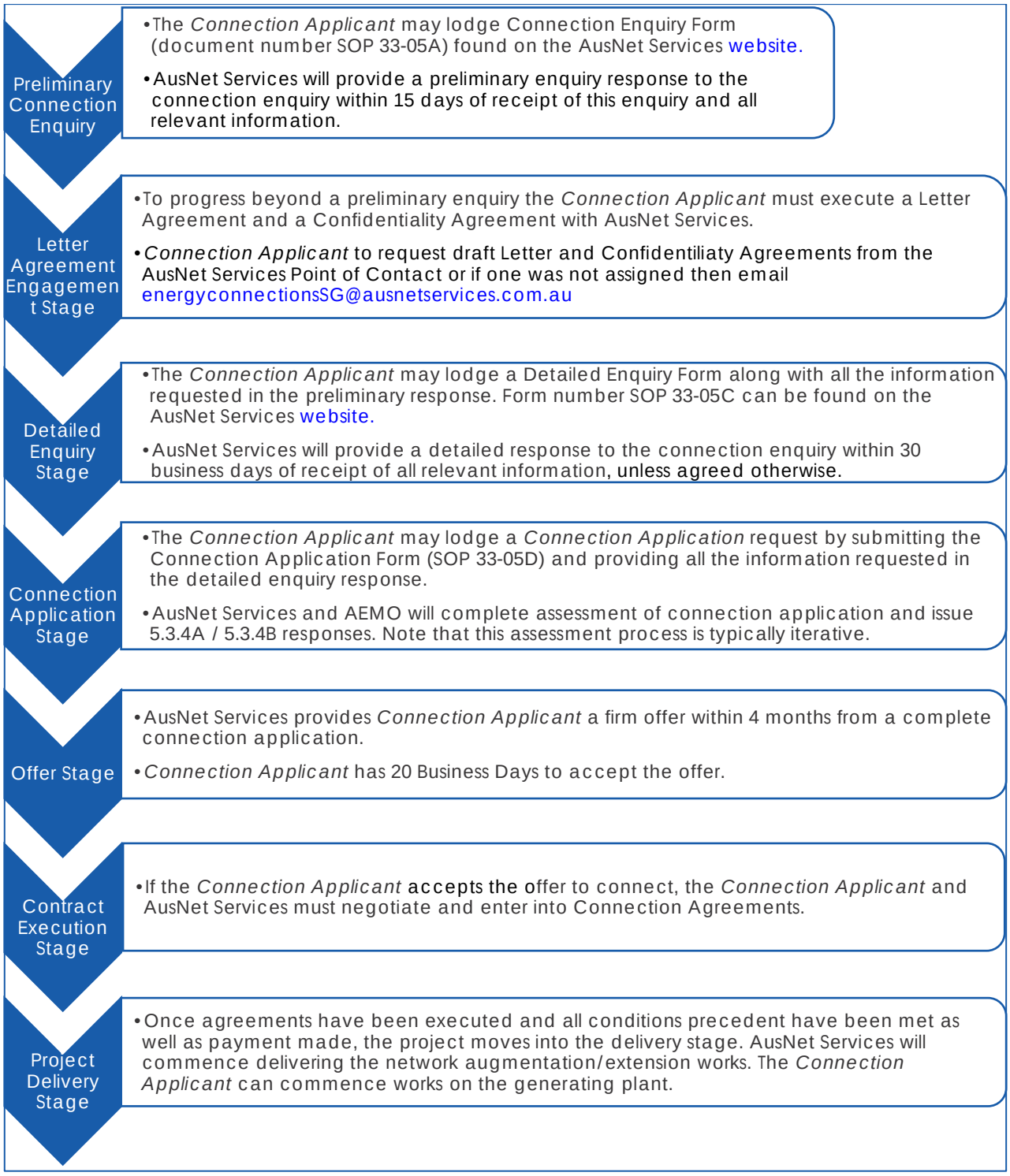


Figure 1 The high-level connection process

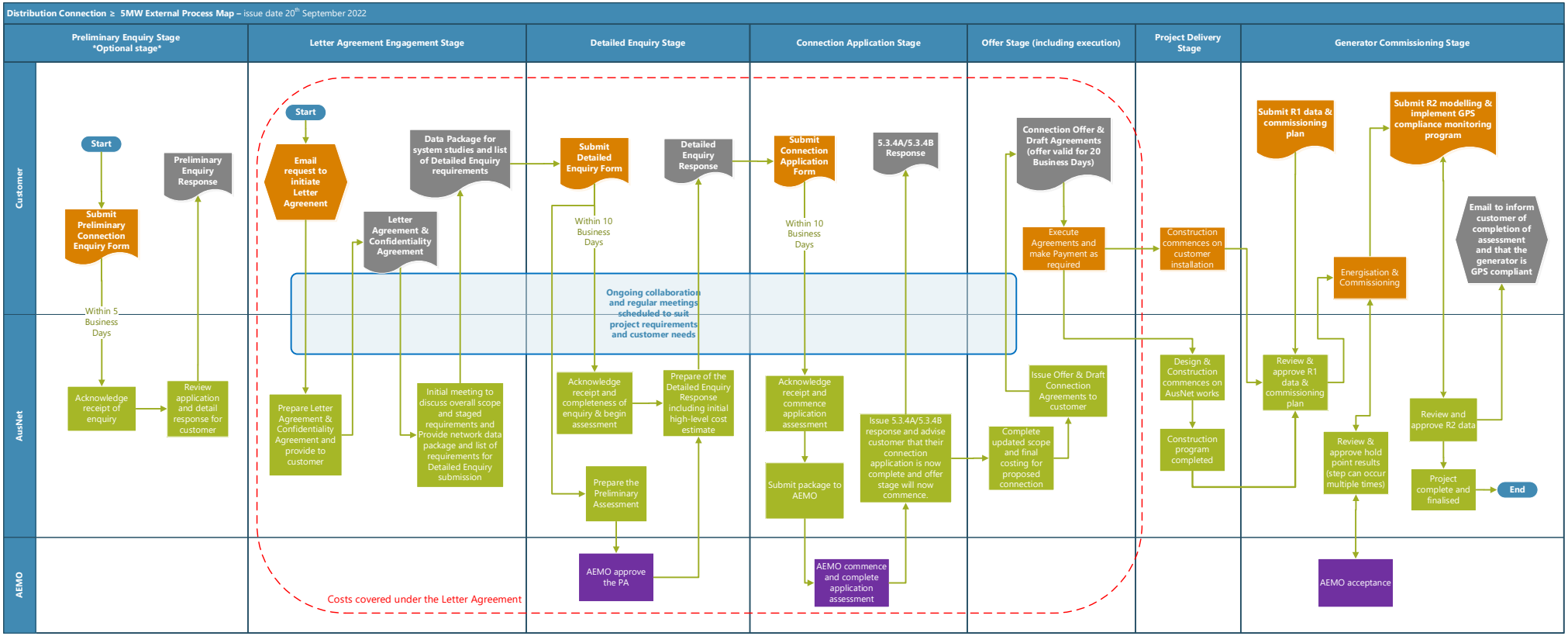


Figure 2 Connections Process for 5MW and greater generator connections

3.1. Preliminary enquiry stage

A Connection Applicant who wishes to make a Connection Enquiry must utilise the Preliminary 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 preliminary 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, including clear details of what is missing.

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.

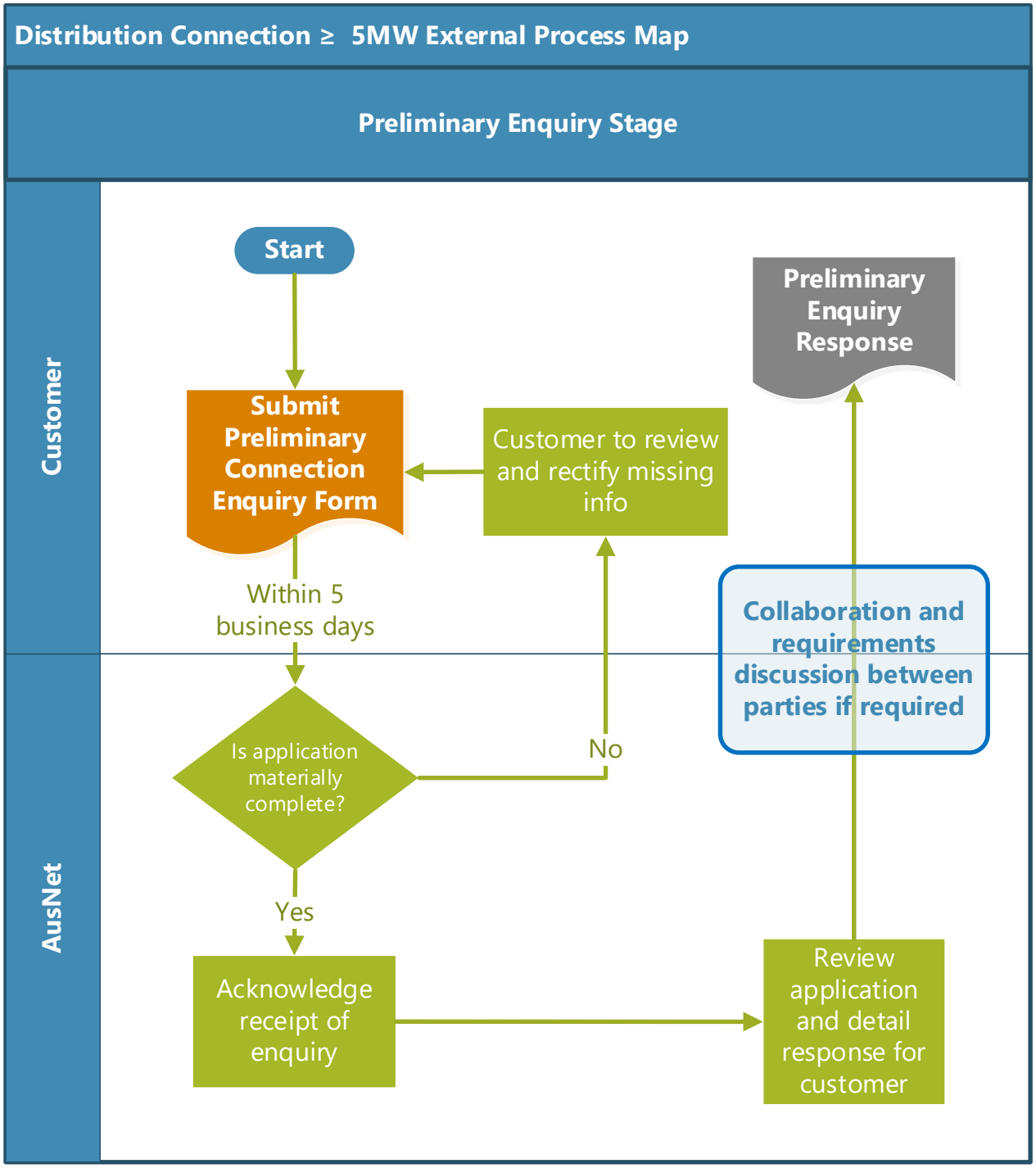


Figure 3 Preliminary Enquiry Stage detailed process map

3.1.1. Preliminary enquiry response

AusNet Services will provide a preliminary response to the connection enquiry within 15 business 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' connection process (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.

An initial advance payment of $100,000 is payable at execution of the letter agreement. Ongoing fees will be incurred on an hourly rate against the Advance Payment until it is exhausted at which point a new invoice will be issued.

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.

Once the Letter Agreement and Confidentiality Agreement are executed by both parties an initial meeting will be scheduled to review the scope of an requirements for each subsequent step. After this meeting, AusNet will provide the network models and the required studies to be prepared by the applicant.

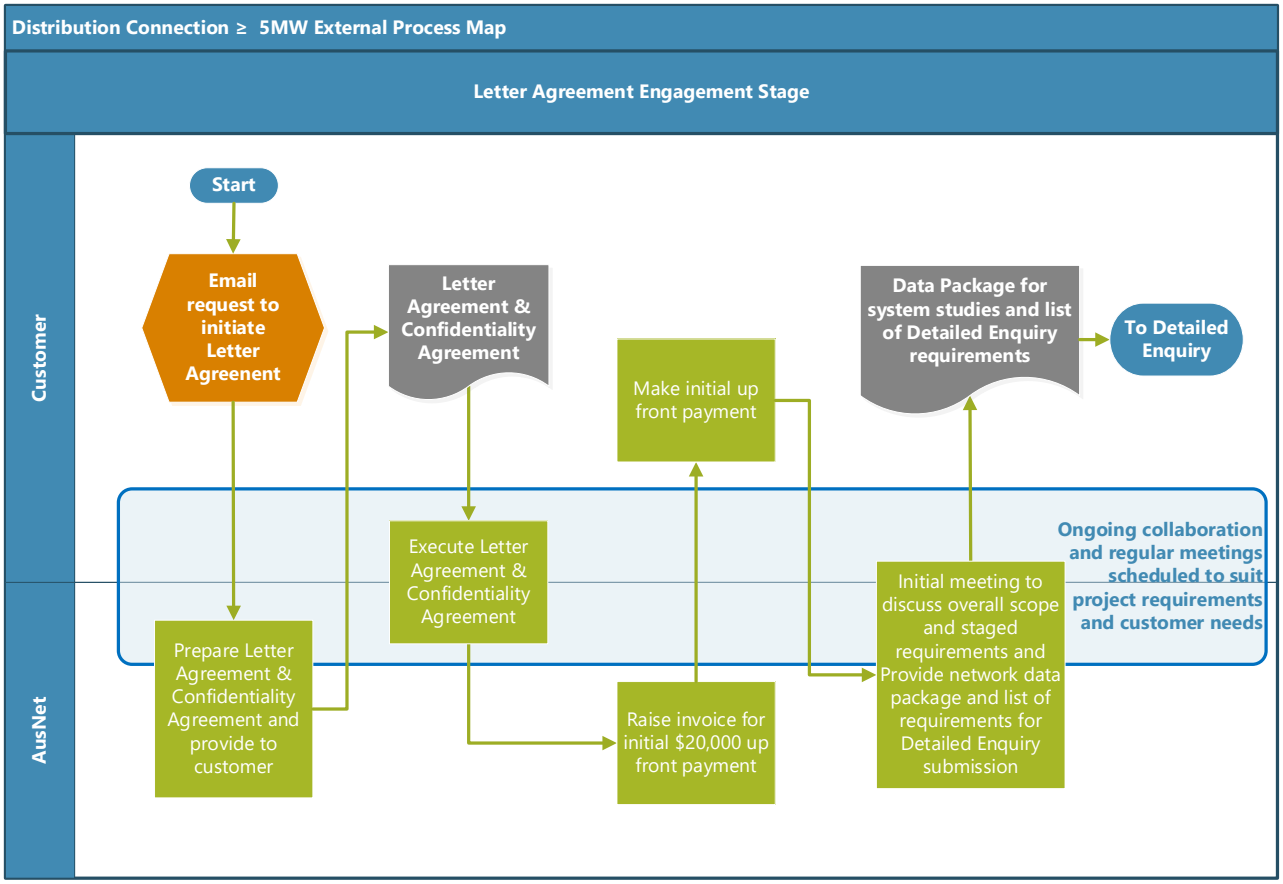


Figure 4 Letter Agreement Stage detailed process map

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 10 *Business Days* after receiving such request and relevant information, will provide a written acknowledgment (in the form of an email). If the information provided (as requested in the preliminary enquiry response) is incomplete in a material respect, AusNet Services will advise the *Connection Applicant* of the deficiency and what is required to address it.

Concurrently to this, after the submission of the Detailed Enquiry Form, AusNet Services will begin to prepare the *Preliminary Assessment (PA)* for the proposed generator connection.

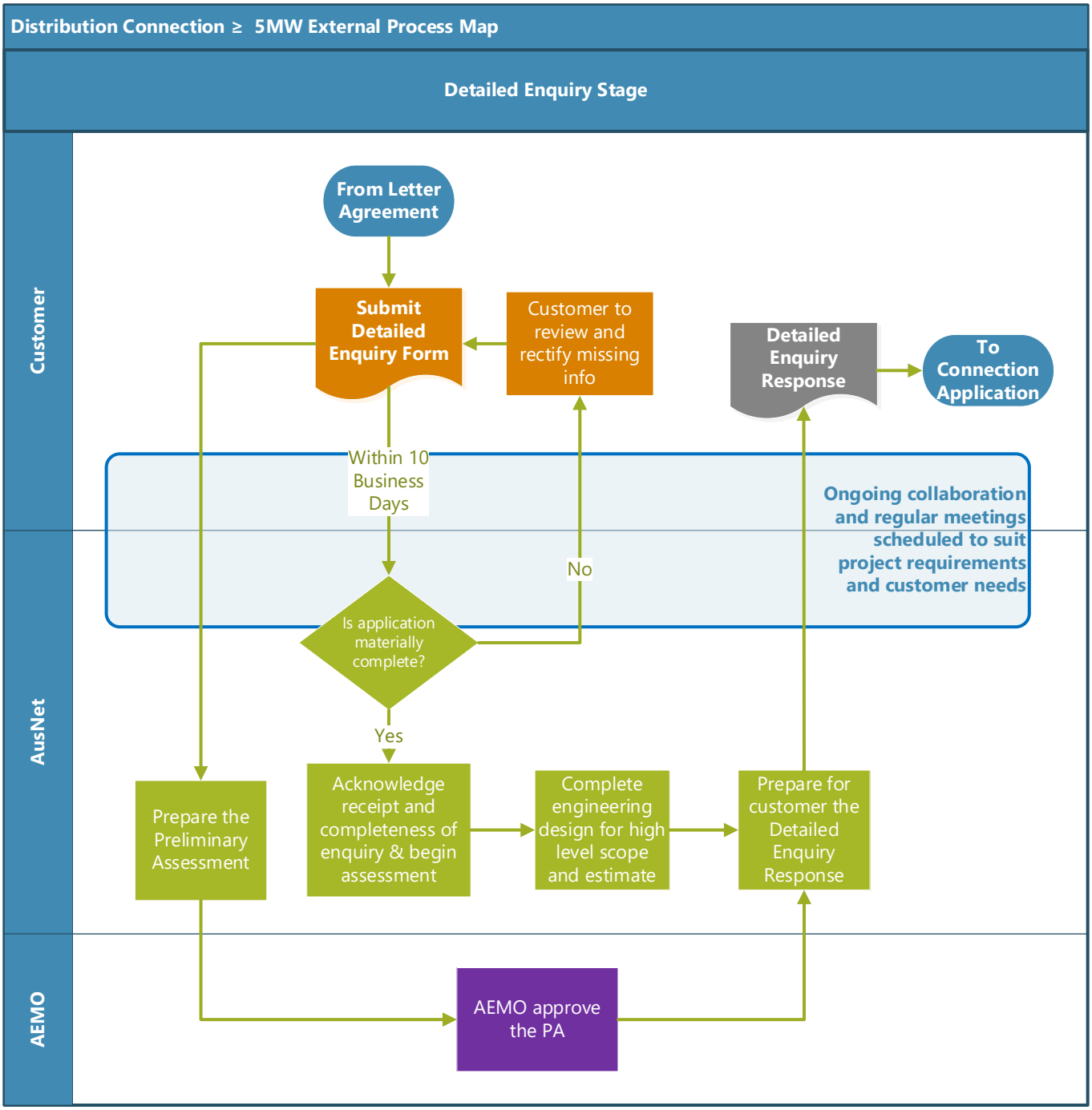


Figure 5 Detailed Enquiry stage detailed process map

3.3.1. Detailed enquiry response

AusNet Services will provide a detailed enquiry 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. Steady state studies are a fundamental part of the required information, and the review of the results and conclusion can be an iterative process.

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 (PA) of the new connection undertaken in accordance with the system strength impact assessment guidelines[1] and clause 5.3.4B of the NER. Dependent on the final conclusion of the PA which is approved by AEMO and if the customer elects to pay the System Strength Charge, Stability Assessment and Full Assessment (FA) in connection application stage may be required.
- 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

Where connection of the Embedded Generator requires extensions and/or augmentation to the distribution network (22kV/66kV), these works can be considered as "Contestable". The *Connection Applicant* may choose to undertake these works; however, they must engage AusNet Services approved and accredited designers and constructors to undertake these network extensions and augmentations (including tendering). AusNet Services' tendering policy will be applicable as per the Section 5 in Electricity Distribution Code of Practice. There are certain tasks which only a DNSP can perform, such as interface works, design review, endorsement and construction audits and network audits which are deemed to be considered as non-contestable. In addition, secondary works within existing zone substations/terminal stations, secondary work on existing protection devices on 22kV/66kV lines and communications related works at existing zone and/or terminal station are considered to be non-contestable.

Contestable works on 22kV network

- New 22kV overhead and/or underground installations, including fibre optic cable (OPGW/ADSS); and
- Augmentation of existing 22kV network.

Contestable works on 66kV network

- New 66kV overhead and/or underground installations, including fibre optic cable (OPGW/ADSS); and
- New switching station works.

Augmentation of 66kV network is considered as non-contestable in general, considering the technical feasibility and safety of proposed augmentation works of the existing 66kV network. However, AusNet Services may consider 66kV

[1] https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/system-strength-impact-assessment-guidelines

augmentation works as contestable based on the scope, impact on the network safety, operation, and reliability. Where there are network extensions the *Connection Applicant* will enter into a Network Extension Agreement with AusNet Services which sets out the parties' rights and obligations in relation to the extension works that AusNet Services will carry out to enable the *Connection Applicant's* connection to the electricity distribution network. Where there are network augmentations (insofar as it involves more than an extension) that the *Connection Applicant* opts to manage as Contestable works, *the Connection Applicant* will enter into a Network Modification Agreement which sets out the parties' rights and obligations in relation to the *Connection Applicant's* construction of certain network assets. These assets are gifted to AusNet Services on completion and will then form part of its electricity distribution network.

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 which is typically an iterative process. AusNet Services will support and assist the *Connection Applicant* to submit a complete Connection Application. AusNet Services will consult with AEMO on AEMO advisory matters to facilitate the endorsement of 5.3.4 A/B letter. Once AusNet Services deems a connection application as complete, it will then commence the offer preparation stage.

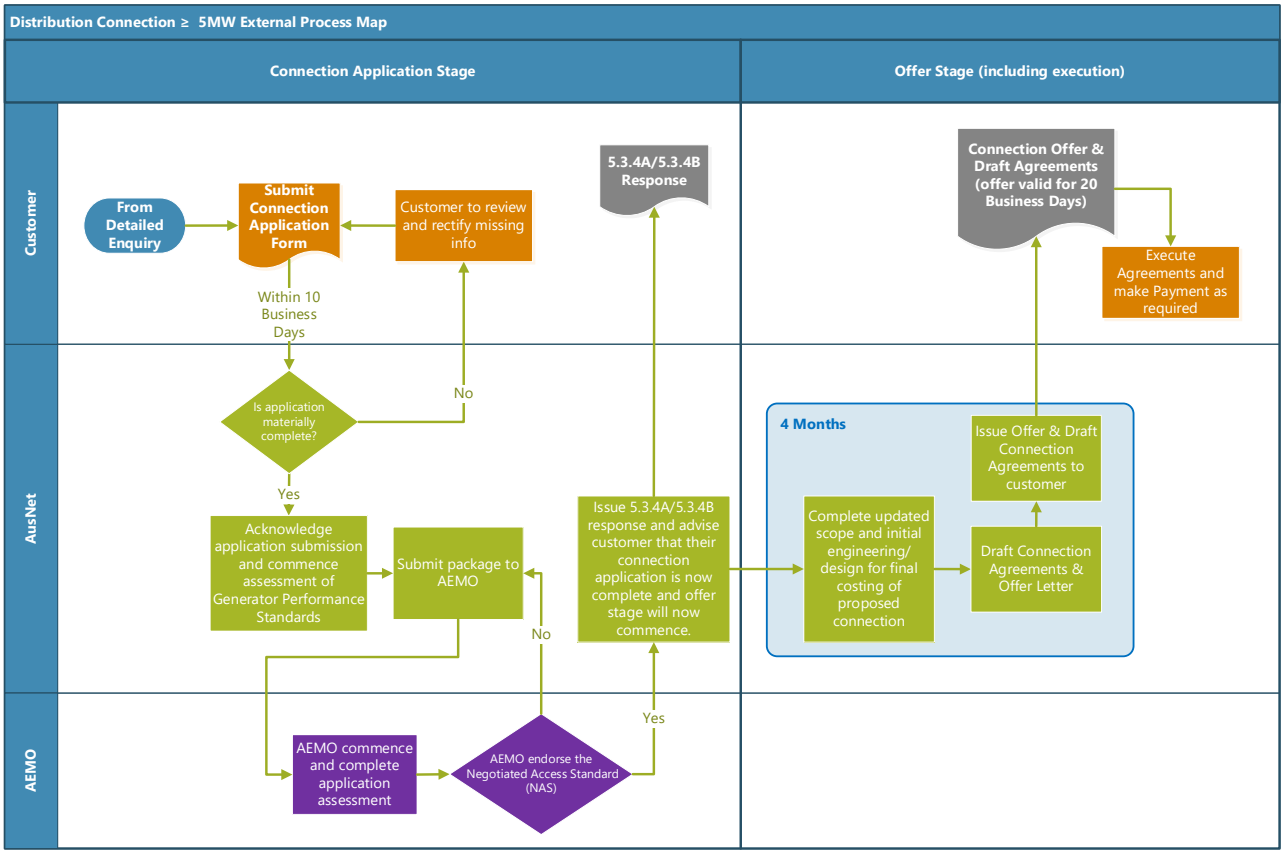


Figure 6 Connection Application and Offer stage detailed process map

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.

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 and generator commissioning 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.

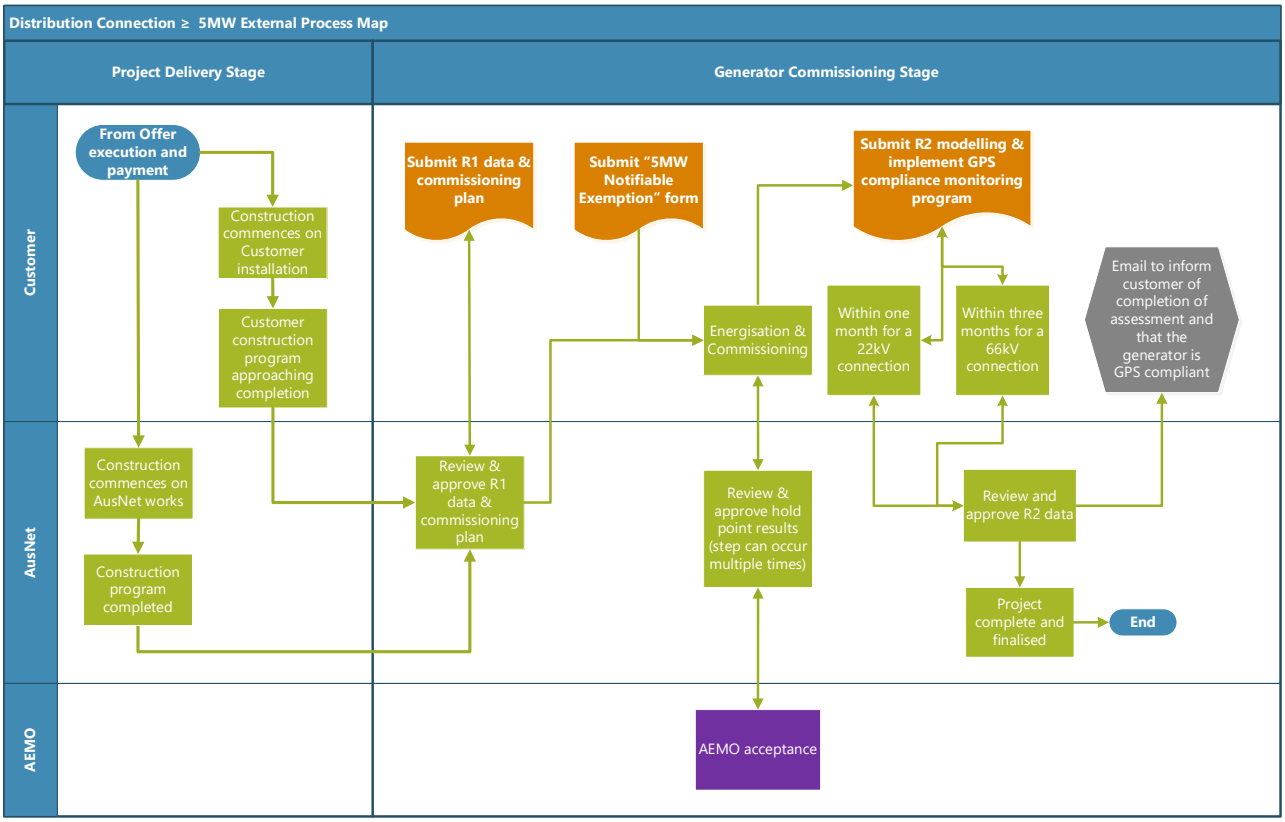


Figure 7 Project Delivery and Generator Commissioning stage detailed process map

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, S5.2.5, 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

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

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

4.1.1.1. Reactive power capability (S5.2.5.1)

According to NER Clause 5.2.5.1 (a), the *Embedded Generators* must be capable of supplying and absorbing an amount of reactive power of at least 0.395 of the rated power at any voltage level at the point of connection.

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

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.

AusNet allocates an acceptable harmonic and flicker emission level on a case-by-case basis. The *Embedded Generator* is required to provide detailed information about their plant and proposed connection arrangement to prove its compliance to the allocated levels. Any deviations from the allocation need to be rectified by the *generator* to meet AusNet's requirements.

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

- 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. Voltage and reactive power control (S5.2.5.13)

Embedded Generator must have the ability to operate in and switch between different control modes to regulate voltage, reactive power and power factor according to NER Schedule 5.2.5.13. 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.

For connections to the *sub-transmission network* (66kV) and *distribution network* (22kV), the preference is voltage droop control. The voltage set-point and droop values to be adopted will be determined by the detailed systems studies. The customer can study other control strategies and present the results if another control mode is preferred.

4.1.1.4. 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 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.

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

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 2and 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.

4.1.1.5. 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].

4.1.2.2. 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 34.7. Noting the changes to the AEMO connection requirement may supersede AusNet's requirements[5].
- Electromagnetic Transient (EMT) model – compatible with PSCAD / EMTDC Version 5 and Intel OneAPI Fortran Compiler Classic 2021.x with no dependency on non-redistributable software. Noting the changes to the AEMO connection requirement may supersede AusNet's requirements.

[4] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Network-Data/Policy-on-provision-of-network-data
[5] https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/modelling-requirements

The model package and associated documentation must comply with the requirements of AEMO's Power System Model Guidelines[6]. 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 define 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 study also assesses the *Embedded Generator*'s response to voltage and frequency disturbances in the network and the network's stability with the presence of the *generator*. The dynamic assessment of the *Embedded Generator* includes but is not limited to reactive capability, protection settings and the performance in controlling voltage, controlling frequency and controlling active and reactive power according to NER. The study results will define and confirm the access standards proposed in the GPS.

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;

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

- 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.

- Anti-island protection,
- For larger HV installations the HV/LV interconnecting transformer must ensure that earth faults on the generator side are not transferred to the network (our) side.

- 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, BESS, 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 8.

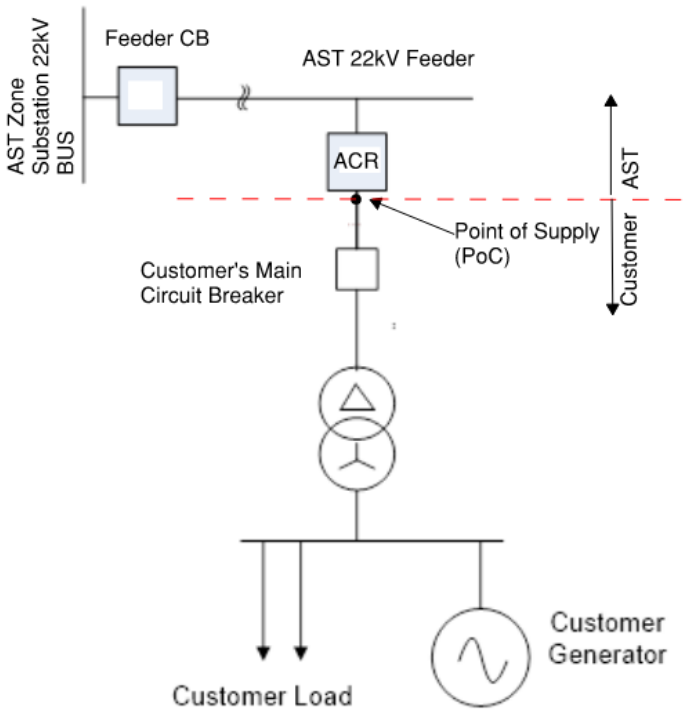


Figure 8 Typical HV Embedded Generator installation (22 kV Connection)

Meanwhile Figure 9 lists the minimal protection requirements for the interconnection of 22 kV only.

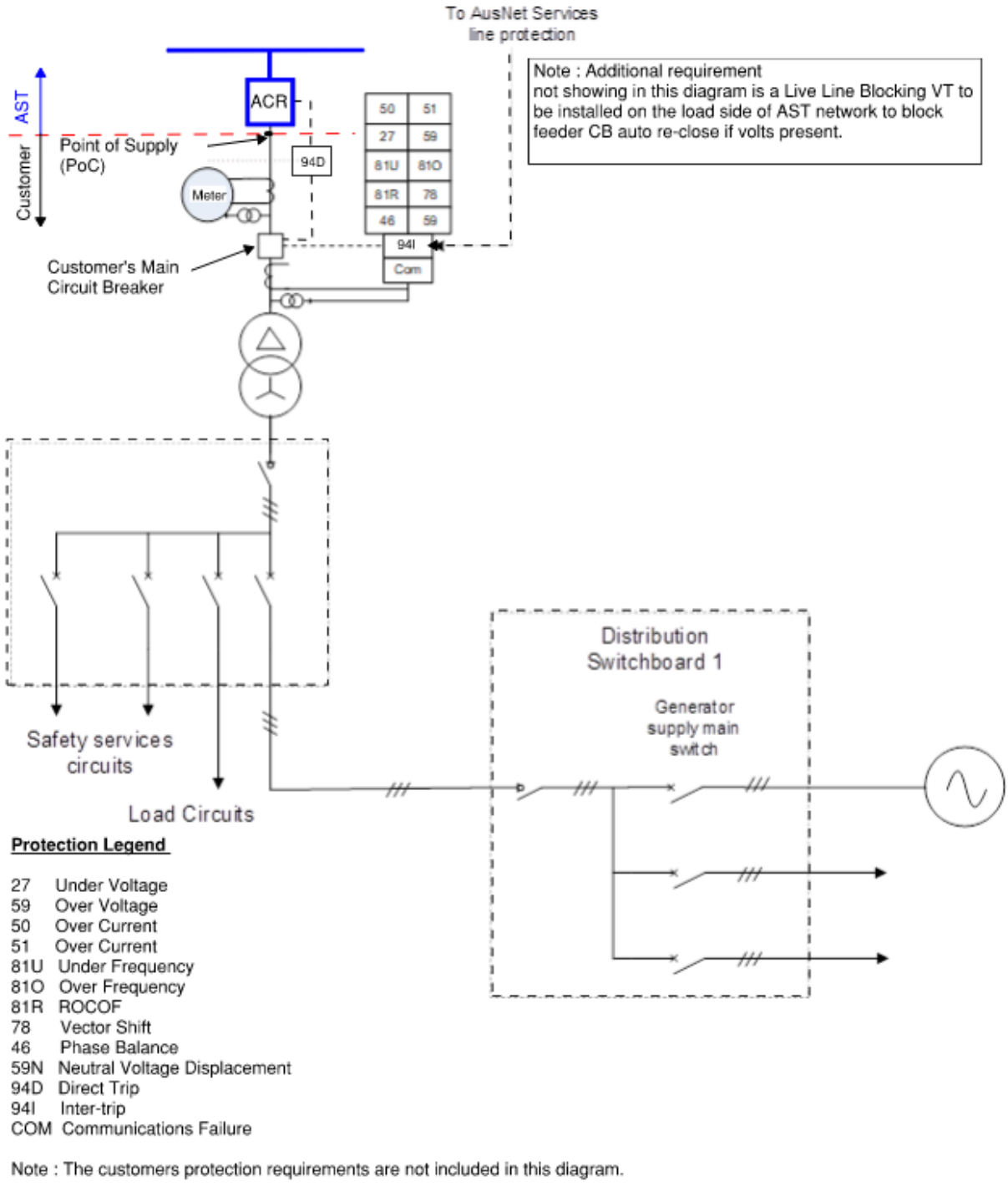


Figure 9 Minimum requirements for 22 kV generator connection

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 10 below.

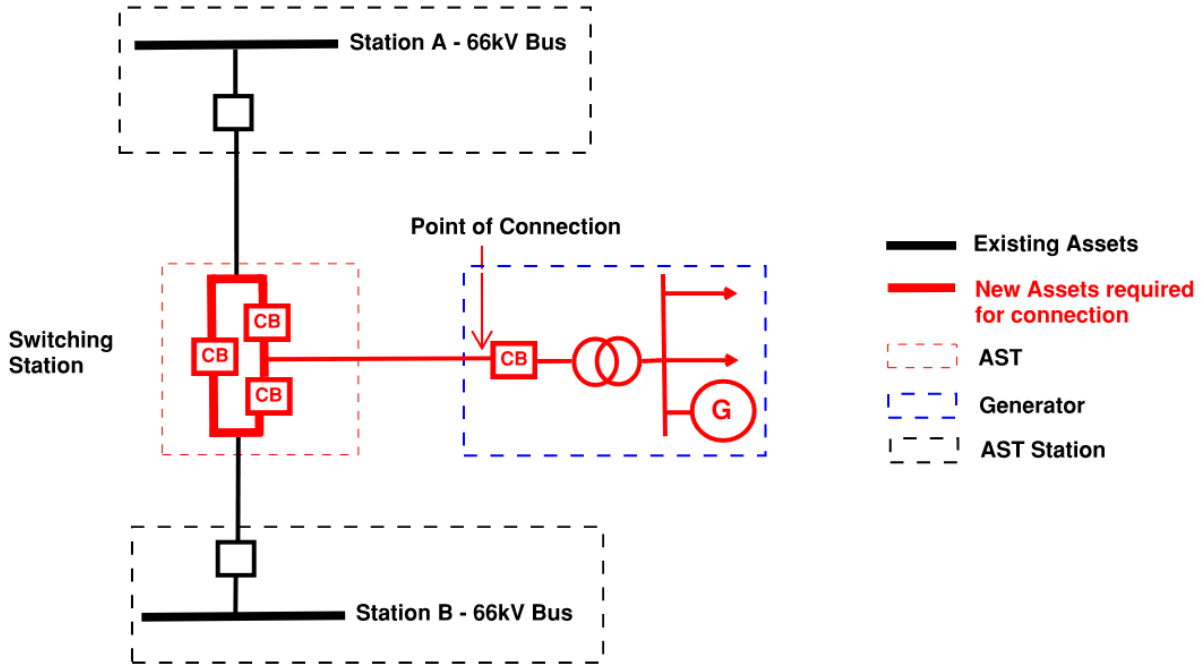
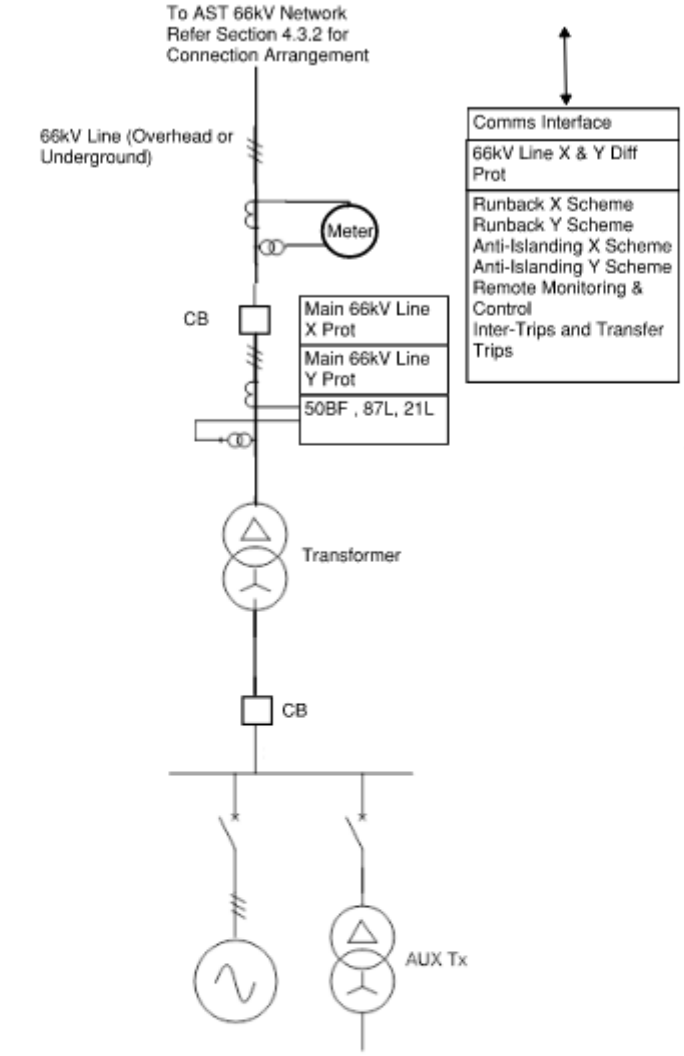


Figure 10 Typical HV Embedded Generator installation (66 kV Connection)

Alternative connection arrangements with different Circuit breakers/bus configurations may be considered subjected to further consideration of the location of generator, configuration of existing 66kV network and other operational consideration of the 66kV lines. In addition, different configurations are applicable when a generator is connected directly on to an AST Station.

Customer should understand the impacts on the reliability of the connection based on alternative configurations and should be agreed at the contract negotiation phase.

In addition, hard tee connection with no circuit breaker on open loop or closed loop systems are not allowed in AST network due to inherent security and reliability issues associated with these type of connection arrangements.



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 11 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 AST station A and AST station B; the following protection will be required at AST station A as a minimum:

- X and Y current differential protection with built-in distance protection for 66 kV Lines between switching station and AST station.
- X and Y CB failure protection with associated communications for remote trips between switching station and AST station.
- X and Y distance protection where communication infrastructure not available for current differential scheme and a protection study has determined duplicated distance protection can provide suitable line and remote backup protection.
- 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 AST station A shall be provided at AST station B.

The following protection will be required at the Switching Station:

- X and Y current differential protection with built-in distance protection for 66 kV Lines between switching station and each AST station. Or where proven by a Protection Study and agreed by AST, X and Y distance protection.
- X and Y CB failure protection with associated communications for remote trips between switching station and each AST station;
- duplicated anti islanding schemes with associated communications for remote trips between switching station and each AST station;
- duplicated runback schemes for *Embedded Generator* with associated communications for remote trips between switching station and each AST station;
- X and Y current differential protection with built-in distance protection for 66 kV Line(s)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. and Appendix C for further information on comms requirements.

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/generator to AST Station or switching station:

- X and Y current differential protection with build-in distance protection for 66 kV Lines between switching station and each AST Station.
- X and Y CB failure protection with associated communications for remote trips between switching station and each AST Station;
- 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 interconnection protection which may include LOM, ROCOF, anti-islanding ,under and over-frequency protection etc.
- duplicated under and over-voltage protection;
- overcurrent protection; and
- duplicated direct inter-trip function for inter-trip received from AST station or switching station.

4.4. Communications and remote monitoring and control

On 22kV connections, depending upon the protection, remote monitoring and load management requirements, communications services may be required between the Embedded Gen, AST ACR, AST Zone Substation and AST Control Centre.

On 66kV connections, depending upon the protection, remote monitoring, constraint and runback requirements, communications services may be required between the customer connection substation, the contestable switching station, multiple AST Terminal Stations/Zone Substations and AST Control Centre as well as AEMO.

AST will provide communications to the connection point, the *Embedded Generator* to provide communication path from connection point to customer switchgear and SCADA. Note: Isolation of the two earthing systems is required either by the use of fibre optic path or intermediate relay to provide isolation.

Refer Appendix -C for further information on possible communication options available for generator connections.

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;
- Remote trip of AusNet Services incomer switch (refer to "*Embedded Generator* Inter-Trip" for more details); and
- Charge/ Discharge signalling and battery status monitoring signals will be included for Battery Installations based on the network requirements.

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 AST Station (or switching station) and the *generator* station.

Optical fibre-based communication links are preferred. Refer Appendix -C for further information on possible communication options available for generator connections.

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. Load/generation management & runback schemes

Based on the connection point on the feeder, feeder configuration, network constraints and existing DFA schemes (22kV network), a load/generator management scheme may be required to constraint and/or reduce generation/load. Similarly, on the 66kV network constraints may be required to prevent network overloads. Therefore, it may be necessary to implement a load/generation management scheme or a runback scheme to manage the level of generation/load and maintain the network security and stability.

AST determines the functional requirements of the proposed load/generation management or runback scheme during the connection application phase and advises the requirement of communications infrastructure to implement the scheme.

Refer Appendix C and D for further details on Communications options and Functional requirements of load/generation management and runback schemes.

4.6. Control systems required at power stations

4.6.1. 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.

4.6.2. 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;*
- acknowledgement of Intertrip signals received from AusNet Services; and
- Charge/Discharge signalling and battery status monitoring signals will be included for Battery Installations based on the network requirements.

4.6.3. Communication links required at power stations

Communications requirements are determined by the protection, control and monitoring requirements. Details are given in Appendix- C. In general, 22kV applications require a single communications path. 66kV applications generally require duplicated communications, although, diverse path requirements will be subject to the outcome of the protection studies and control requirements. Where duplicated requirements over a non-diverse path of comms (Fibre Optic) have been accepted, fail safe operation upon detection of comms failure is required. Sufficient cores should be provided in optical cable for protection, control, and communication functions.

4.7. 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.

4.7.1. 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*.

4.7.2. 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.

4.8. 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.

- Increase thermal rating of plant and equipment (e.g. conductors) to enable *generator* connection
- Maintain network fault levels (short circuit ratings) within VEDC
- Maintain power quality within VEDC
- Protection and coordination work required for safe operation of the *generator*
- 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[7] and asynchronous[8] generators which can be used by the customer 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;
- 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:
  - may impact the MW, MVAr, voltage or frequency of the generating system; or
  - has the potential to impact the performance of the generating system as outlined in the Registered Performance Standards or any other network configuration; and

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

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

- 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

Connection fees and charges play a crucial role in the process of establishing new connections to Ausnet services. Ausnet has a responsibility to ensure that the costs associated with delivering connection services are recovered directly from the Connection Applicants and not imposed on all customers. To achieve this, Ausnet token the approach to receive the payments in advance which acts as a safeguard, allowing costs incurred during the connection process to be deducted from it that can protect Ausnet wider customer base in case a Connection Applicant faces liquidation.

The typical cost listed in Table 3 for connection services are determined based on the estimated effort required for each phase, which is then multiplied by the approved current hourly rates. All pricing provided below is exclusive of GST.

Table 3 Estimated Charges for the services provided by Ausnet team

Connection phase	CH5 Generation
Preliminary Enquiry	0
Detailed Enquiry/ Feasibility Assessment	$ 80,000
Connection Application	$ 300,000
contract negotiation and offer	$ 135,000
Estimated total application cost	***$ 515,000***

Through the Letter Agreement execution, an initial advance payment of $100,000 is invoiced. Ongoing fees will be incurred on an hourly rate against the Advance Payment until it is exhausted at which point a new invoice will be issued. It is important for Connection Applicants to understand that the payment values provided are estimates of the average effort involved. In cases where the actual effort exceeds the estimated amount, Ausnet will issue subsequent invoices to maintain a positive balance in the account, allowing the work on the Connection Application to continue.

Furthermore, if a customer decides not to proceed with their connection application at any point, the account will be finalized. Any unused balance remaining in the payment account can be returned to the Connection Applicant upon their written request to terminate the Letter Agreement (LA).

6.1. Other Expenses

In addition to the fees noted in Table 3, other expenses may apply that will be pass through such as costs associated with any reports or consultation with third parties such as, but not limited to other Distribution or Transmission Network Service providers and AEMO.

The fees above do not include the cost of any design or construction works undertaken by Ausnet Services. An estimate of these fees will be provided within the Option to Proceed prior to commencing works.

7. Connection agreements

Ausnet provides Model Agreements in conjunction with the Detailed Enquiry Response. 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

Appendix C – Communications options for generator connections

Appendix D – Functional requirement of load/generation management and runback scheme

10. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE
1	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	23/01/2020	Maha Ismail / Erika Twining	Fourth issue – incorporated recent NER changes including system strength requirements.
05	28/10/2022	Bill Fahey / Forough Taki	Fifth Issue – Updates on connection process (Section 3), section 4.1, 4.3 and 6.

Appendix A – typical test for synchronous machine

To assist the applicant with the preparation of a commissioning plan, Table A-1 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 A-1 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	Quality of supply

	Power factor tests	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 B-1 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 B-1 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

Appendix A. Communications options for generator connections

AusNet has provided various potential communications options for generator connections based on the generator type, control and protection requirements, network configuration etc. Selection of the communication option is based on the protection and control requirement, Functional requirement of load management or runback scheme and generator's preference in participating AEMO's dispatch market. AST will assess and recommend the requirement of a communication options based on above at the connection application phase.

Preference of the communications options are listed considering the reliability of the link and to provide more certainty to generator for being available to generate to the network, However, Generator can select an option based on the needs considering the capital cost of the solution and expected reliability of the generation.

Below table summarises potential communication options available for generator's consideration.

Tabel C-1: Communications options for 66kV Connections

Connection Type	Direct Trip (ACR @ PoC)	Inter-Trip (FDR CB @ ZSS)	Load/generation Management /Runback Schemes	AGC /FCAS (AEMO dispatch Management)[1/2]	Communications Options
<5MW Solar Farm (IES) (22kV Network)	YES	NA	YES	NO	4G
<5MW BESS (IES) (22kV Network)	YES	NA	YES	YES	FIBRE OPTIC (AST)
					FIBRE OPTIC (PUBLIC)
					POINT-POINT RADIO
				NO	FIBRE OPTIC (AST)
					FIBRE OPTIC (PUBLIC)
					POINT-POINT RADIO
					4G
1.5MW< C <5MW SYNCHRONOUS (22kV Network)	YES	YES	YES	YES	FIBRE OPTIC (AST)
					FIBRE OPTIC (PUBLIC)
					POINT-POINT RADIO
				NO	FIBRE OPTIC (AST)

					FIBRE OPTIC (PUBLIC)
					POINT-POINT RADIO
					4G[3]
>5MW Solar Farm (IES), BESS, SYNCHRONOUS (22kV Network)	YES	YES	YES	YES	FIBRE OPTIC (AST)
					FIBRE OPTIC (PUBLIC)
					POINT-POINT RADIO
				NO	FIBRE OPTIC (AST)
					FIBRE OPTIC (PUBLIC)
					POINT-POINT RADIO
					4G[3]

Tabel C-2: Communications options for 66kV Connections

Connection Type	Protection and Control	AGC /FCAS (AEMO dispatch Management)[1/2]	Communications Options
>5MW Inverter Based, BESS, SYNCHRONOUS on **66kV** Network	Protection, Anti-Islanding, Runback/Special Control Scheme[4]	YES	FIBRE OPTIC (AST)
			FIBRE OPTIC (PUBLIC)
			POINT-POINT RADIO

Notes:

1. Signals and communications link to AEMO for AGC and FCAS market operation can be provided through AusNet communications link upon customer's request.
2. 4G is not suitable for communications requirement for AGC and FCAS participation.
3. 4G for inter-trip protection is offered on case-by-case basis, upon evaluation of the generator type, capacity, location of the generator, network configuration and risk on the network in the event of communication links failure. A site-specific assessment should be conducted at the connection application phase.
4. Duplication requirements (including diverse path duplication) on 66kV connections is subject to protection requirements and must be documented in a Protection Study

Below table outlines the aspects of potential communications options, based on reliability, Capital cost and the network security point of view.

Tabel C-3: Characteristics of Communication media

Communication Media	Reliability	Capital Cost	Network Security
AusNet Fibre (AST)	High	High/Significant	High
Public Fibre (Third party providers)	High	Medium/Significant	Dark fibre is an acceptable solution. If shared/managed network to be used, further security assessment is required
Point to point Radio	Medium	Very High/significant, unless existing infrastructure available to leverage	High to Medium
4G	Low	Low	Acceptable solution for SCADA purposes.
			Acceptable solution for inter-trip protection of 22kV Connections and it is to be evaluated on case-by-case basis.

Appendix B. Functional requirement of load/generation management and runback schemes

Based on the connection point on the feeder, feeder configuration, network constraints and existing DFA schemes (22kV network), a load/generator management scheme may be required to constraint and/or reduce generation/load. AST has developed a high-level guidance on the potential load/generation management scheme and runback scheme based on various factors including functional requirements, response time and connecting voltages.

A comprehensive system study should be completed prior to determine the option which is being implemented in the generator connection at the connection application phase.

SCADA based solution is developed within AST SCADA Master Station and issue signals/commands based on a calculation of network parameters based on different network conditions.

Hardware based solution is to install protection relays and associated communications equipment/channels to communicate network information amongst various stations within AST network.

Tabel D-1: Functional Requirement of Runback, Load/Generation management Schemes

Network (Connecting Voltage) and Network Condition	Assets to be Monitored	Solution	Functional Req	Expected response Time	Comms Fail Strategy	Terminology
System Normal (22kV/66kV)	Load Flow Only (Lines)	SCADA Based Solution	**Constraint** load/generation	1min-2min	Trip the generator if no response to heartbeat signal ***(Time will be determined on case-by-case basis)***	**Load /Generation Management Scheme**
N-1 (66kV)	Load flow and Status of Lines/CBs.	Hardware Based Solution	**Trip and/or Constraint** load/generation	Immediate	Trip gen if coms fail **>30s.**	**Runback Scheme**
N-1 (Gens connected on 22kV Network, needing 66KV management)	Load flow and Status of Lines/CBs.	Hardware Based Solution	**Trip and/or Constraint** load/generation	Immediate	Trip gen if coms fail **>30s.**	**Runback Scheme**
	Load Flow Only (Lines)	SCADA Based Solution	**Constraint** load/generation	1min-2min	Trip the generator if no response to heartbeat signal ***(Time will be determined on case-by-case basis)***	**Load /Generation Management Scheme**

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