Guidelines for connection of generators:

Greater than 30 kVA, and not greater than 10 MW, to the Western Power distribution network

January, 2017.

Contents

1 INTRODUCTION 3

1.1 WHO THE GUIDELINES APPLY TO 3
1.2 QUALIFIER 3

2 WESTERN POWER POLICY 3

3 APPROVALS REQUIRED 3

3.1 WESTERN POWER 3
3.2 OTHER APPROVALS 3

4 KEY TECHNICAL ISSUES 4

4.1 SYSTEM ISSUES 4
4.2 CONNECTION ISSUES 4

5 REQUIREMENTS OF THE WESTERN POWER'S TECHNICAL RULES 5

5.1 APPLICABLE CLAUSES 5

6 INITIAL ASSESSMENT OF IMPACT OF A GENERATOR ON THE DISTRIBUTION SYSTEM 7

7 REQUIREMENTS OF CLAUSE 3.6 OF THE TECHNICAL RULES 7

7.1 3.6.3 INFORMATION TO BE PROVIDED BY THE GENERATOR 7
7.2 3.6.10 PROTECTION 8
7.2.1 Islanding protection 8
7.3 3.6.11 COMMISSIONING AND TESTING 13
7.4 3.6.12 TECHNICAL MATTERS TO BE COORDINATED 13
7.5 5.3 POWER SYSTEM OPERATION CO-ORDINATION RESPONSIBILITIES 13

APPENDIX 1 - ADDITIONAL REFERENCE DOCUMENTS 14

A.1 AUSTRALIAN AND INTERNATIONAL STANDARDS 14

1 Introduction

1.1 Who the guidelines apply to

This document is intended to assist Users planning to connect small generators to the Western Power Network (WPN). It addresses planning, design, compliance and operational issues. It provides detailed explanation of the requirements of section 3.6 of the Technical Rules applicable to all generator types up to 10 MW (except approved AS/NZS 4777 compliant inverter connected generating units – rated up to 10 kVA single phase and up to 30 kVA three phase – in respect of which section 3.7 applies).

This document complements another document "*Detailed customer connection schedules for small generator installations*" and both documents are available from the Western Power internet site.

The approved Technical Rules are available from Economic Regulation Authority (ERA) internet sites.

1.2 Qualifier

This document is a guideline and does not diminish, alter or replace any requirements. If an inconsistency should arise, the Technical Rules document shall prevail.

2 Western Power policy

Western Power will provide a connection to the distribution network for any generator in this category, provided that:

a) the safety of Western Power operational personnel, other customers, contractors and the general public is not put at risk;

b) the integrity of other customers' plant and equipment is not put at risk;

c) reliability and quality of supply to other customers is not adversely affected; and

d) the proposed plant meets the requirements of the Technical Rules.

3 Approvals required

3.1 Western Power

All exporting and non-exporting generators seeking a connection to the Western Power's network (WPN) must make a formal application for network access in accordance with Western Power policies and procedures.

3.2 Other approvals

It is the responsibility of the generators to meet all registration requirements, environmental and safety codes, and to seek approval from any relevant bodies including but not limited to: Economic Regulation Authority (ERA), Energy Safety, applicable local government, Environmental protection Authority (EPA) and various other applicable Australian Standards.

4 Key technical issues

Promotion of renewable sources of energy is likely to result in an increasing amount of distribution connected generation in the WPN, both intermittent and non-intermittent. Of initial concern to Western Power in evaluating applications will be the impact of proposed generators on other users and on the system in the vicinity of the point of connection. However, the collective impact of all distribution connected generators is also important and will be assessed.

4.1 System issues

As the penetration of distributed generation increases it will become increasingly important that a power system disturbance does not result in the disconnection of multiple small generators, which would compound and magnify the effect of the disturbance. This could eventually have significant impact on the control of system frequency in the WPN, which being a small isolated system, is more vulnerable to frequency excursions than larger systems and those with interconnection and support from neighbouring systems.

Protecting the system from the disturbance that disconnection of multiple small generators in sympathy with a large transmission connected generator would create, carrying an increased amount of spinning reserve thus increasing the cost of system operation. Consequently Section 3.6 of the Technical Rules also addresses the fault ride through (FRT) capability, rotor angle stability and the frequency performance of distribution connected generators.

4.2 Connection issues

Issues that arise when connecting generators to the distribution system and which are addressed by Section 3.6 of the Technical Rules are:

a) Network operators must be confident of the status of embedded generation when performing switching and maintenance. Depending on the degree of risk posed by facilities, this will require varying combinations of automatic protections, interlocks, inter-tripping, and remote indication, control and interlocking from the network control centre.

b) Embedded generators exporting to the network may create switching hazards for network operators by causing switch ratings to be exceeded.

c) Embedded generation is not common in the network at present and distribution switchgear is generally not equipped with synchronizing and back-feed facilities.

d) Inadvertent islanding of an embedded generator on to a part of the distribution network may create operator safety and quality of supply problems. The generator protection may be unable to detect certain network faults. Inadvertent reclosing of a switch on to an undetected island may result in severe customer plant damage.

e) An embedded generator may substantially increase distribution network fault levels and thermal loadings so that plant ratings may be exceeded in the network and at other customer facilities.

f) The connection and disconnection of a generator will cause disturbing voltage transients and step voltage changes to the extent that the voltage limits at the point of connection and at other customer connections on the same feeder may be exceeded.

g) Inverter connected and wind generation will contribute to network harmonics and flicker at other customer installations.

h) Distribution connected generators are generally more likely to become unstable during power system disturbances than transmission connected generators because of low inertia, higher interconnecting impedances and slower distribution system fault clearing times, thereby amplifying the disturbance and slowing the restoration.

In the assessment of an application for embedded generator access, the main issues Western Power will cover are:

i) risks to the safety of public, operating personnel and plant;

j) the proportion of time the generator will remain connected and implications for protection and operational safety;

k) the performance of proposed protection systems and compliance with relevant standards;

l) protection against islanding of a generator with parts of the local distribution system;

m) visibility to maintenance staff and control centre operators of generating plant status and requirements for isolation and remote control;

n) short circuit currents, plant and switchgear ratings;

o) local voltage rise and voltage transients caused by the generator;

p) network thermal loadings;

q) levels of harmonics and flicker;

r) generator instability and the likely consequences.

In terms of the collective effect of small generators on overall system security, the main issues Western Power will consider are:

s) generator fault ride through capability;

t) generator under and over frequency performance, including islanding.

5 Requirements of the Western Power's Technical Rules

5.1 Applicable clauses

While other parts of the Technical Rules document can apply to small generators, the requirements for embedded generators are found primarily in Section 3.6 "Requirements for connection of small generators to the distribution network". Table 3.4 of section 3.6 provides references to the applicable clauses of section 3.3 "Requirements for connection of generators". To further assist Users, sections of the Technical Rules (other than 3.6) that may be of significance to an embedded generator facility are listed in Table 1 below.

Table 1 - Clauses of WPN Technical Rules applicable to distribution connected generators

Clause	Requirement	Notes on content
1	General	
2.2	Power system performance standards	Standards for voltage, frequency, harmonics, flicker etc to the extent required by clause 3.6.8.

2.3	Obligation of the Network Service Provider in relation to power system performance	NSP study of system performance with proposed connections may determine particular User performance requirements and network augmentations.
2.5.5	Planning criteria: High Voltage Distribution System	Relates to standards of reliability of the network.
2.5.6	Planning criteria: Low Voltage Distribution System	Relates to standards of reliability of the network. Obligation to connect underground.
2.5.7	Fault limits	Relates to permissible User contribution to fault current at point of connection.
2.5.8	Maximum fault currents	Design and construction standards for fault current withstand.
2.7	Design and construction standards	Obligation of the NSP (and hence User) to comply with recognised standards.
2.8	Distribution conductor or cable selection	Obligation of the NSP to accommodate forecast load growth in selection of conductor or cable size.
2.9	Transmission and Distribution system protection	Includes reference to requirement for independence of islanding protection types.
3.2.3	User's power quality monitoring equipment	Possible requirement for the User to accommodate NSP power quality monitoring and recording equipment.
3.3	Requirements for connection of generators	Additional parts thereof referred to in Table 3.5 of clause 3.6.
3.4	Requirements for connection of loads	Where the facility subject of the access application includes an associated load.
3.5	User's protection requirements	The qualifier of clause 3.5.1(a) applies to the islanding protection for all small power stations under clause 3.6.
3.7	Requirements for connection of energy systems to low voltage distribution system via inverters	Whereas clause 3.7 only covers installations up to 30 kVA in accordance with AS 4777, the requirements nevertheless apply in principle to larger inverter-connected energy systems otherwise covered by clause 3.6.
4.1	Inspection and testing	All aspects of rights, requirements and obligations related to testing and commissioning of an installation.
4.2	Commissioning of User's equipment	The requirements of clause 4.2 form part of the commissioning requirements for distribution connected generators.
4.3	Disconnection and reconnection	Defines circumstances under which the NSP will exercise right to disconnect. Relevant for power stations of all sizes.
5.1	System operation and coordination:	Relates to roles of market operations and

	Application	network operations.
5.3	System operation coordination responsibilities & obligations	Defines both NSP and User obligations.
5.7	Power system security operation and coordination	Relates to the obligations of the User to advise the NSP and NSP management of supply shortfall events, including requirement to reduce loads.
5.8	Operation and maintenance planning	For power stations exporting more than 1MW.
5.9	Power system operating procedures	Requirement for User to follow procedures and rules.
5.10	Power system operation support	Relates to remote control and monitoring, standards and protocols.
5.11	Nomenclature standards	
Attachment 10	Distribution system connected generators up to 10MW	Information to be supplied with application for connection.
Attachment 12	Testing and commissioning of small power stations	Testing and commissioning requirements for connection to the distribution system.

6 Initial assessment of impact of a generator on the distribution system

While a formal Western Power response to an application for access will usually require load-flow, fault level, and in some cases, harmonic and dynamic studies, it is usually possible to conduct an approximate initial assessment of the extent to which a proposed installation would impact the local power system.

Sections that follow provide methods for quick assessment (where feasible) of the extent to which a proposed installation might affect the integrity of the network and operational safety.

7 Requirements of Clause 3.6 of the Technical Rules

The following section clarifies some of the requirements of the clause 3.6 of the Technical Rules for the embedded generators.

7.1 3.6.3 Information to be provided by the Generator

The application form for connection of a distribution generator is available on-line from Western Power:

http://www.westernpower.com.au/mainContent/connectionsUpgrades/newConnections/Generators.html

This document is based on Attachment 10 of the Technical Rules. The application form assumes that no transient stability studies will be required. Should such studies be required, Western Power will request additional information similar to that specified for transmission connected generators including models for dynamic simulation.

7.2 3.6.10 Protection

Protection requirements for small generators are defined by clause 3.6.10.

The Technical Rules requires duplication of the islanding protection. This duplication is not required for bumpless transfer generators, as per clause 3.6.10.1(l) for rapid bumpless transfer and clause 3.6.10.3(b) for gradual bumpless transfer. To provide guidance in what Western Power may require for individual applications Table 2 shows an interpretation of these protection requirements.

7.2.1 Islanding protection

Following network switching both manual and automatic, there is the possibility that an embedded generator will become islanded with a section of the Western Power network. This constitutes a hazard with implications for operator safety, quality of supply, protection incompatibility, and potential damage to the embedded generators through out of synchronism switching.

Required islanding protection would normally detect this situation and disconnect the embedded generator. It is important that the islanding protection operates within the specified 2 seconds to avoid out-of-synchronism operation of a recloser and thus avoid damage to the generator.

Where sustained parallel operation is the mode of the generating unit, a specialist loss of mains protection function must be included in each of two independent *protection schemes*. Generating units designed for gradual bumpless transfer must be protected with at least one type of loss of mains protection. The protection functions used must be selected and set to enable them to detect the islanding condition.

Where there is no export of power into the network and the aggregate rating is less than 150kVA, both independent islanding *protection schemes* can be in the form of a directional power function that will operate for power export. Directional overcurrent relays may also be used for this purpose.

There is the possibility that, should the residual network load approximately match the generator export at the time, the loss of mains protection would not detect the abnormal situation. In these circumstances, when Western Power believes that rate of change of frequency and voltage vector shift will not adequately safeguard from islanding, then, Western Power may also specify remote control and/or interlocking so that, for example, the operation of a zone substation circuit breaker also trips the connection to the generator.

Table 2: Summary of protection requirements for inverter coupled generating units between 30kVA and 10 MVA

Protection* required for *distribution system (see all Notes below)		**Permanent parallel operation Occasional parallel operation**			
		Distribution HV connected		**Distribution LV connected**	
Type	**Technical Rules 2016 Clause(s)**	**No export**	**Export**	**Aggregate capacity kVA**	
				up to 1 MVA	**> 1 MVA**
Under / over *voltage* & *frequency*	3.6.10.1(f) & 3.6.10.3	✓	✓	✓	✓
Overcurrent	3.6.10.1 (f)	✓	✓	✓	✓
Loss of one or more phases	3.6.10.1(h)	✓	✓	✓	✓
Directional power (export)	3.6.10.1(h) & (i)	✓	✓	✓	✓
***Directiona*l overcurrent**	3.6.10.1(h) & (i)	✓	✓		✓
Rate of change of *frequency*	3.6.10.3	✓	✓	✓	✓
Voltage vector shift	3.6.10.3	✓	✓	✓	✓
Neutral *voltage* displacement see Note 8	3.6.10.1(g)	✓	✓		✓
Earth fault	3.6.10.1(g)	✓	✓	✓	✓
Sensitive earth fault	3.6.10.1(g)	✓	✓		
***Disconnection* by timer**	3.6.10.1(k)				
Pole slipping see Note 3	3.6.10.2	**a/r**	**a/r**	**a/r**	**a/r**

Notes:

1. The ✓ symbol indicates required *protection*.
2. Loss of a *protection supply* must immediately trip all switches that depend on that *supply* for operation of their *protection*.
3. Term “a/r” means ‘as required’, will be determined as per clause 3.6.10.2
4. Requirements are determined by the Technical Rules. This table is for guidance only.
5. Protection functions shaded light green are alternatives for export limiting. Directional power (export) protection monitors power in the export direction not to exceed the export limit:
   a) directional/reverse power protection is not required under cl. 3.6.10.1(i) where an approved inverter has an agreed connection at its name plate capacity
   b) if an inverter is capable of exceeding the agreed export limit (at all), then directional/reverse power protection is required.
   c) reverse power protection is set and tested with settings taking account of the pickup current in sensing devices. No more sensing allowance can be made other than that required for reliable operation of the protection relay in preventing exported power.
6. Protection functions shaded blue are alternatives for loss of mains protection.
7. Protection functions shaded yellow are alternatives for earth fault protection. The use of overcurrent earth fault protection or neutral voltage displacement depends on the type of the earthing arrangement in the installation (earthed/unearthed). For example, the earth fault overcurrent protection is required in earthed systems.
8. NVD exemption may apply for eligible LV connected inverters rated at greater than 30 kVA and not more than 1 MVA.

Table 3 Summary of protection requirements for small generating units up to 10 MVA (no inverter)

Protection **required for** ***distribution system*** (see all Notes below)		**Permanent parallel operation Occasional parallel operation**				**Short term test parallel**		**Bumpless Transfer**	
		HV connected		**LV connected**					
Type	**Technical Rules 2016 Clause(s)**	**No export**	**Export**	**Aggregate capacity kVA**		**HV connected**	**LV connected Aggregate capacity above 1 MVA**	**Rapid (≤ 1s)**	**Gradual (≤ 60s)**
				≤ 150	**>150**				
Under / over *voltage* & *frequency*	3.6.10.1(f) & 3.6.10.3	✓	✓	✓	✓	✓	✓		✓
Overcurrent	3.6.10.1 (f)	✓	✓	✓	✓	✓	✓		✓
Loss of one or more phases	3.6.10.1(h)	✓	✓	✓	✓	✓	✓		✓
Directional power (export)	3.6.10.1(h) & (i)	✓	✓	✓	✓	✓	✓		✓
Directiona**l overcurrent**	3.6.10.1(h) & (i)	✓	✓		✓		✓		
Rate of change of *frequency*	3.6.10.1(h) 3.6.10.3	✓	✓	✓	✓	✓	✓		
Voltage vector shift	3.6.10.1(h) 3.6.10.3	✓	✓	✓	✓	✓	✓		✓
Neutral *voltage* displacement	3.6.10.1(g)	✓	✓	✓	✓	✓	✓		
Earth fault	3.6.10.1(g)	✓	✓			✓			
Sensitive earth fault	3.6.10.1(g)								
***Disconnection* by timer**	3.6.10.1(k)					✓	✓	✓	✓
Pole slipping see Note 3	3.6.10.2	**a/r**	**a/r**	**a/r**	**a/r**	**a/r**	**a/r**	**a/r**	

Notes:

1. The ✓ symbol indicates required *protection*.
2. Loss of a *protection supply* must immediately trip all switches that depend on that *supply* for operation of their *protection*.
3. Term “a/r” means ‘as required’, will be determined as per clause 3.6.10.2
4. Requirements are determined by the Technical Rules. This table is for guidance only.
5. Protection functions shaded light green are alternatives for export limiting. Directional power (export) protection monitors power in the export direction not to exceed the export limit:
   a) directional/reverse power protection is not required under cl. 3.6.10.1(i) where an approved inverter has an agreed connection at its name plate capacity
   b) if an inverter is capable of exceeding the agreed export limit (at all), then directional/reverse power protection is required.
   c) reverse power protection is set and tested with settings taking account of the pickup current in sensing devices. No more sensing allowance can be made other than that required for reliable operation of the protection relay in preventing exported power.
6. Protection functions shaded blue are alternatives for loss of mains protection.
7. Protection functions shaded yellow are alternatives for earth fault protection. The use of overcurrent earth fault protection or neutral voltage displacement depends on the type of the earthing arrangement in the installation (earthed/unearthed). For example, the earth fault overcurrent protection is required in earthed systems.

7.3 3.6.11 Commissioning and testing

As stated, requirements for embedded generators are listed in Attachment 12.

Western Power document "*Detailed customer connection schedules for small generator installations*", Schedule C Part 1 – Commissioning, and Part 2 – Approval to Operate, are templates based on Attachment 12.

7.4 3.6.12 Technical matters to be coordinated

Matters to be coordinated include the general design of the User's facility in accordance with good engineering practice and relevant standards. Some of these issues are beyond the scope of this document. However of particular importance will be the vector grouping and tap range of the connecting transformer and the load and fault ratings of other primary plant such as circuit breakers and switches. These will be the most costly items in terms of the viability of connecting to the network.

7.5 5.3 Power system operation co-ordination responsibilities

The title of this section explains well its purpose. Relevant clauses from this section of the Rules are listed in Table 1 of this document. Obligations of the user in relation to operation and coordination are summarised in Western Power template document "*Detailed customer connection schedules for small generator installations*", Schedule B Part 1 – Operating Procedures and Part 2 –Remote control monitoring and communications.

Appendix 1 - Additional Reference Documents

A.1 Australian and international standards

AS 3010 (2005)	Electrical installations – Generating sets
AS 1359 (1997)	General requirements for rotating electrical machines
AS/NZS 3000	SAA Wiring Rules - in particular sections relating to earthing, clearances and hazardous areas
AS/NZS 4777	Grid Connection of Energy Systems via Inverters
AS 1940	Storage and handling of flammable and combustible liquids
AS 60947.6.2 (2004)	Automatic transfer switches
IEC 60255	Protective relays series of standards