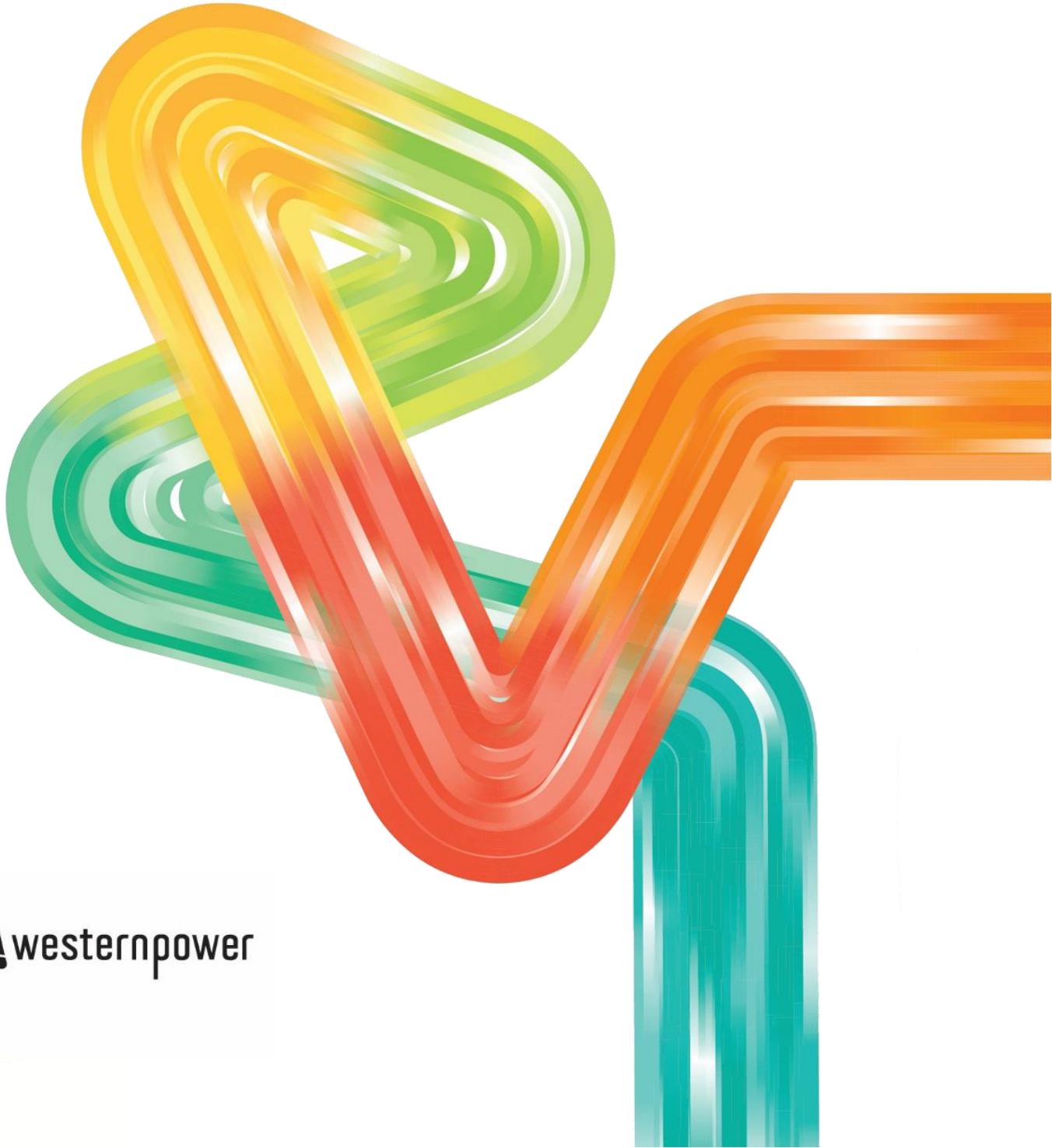
Technical Rules Review

Submission to the Economic Regulation Authority

Public

30 July 2021



westernpower

Contents

List of tables

List of figures

Glossary

Term	Definition
Access Code	Electricity Networks Access Code 2004 established under the Electricity Industry Act 2004
Act	Electricity Industry Act 2004
AEMO	Australian Energy Market Operator
AQP	Applications and Queuing Policy
AS	Australian Standard
CBEMA	Computer Business Equipment Manufacturers Association
DER	Distributed energy resources
DNO	Distribution Network Operator
EMT	Electromagnetic transient
ERA	Economic Regulation Authority
ER P2/6	Engineering Recommendation P2, revision 6 used in Great Britain
FOS	Frequency Operating Standards
GPS	Generator performance standard
HILP	High Impact Low Probability
HV	High voltage
ITIC	Information Technology Industry Council
kV	Kilovolts
LV	Low voltage
MITS	Main Interconnected Transmission System
MVA	Megavolt ampere
MW	Megawatt
NATA	National Association of Test Laboratories
NCR	Normal Cyclic Rating
NEM	National Electricity Market
NER	National Electricity Rules
NETS	National Electricity Transmission System
NFIT	New facilities investment test
NTC	Network Technical Code
RRST	Rapid response spare transformer
SQSS	Security and Quality of Supply Standards

SWIS	South West Interconnected System
TNO	Transmission Network Operator
UFLS	Under-frequency Load Shedding
WEM	Wholesale Electricity Market
WEM Rules	The Wholesale Electricity Market Rules established under the Electricity Industry (Wholesale Electricity Market) Regulations 2004 (WA)

Executive summary

The Western Australian energy sector has been facing significant change over the last decade, driven by the widespread uptake of customer owned rooftop PV systems, changes in the generation mix towards more renewable generation (displacing fossil fuelled generators), and new technologies such as energy storage solutions, stand-alone power systems and microgrids.

Whilst a transition to renewables in the generation mix creates more opportunities for low cost and low emissions energy for Western Australians, the sometimes irregular nature of these sources can pose challenges for us at Western Power, in managing our assets and maintaining the reliability and security of the network.

To better plan and manage the changes in the energy sector, and deliver a more affordable, reliable and sustainable energy for our future, in March 2019 the Energy Minister Bill Johnston, announced the State Government's Energy Transformation Strategy. Their vision is, "to provide safe, secure, reliable, low-emission power to Western Australian households and business at the lowest sustainable cost, while allowing new technology to connect and giving people more control over their electricity use,"

To support the State Government's Energy Transformation Strategy, community expectations and changes in the energy market, Western Power are proposing amendments to the Technical Rules.

The Technical Rules are a set of technical requirements for the planning, design, operation and performance of the South West Interconnected System (SWIS). They also provide performance and technical specifications for user equipment connection to the network, facilitating the secure and reliable supply of power for customers in the SWIS.

As per Chapter 12 of the Access Code, Western Power is responsible for the development and application of the Technical Rules, with the Economic Regulation Authority (ERA) playing a key role in approving and publishing the Technical Rules.

Since the Technical Rules commenced on 1 July 2007, except for a mandatory review in 2011 under section 12.56 of the Access Code, changes and updates to the Technical Rules have been infrequent and relatively minor.

A review of the proposed amendments began in January 2020. For the review, Western Power established a working group which included Western Power Engineers, Western Power's consultants (GHD Advisory), the Australian Energy Market Operator (AEMO), Energy Policy WA and the ERA as an observer.

Through the review, Western Power considered more than 100 individual issues that ranged in scope from interpretational issues associated with a single clause to gaps that required the redrafting of significant section of the Technical Rules. All chapters of the Technical Rules and Attachments were considered in the review.

Customer forums were held in June 2021 to create awareness on the proposed changes and drafting and seek feedback to ensure that the proposed changes to user obligations, were fair and reasonable, and fit for purpose. Invitees included residents, land developers, retailers, businesses, local governments, government trading enterprises, electricians, consultants and service providers, large distribution connected generators, select transmission connected generators, AEMO, Energy Policy WA and the ERA.

This submission and the accompanying proposed Technical Rules drafting represents the culmination of the Technical Rules review process. The changes proposed, if accepted, should ensure customers continue to receive reliable and secure power.

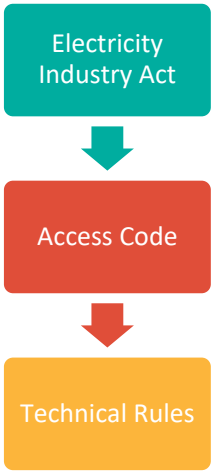
The proposed amendments to the Rules will:

- Align with the requirements of Wholesale Electricity Market Rules (WEM Rules) amendments and the government policy decisions by Energy Policy WA.
- Clarify and update the roles and responsibilities for Western Power, AEMO and Users (loads and generators connected to the South West Interconnected Network).
- Provide improved clarity on system performance standards.
- Introduce system performance standards for stand-alone power systems and disconnected microgrids.
- Improve the network investment planning principles and criteria.
- Facilitate easier connection of inverter-based generators, loads and energy storage systems through the introduction of clearer and more suitable performance standards and technical requirements.
- Improve compliance requirements for Users and reduce exemption requirements.
- Improve operational planning and coordination of efforts with AEMO.

Western Power requests the ERA, with the support of the Technical Rules Committee, consider this request to change the Technical Rules.

1. Introduction & background

The Technical Rules are a key regulatory and technical document that governs the Western Power network. They stipulate the requirements that facilitate the secure and reliable supply of power for customers in the southwest of Western Australia.



Technical Rules provide the standards, procedures and planning criteria governing the design, construction and operation of a covered electricity network and the standards for the facilities, loads and generators that connect to the network to meet reliability, power quality and safety standards.

The Technical Rules are provided for in Chapter 12 of Electricity Networks Access Code 2004 (the Access Code), which in turn was established in accordance with Part 8 of the *Electricity Industry Act 2004* (the Act).

The objectives of the Technical Rules are outlined in section 12.1 of the Access Code. These are that the Rules:

- are reasonable; and
- do not impose inappropriate barriers to entry to a market; and
- are consistent with good electricity industry practice; and
- are consistent with relevant written laws and statutory instruments.

Section 12.5 of the Access Code also clarifies that where a contract for services provided by means of a covered network is inconsistent with the Technical Rules for that network, then the Technical Rules prevail unless section 12.4A of the Access Code applies[1] or an exemption from the Technical Rules granted under section 12.34 or 12.41 of that Access Code affects that contract.

The Access Code objective is “to promote the economically efficient investment in and operation of and use of, networks and services of networks in order to promote competition in markets upstream and downstream of the networks”.

[1] Section 12.4A relates to the point of interconnection between a non-covered network and a covered network.

1.1 Purpose of the Technical Rules review

Since commencing on 1 July 2007 and, except for a mandatory review under section 12.56 of the Access Code in 2011, the Technical Rules have been subject to infrequent and relatively minor changes. Meanwhile, the characteristics of the SWIS where the Technical Rules apply has been changing. Changes have been driven by:

- Connection of significant amounts of inverter based generation (wind and solar farms), and
- Increasing levels of distributed energy resources (DER), including rooftop photovoltaic (PV) systems, behind-the-meter storage and electric vehicles.

The changing technical characteristics present challenges that must be met to deliver a secure and reliable supply of electricity to customer. Addressing these challenges requires:

- Effective coordination between Western Power and AEMO,
- Robust network planning criteria,
- Clearly defines roles and responsibilities for Users, Western Power and AEMO,
- Revisions to the User technical requirements and the processes used to assure compliance with those requirements,
- Revision of the Technical Rules to address technology bias and clarify requirements for new technologies including electricity storage facilities, microgrids and stand-alone power systems.

In response to changes on the way the power system and network is used, broader policy and regulatory reforms have also been or are being progressed. Boarder policy and regularly reforms that changes proposed of the Technical Rules seek to align with include:

- Changing the governance of WEM Rules and Technical Rules
- Introduction of a constrained access market (likely from 2022)
- Re-design of reserve capacity and ancillary service markets
- Changing metering and settlement requirements
- Introduction of a reliability and security framework with Energy Policy WA (State Government) taking the role of coordinator

The purpose of the Technical Rules review is to:

- Respond to the rapidly changing characteristics of the SWIS
- Address legacy issues
- Achieve better alignment with broader policy and regulatory reforms
- Establish a refreshed and robust starting point following regulatory changes that allow anyone to request a rule change

In undertaking the Technical Rules review and developing the changes proposed via this submission, Western Power has considered addressing the matters above and the solutions that align with the Technical Rules objectives as outlined in section 12.1 of the Access Code.

1.2 Review process

Over the past year and a half, Western Power has undertaken a comprehensive review of the Technical Rules. The review considered more than 100 individual issues that ranged in scope from interpretational issues associated with a single clause, to gaps that required the redrafting of significant section of the Technical Rules. All chapters of the Technical Rules and Attachments were considered in the review.

Western Power used a systematic approach to reviewing the Technical Rules. Sections of the Technical Rules that covered similar topics were grouped into a series of work packages. For each work package, potential issues were identified based on:

- Data in Western Power's existing issue register – an internal document where issues with clauses or sections of the Technical Rules are recorded. Issues identified in the register date back to 2007.
- Records of exemptions from the Technical Rules.
- The requirement for updates to align with broader policy and regulatory reforms
- A review of contemporary standards that suggest a potential gap or misalignment in requirements compared with other jurisdictions.
- Input provided by AEMO.

A series of 'issues' and 'solutions' workshops were then conducted to:

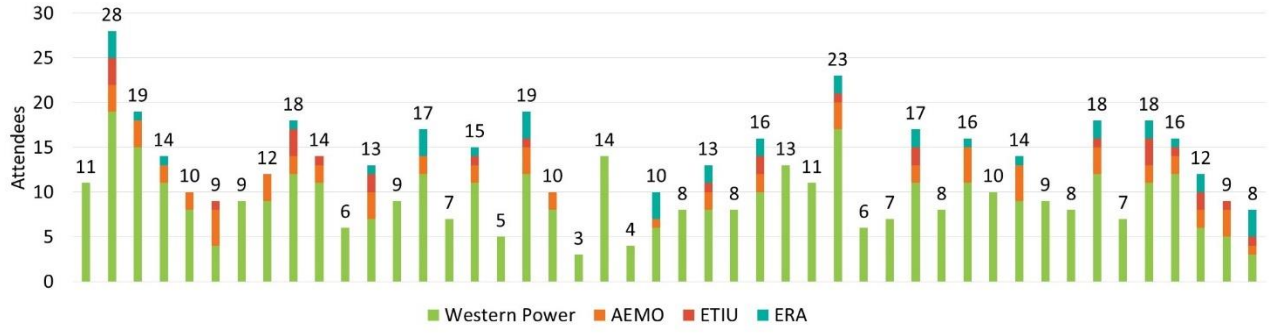
1. Confirm whether identified issues required solving through this Technical Rules review
2. Identified any additional issues that should be addressed through the review.
3. Present and test options addressing the identified issue or issues, including 'no change' options where appropriate.
4. Select the preferred option and clarify the reasons for selection of the preferred option.

Four organisations were invited to participate in the workshops. The organisations and the capacity in which they participated was as follows:

- Western Power (active participant, decision maker)
- AEMO (active participant)
- Energy Policy WA (observer)
- Economic Regulation Authority (the ERA) (observer)

Through the course of the review, 66 people across the four organisations were involved in 46 facilitated workshops and discussions between February 2020 and April 2021 (Figure 1-1).

Figure 1-1: Number of attendees at facilitated discussions



1.3 User consultation

Several of the proposed changes will directly affect Users connected or seeking to connect to Western Power's systems. This includes:

- Re-organisation of Chapter 3 requirements to facilitate navigation.
- Introduction of generator performance standards consistent with the WEM Rules for large generating systems (>5 MVA).
- Updates to the generator performance standards for small generating systems (≤5 MVA)
- Remove technology gaps (inverter connected generator, energy storage systems) and ambiguity for loads.
- Clarification on technical requirements that reduce the need for exemptions (e.g., main switch requirements, compliance and monitoring obligations).
- Alignment of requirements for remote monitoring with other jurisdictions and with revised technical requirements for voltage and reactive power control.
- Adoption of updated Australian Standard requirements for inverter connected small generating systems.
- Simplify protection requirements, including grouping these requirements into a single section.

Western Power held two User forums in June 2021 and invited submissions for a two week period following the forums.[2]

- 69 participants attended the user forum focused on large generating systems on 9 June 2021.
- 71 participants attended the user forum focused on small generating systems on 10 June 2021.

No requests for modifications or changes in the approach were received in response to Western Power's invitation. As such, changes reflected in this submission reflect those changes outline in the User forums.

1.4 Outcomes of the review

This submission represents the culmination of the Technical Rules review process. The changes proposed, if accepted, should ensure customers continue to receive reliable and secure power. Changes when made will also:

- Enable higher levels of decarbonisation on the SWIS through enhanced performance standards.
- Supporting cost-efficient decentralisation of power supplies by facilitating disconnected microgrids and stand-alone power systems.
- Provide for efficient network development guided by enhanced planning criteria.
- Deliver additional grid robustness and resilience by facilitating energy storage technologies.
- Allow for more efficient grid connection process with fewer exemptions required.

Many of the changes will clarify, simplify and improve the way Western Power manages and invests in the SWIS. Advantages for Western Power (many of which flow on to Users) include:

[2] Both forums covered general changes for Users and the requirements for loads.

- Providing clear investment signals for Western Power as the improved transmission and distribution system planning criteria will be more flexibly respond to changes in demand, more fully incorporate risk-based planning methods, and provide for clearer outage restoration times.
- Providing clear technical requirements for stand-alone power systems and battery connections, thus provide clarity for Western Power investments and customer connections.
- Providing new technical requirements for disconnected microgrid performance, operations and management and, as a result, close the current gaps in planning, design and operations of these aspects of the network.
- Improving internal and external processes with greater alignment with WEM Rules and Access Code.
- Improving the customer experience through the new and improved classifications for inverter based distribution generator connections.
- Improving the visibility, reliability and security of the system through the revised generator performance standards for greater than 5 MVA generators. The changes will also improve customer experience.
- Improving the monitoring and reporting of compliance to the Rules thus improving network safety, reliability and security.
- Enhancing the working relationship with AEMO, as the review will resolve several roles and responsibility overlaps with AEMO including – planning, system restart, underfrequency load shedding, voltage management and outage planning.

1.5 Transition to updated Technical Rules

Changes to the Technical Rules come into effect on the date the changes are approved by the Economic Regulation Authority.

All customer connection applications and Western Power projects initiated post the approval date must adhere to the new Rules.

Customer connection applications and Western Power projects that commenced prior to the approval of the Technical Rules will be assessed on a case by case basis. In determining whether the new requirements should be met for these in-progress applications and projects, Western Power will consider the degree of maturity of the project and readiness for the proposed change when determining whether the revised Technical Rules should apply. Western Power will employ fair judgement and will be reasonable in its determinations.

Western Power notes that proposed changes to grandfathering and ongoing suitability clauses (discussed in section 2.6 of this report) provide a framework that recognise prior version of the Technical Rules should continue to apply and introduces a mechanism for revised Technical Rule provisions to be complied with following modifications or for power system performance requirements.

1.6 Terminology used in this report

All references to the Technical Rules are references to the current version of the Technical Rules unless otherwise specified. This convention has been adopted as the clause numbering the updated Technical Rules is subject to change. The current version of the Technical Rules is version 3 from 2016. Previous versions referred to in this submission include version 1 from 2016 and version 2 from 2016.

Where revised clause numbers are referenced, the convention ‘proposed Technical Rules’ is used.

References to large and small generators and generating systems in this report use the proposed new Glossary definitions for large and small generating systems:

- references to large generators in this report mean generating systems with a total rated capacity exceeding 5 MVA, and
- references to small generators mean generating systems with a total rated capacity equal to or less than 5 MVA

These conventions are consistent with proposed changes outlined in section 3 of this report.

1.7 Structure of this document

The remaining structure of this document is summarised in Table 1-1.

Table 1-1: Structure of this submission

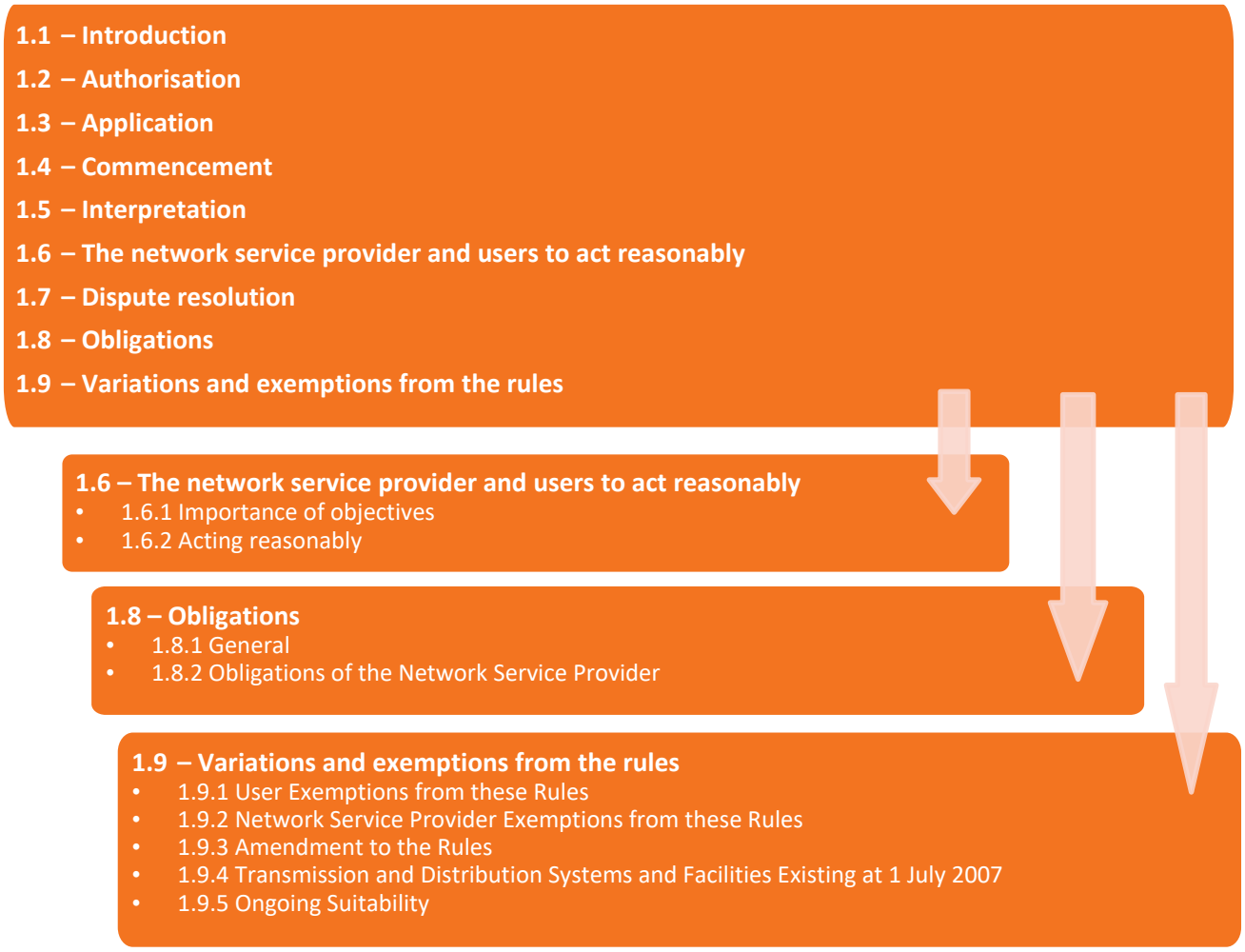
Section of this report	Coverage
Section 2	Changes proposed to chapter 1. This chapter covers general requirements.
Section 3	Changes proposed to sections 2.1 to 2.4. These sections outline the transmission and distribution system performance requirements.
Section 4	Changes proposed to sections 2.5 to 2.8. These sections outline the transmission and distribution system planning requirements.
Section 5	Changes proposed to section 2.9 of the Technical Rules. This section outlines the transmission and distribution system protection requirements.
Section 6	Changes proposed to Chapter 3 of the Technical Rules. This chapter covers User requirements.
Section 7	Changes proposed to Chapter 4 of the Technical Rules. This chapter covers inspection, testing, commission and decommissioning requirements.
Section 8	Changes proposed to Chapter 5 of the Technical Rules. This chapter covers the transmission and distribution system operation and coordination requirements.
Section 9	Changes proposed to introduce a new Chapter 6 of the Technical Rules. A new chapter is required to address requirements for disconnected microgrids and stand-alone power systems.
Section 10	Changes to Attachments to the Technical Rules, and changes spanning multiple chapters.

2. General requirements

General requirements are set out in Chapter 1 of the Technical Rules. This includes general provisions on the authorisation, application, commencement and interpretation of the Technical Rules. Sections 1.6 to 1.8 cover requirements to act reasonably and mechanisms for dispute resolution, as well as general User obligations and Network Service Provider obligations. Finally, section 1.9 covers variations and exemptions from the Technical Rules.

Chapter 1 also covers exemptions and variations from the Technical Rules as well as ongoing suitability requirements.

The structure of these sections of the Technical Rules is illustrated in the following diagram.



The limitations, issues and proposed solution to address issues that have been identified through the Technical Rules review process are discussed in the sub-sections that follow.

2.1 Authorisation

Clause 1.2 sets out authorisations of the Technical Rules and aligns with Chapter 12 of the Access Code. This clause provides a list to guide readers regarding the matters addresses by the Technical Rules.

2.1.1 Current issue

Changes proposed in this request need to be reflected in an updated list of authorisations. The following issues with the current list were identified:

- Lack of alignment with recent updates to Chapter 12 and Appendix 6 of the Access Code.
- The coverage of disconnected microgrids and stand-alone power systems is not clear.
- Better linkage between Technical Rules and WEM Rules is required. Some authorizations are required to clarify requirements for coordination between Western Power as the Network Service Provider and AEMO.
- As discussed in section 10.4 of this report, references to System Management need to be updated to reflect transfer of relevant functions to AEMO.

2.1.2 Solution options & preferred solution

Western Power considered options to address the above concerns, which included:

a) Updates to address the issues identified above.

b) No change.

Western Power proposes changes consistent with option a). The proposed changes clarify the authorisations of the Technical Rules, align with updates to the Access Code, clarify the coverage of disconnected microgrids and stand-alone power systems, and clarify coordination between AEMO and Western Power. Minor wording amendments also improve clarity.

2.2 Application of the Technical Rules

Section 1.3 of the Technical Rules sets out the application of the Technical Rules. Under current drafting, the Rules apply to the Network Service Provider in its role as the owner and operator of the transmission and distribution system, System Management in its role as operator of the power system, and Users of the transmission or distribution system.

2.2.1 Current issue

The application of the Technical Rules needs to be updated in order to reflect the following changes:

- Coverage of stand-alone power systems and disconnected microgrids.
- Movement of the System Management role to AEMO.

Stand-alone power systems and disconnected microgrids that are owned by the Network Service Provider legally form part of the covered network and the SWIS even when electrically not connected the broader transmission or distribution sections of the SWIS. Clause 1.3(a) of the Technical Rules provides that references to the Network Services Provider refers to the provider for the SWIS and is the Electricity Corporation, a statutory corporation established by the Electricity Corporations Act (2005) (WA). As such, coverage of these systems is provided for under the current drafting. However, as these systems are new to the Technical Rules and to avoid any confusion, Western Power considered specifying these systems in clause 1.3.

2.2.2 Solution options & preferred solution

Western Power considered the following options for addressing the above concerns:

a) Expand clause 1.3(b)(1) and (3) of the Technical Rules to include disconnected microgrids and stand-alone power systems owned by the Network Service Provider.

b) Define the role for AEMO clause 1.3(b)(2) of the Technical Rules and cross-reference to clause 2.1A in the WEM Rules, which outlines AEMO obligations.

c) Options a) and b).

d) No change.

Western Power has proposed changes that align with option c). The changes will align with updates to the Technical Rules to cover disconnected microgrids and stand-alone power systems (discussed in chapter 8).

The changes proposed to reflect the role of System Management moving to AEMO align with other changes proposed in section 10.4 of this rule change request and align with changes made in higher-order legislation and regulations such as the *Electricity Industry Act* and the WEM Rules.

The retention of the reference to AEMO in this clause does not place any obligations on AEMO. Rather, it clarifies for all users that AEMO has a role within the Technical Rules context. AEMO's role is set out in specific clauses. AEMO does not have any direct obligation under the Technical Rules. However, several clauses require either the Network Service Provider or other Users to advise AEMO of changes.

2.3 Network service provider obligations

The general obligations for the Network Service Provider that are covered by the Technical Rules are set out in section 1.8.2. This section sets out general obligations with more detailed obligations related to specific topics provided in relevant chapters of the Technical Rules.

2.3.1 Current issue

Changes proposed in this request need to be reflected in an updated list of obligations for the network service provided. Specifically, updates are required to cover the following gaps where associated changes are made:

- The inclusion of disconnected microgrids and stand-alone power systems.
- Providing for the review and assessment of generator performance standards.
- Providing a requirement to maintain a register of performance requirements for User facilities.

A gap in the coverage for recovery or contingency plans also exists in clause 1.8.2 of the Technical Rules. Inclusion of a requirement in this clause would make current practice more transparent and ensure these plans are kept up to date.

2.3.2 Solution options & preferred solution

Western Power considered options to address the above concerns, and the proposed solution addresses each of the issues. The proposed solution is consistent with other changes proposed, removes potentially confusing terminology and improves the transparency of practice.

2.4 Variations and exemptions

Sections 1.9.1 and 1.9.2 cover variations and exemptions from the Technical Rules. There are two broad types of exemptions from the Rules:

- Clause 1.9.1 covers User Exemptions from the Rules and provides that a user, applicant or controller may apply to Western Power for an exemption from one or more requirements of its Technical Rules.
- Clause 1.9.2 covers Network Service Provider Exemptions from the Rules. It allows the Network Service Provider to apply to the ERA for an exemption from one or more requirements of the Technical Rules for itself and all applicants, users and controllers of its network.

Collectively, the purpose of these clauses is to provide for compliance with the Technical Rules where it's not economical or technically feasible to meet the requirements of the rest of the Technical Rules.

2.4.1 Current issue

Several potential points of clarity were raised through the course of the Technical Rules review. These included:

- Whether an exemption is needed under the Technical Rules if a generator agrees to a negotiated generator performance standard under the Technical Rules that falls between the minimum and ideal requirements?
- Whether an exemption was needed under the Technical Rules if generators agree on generator performance standards under the WEM Rules?
- Identification of a gap whereby the ERA maintains a list of exemptions and variations granted under the Access Code and in accordance with clause 1.9 of the Technical Rules. However, not provision is made for the Network Service Provider to maintain similar records.

2.4.2 Solution options & preferred solution

Western Power considered several changes to address these issues. The preferred solution incorporates:

- Drafting notes that clarify no exemption is required for a generator performance standard negotiated and agreed under the Technical Rules where the agreed outcome for each standard is within the minimum and ideal generator performance standard.
- A clause explicitly stating that no exemption is needed for a generator that negotiates and agrees on generator performance standards under the WEM Rules.
- A new clause requiring the Network Service Provider to record exemptions or variations in its own right.

The proposed changes make the variation and exemption provisions clearer and will facilitate better tracking of these arrangements by the Network Service Provider going forward. Further, Western Power already records exemptions and variations so the change does not alter existing practice.

2.5 Amendment to the Technical Rules

Section 1.9.3 of the Technical Rules provides clauses relating to amendment of the Technical Rules by two mechanisms:

- Clause 1.9.3(a) relates to rule changes made under the Access Code that will now be subject to the new Technical Rule change process.
- Clause 1.9.3(b) provides a mechanism for User's to prompt changes to the Technical Rules. It allows Users to seek a change via the Network Service Provider where the Technical Rules uses an equal or less onerous standard than provided for in international or Australian Standard. Clause 1.9.3(b) also requires submissions be supported by a report from a competent body, approved by the Australian

National Association of Test Laboratories (NATA), which confirms that the requirements of the proposed International or Australian Standards are equal or more onerous to those of the specified Standard.

2.5.1 Current issue

The Technical Rules change management process has been modified so that any person can submit a proposal to amend the Technical Rules. Previously, clause 1.9.3(b) was the only mechanism through which Users could seek changes to the Technical Rules because the Network Service Provider was the only entity able to submit rule changes to the ERA.

The requirement to support a submission to the Network Services Provider under clause 1.9.3(b) with a report from a competent body, approved by the Australian National Association of Test Laboratories (NATA), is not workable. NATA as labs can only issue reports which they are accredited to provide. To provide a report in the format required for the clause would contravene the NATA rules and regulations for laboratory accreditation and therefore has never been used.

2.5.2 Solution options & preferred solution

Western Power considered the following options to address the above issues:

a) Updating clause 1.9.3 to refer to the new Technical Rule change process outlined in the Access Code.

b) Deleting clause 1.9.3(b) on the basis that all Users can submit requests for changes to the Technical Rules to the Technical Rule Committee.

c) Delete the requirement to provide a NATA approved report in clause 1.9.3(b).

d) No change.

Western Power has proposed changes consistent with option b). All Users can now submit a request for changes to the Technical Rules, including for the types of changes contemplated in clause 1.9.3(b); as such, the clause is no longer needed.

Further, Users who would like to use an alternative international or Australian Standard from those specified in the Technical Rules can apply for an exemption under clause 1.9.1. Western Power notes, in the past, where customers were unable to comply with a technical requirement (e.g., deviation from AS 4777) but believed that another standard was appropriate, they have applied for an exemption with a supporting NATA report and in the past Western Power has accepted this.

The references to clauses in the Access Code remain correct following the changed Technical Rule change process; as such, no change to clause 1.9.3(a) is required.

2.6 Grandfathering and ongoing suitability

Section 1.9.4 of the Technical Rules relates to transmission and distribution systems and User facilities existing on 1 July 2007 and is intended to avoid non-compliance issues that would otherwise arise for the equipment installed before commencement of the Rules that may otherwise apply. The current drafting provides a mechanism through clause 1.9.4(b) for this equipment to be brought up to compliance with any updated Technical Rule requirements when it is upgraded or modified.

Section 1.9.5 covers the ongoing suitability of equipment deemed by section 1.9.4 to comply with the Technical Rules. It places an obligation on Users and the Network Service Provider to ensure the equipment covered by section 1.9.4 are monitored and continue to meet safety and suitability requirements as the conditions of the power system change.

2.6.1 Current issue

Issues identified with section 1.9.4 of the Technical Rules include:

- Gap for equipment that is installed after 1 July 2007, such that there are no clear grandfathering provisions as the Technical Rules continue to change.
- Lack of clarity on the application of the provisions to the replacement of individual components or assets within a sub-system.
  - For example, where protection relays are replaced, but the overall sub-system performance is limited due to other components, it is unclear if further upgrades to the system or sub-system are required to meet revised Technical Rule requirements (as applicable).
  - No consideration to the materiality of the change is given. Following on from the previous point, where part of the system is replaced but the technical limitations persist due to other components, there is no guidance on if the materially of the change should be considered to make further upgrades to meet Technical Rule requirements.
- The terms “modified” and “upgraded” are not defined in the Glossary.
- The current wording of 1.9.4 implies an exemption to all of the Technical Rules, which is not appropriate. For example, current procedural rules should be applied for all Users, and not just Users connected post 1 July 2007.

Issues identified with section 1.9.5 of the Technical Rules include:

- There is no mechanism for the Network Service Provider to require a User to:
  - Demonstrate compliance or that their equipment is being monitored on an ongoing basis
  - Upgrade or modify their equipment to ensure power system performance standards can continue to be met.
- Clause 1.9.4 does not acknowledge clause 1.9.5, which creates a window for the User facilities to be deemed to comply with the monitoring requirements in clause 1.9.5.

2.6.2 Solution options & preferred solution

The purpose of grandfathering clauses is to recognise historical compliance. These provisions avoid the cost of unnecessary upgrades to equipment following a change to the Technical Rules. However, grandfathering is not intended to avoid upgrades when it comes time to replace the equipment. Nor is it intended to create operability issues, power system safety and security concerns by allowing unsuitable facilities to remain connected.

Ongoing suitability clauses work together with grandfathering clauses to ensure the power system needs are not deprioritised over the desire to avoid the cost of necessary upgrades to outdated facilities while at the same time avoiding the cost of unnecessary upgrades.

Western Power considered options that strike a balance between recognising ongoing historical compliance and providing a mechanism to require necessary upgrades to outdated technology. The preferred solution features:

- Broadening section 1.9.4 so that it covers and provides for appropriate grandfathering arrangements for all facilities and equipment covered by the Technical Rules (not just facilities and equipment connected at 1 July 2007). The additional sub-clause covering facilities installed after 1 July 2007 clarifies the version of the Technical Rules that applies is that in force at the time the facility or equipment was commissioned, or a connection agreement was reached (as applicable).

- Modify the existing clause that requires upgraded or modified equipment installed at 1 July 2007 to comply with the updated version of the Technical Rules so that it applies to all equipment covered by the Rules.
- Introduce a requirement for the Network Service Provider to develop, maintain and publish guidelines to inform Users and provide examples of upgrades and modifications covered by clause 1.9.4. The purpose of this guideline is to provide guidance where the terms 'upgraded' or 'modified' could be ambiguous. This clause also addresses 'relevant generator modifications', a term introduced in changes proposed to Chapter 3 of the Technical Rules (see section 6.3.3), which is analogous to the same term used in the WEM Rules.
- Introduce provisions that allow the Network Service Provider to require Users to:
  - demonstrate their equipment is being monitored in accordance with clause 1.9.5(a) and
  - upgrade or modify their equipment to ensure power system performance can continue to be met.

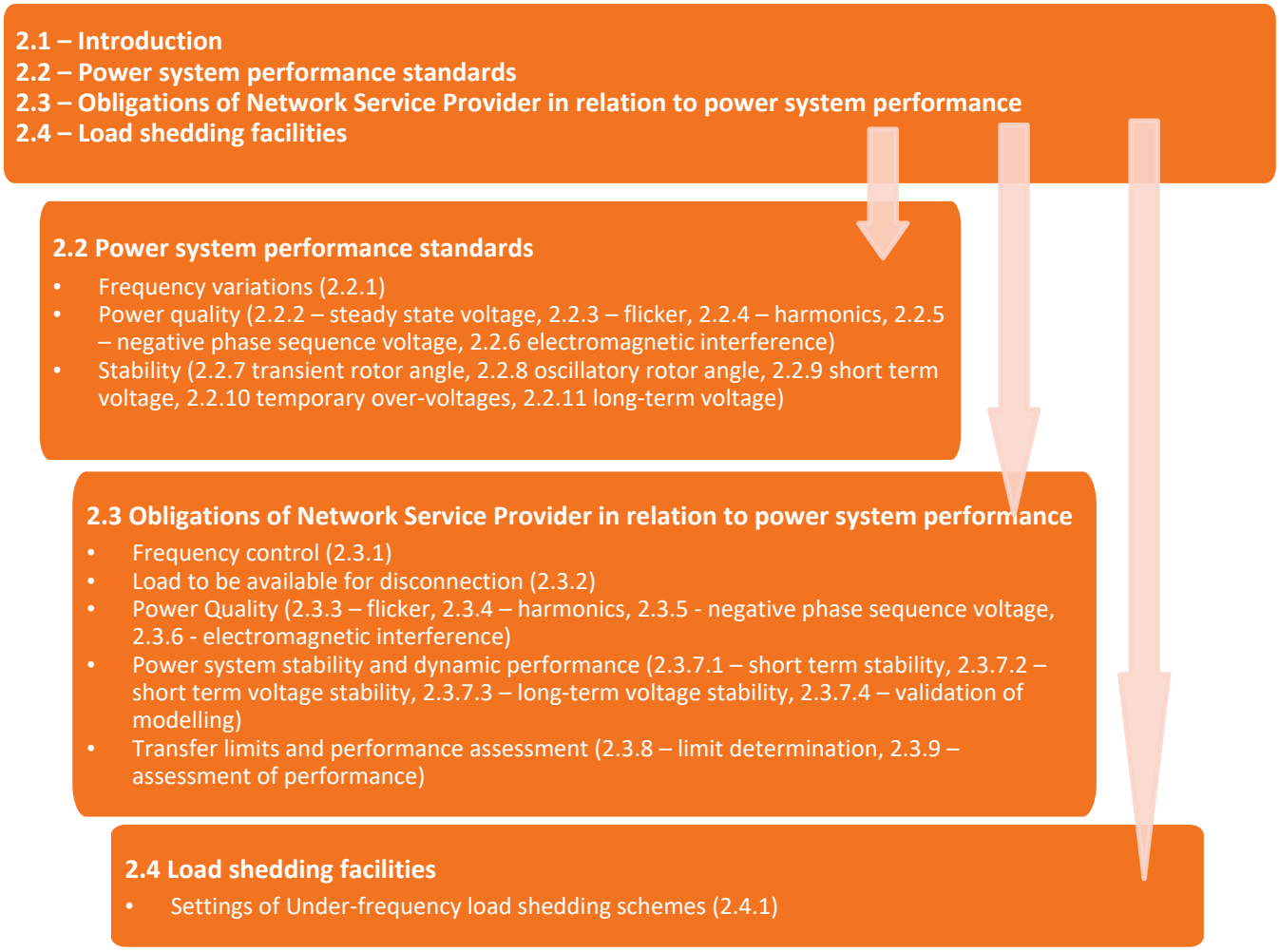
  User's equipment can significantly affect the ability for power system performance requirements to be met. Western Power considers there are circumstances where the most efficient way to meet power system performance requirements is for Users to upgrade their legacy facilities. On this basis, it is prudent to have a mechanism allowing the Network Service Provider to require a User to upgrade legacy facilities and for the Network Service Provider to have a requirement to give a clear rationale for any such requirement.

3. Transmission and distribution system performance

The system performance standards for the transmission and distribution systems are defined in section 2.2 of the Technical Rules, and obligations are placed on Western Power as the Network Service Provider to meet those performance standards in section 2.3. Section 2.4 of the Technical Rules describes functional requirements for the automatic under-frequency load shedding (UFLS) scheme relied upon to control frequency following multiple contingency events.

For the SWIS, system performance standards are also provided for in the WEM Rules. The standards outlined the Technical Rules and associated Network Service Provider obligations should align with and not replicate the obligations in the WEM Rules.

The current structure of sections 2.1 to 2.4 of the Technical Rules is illustrated in the following diagram.

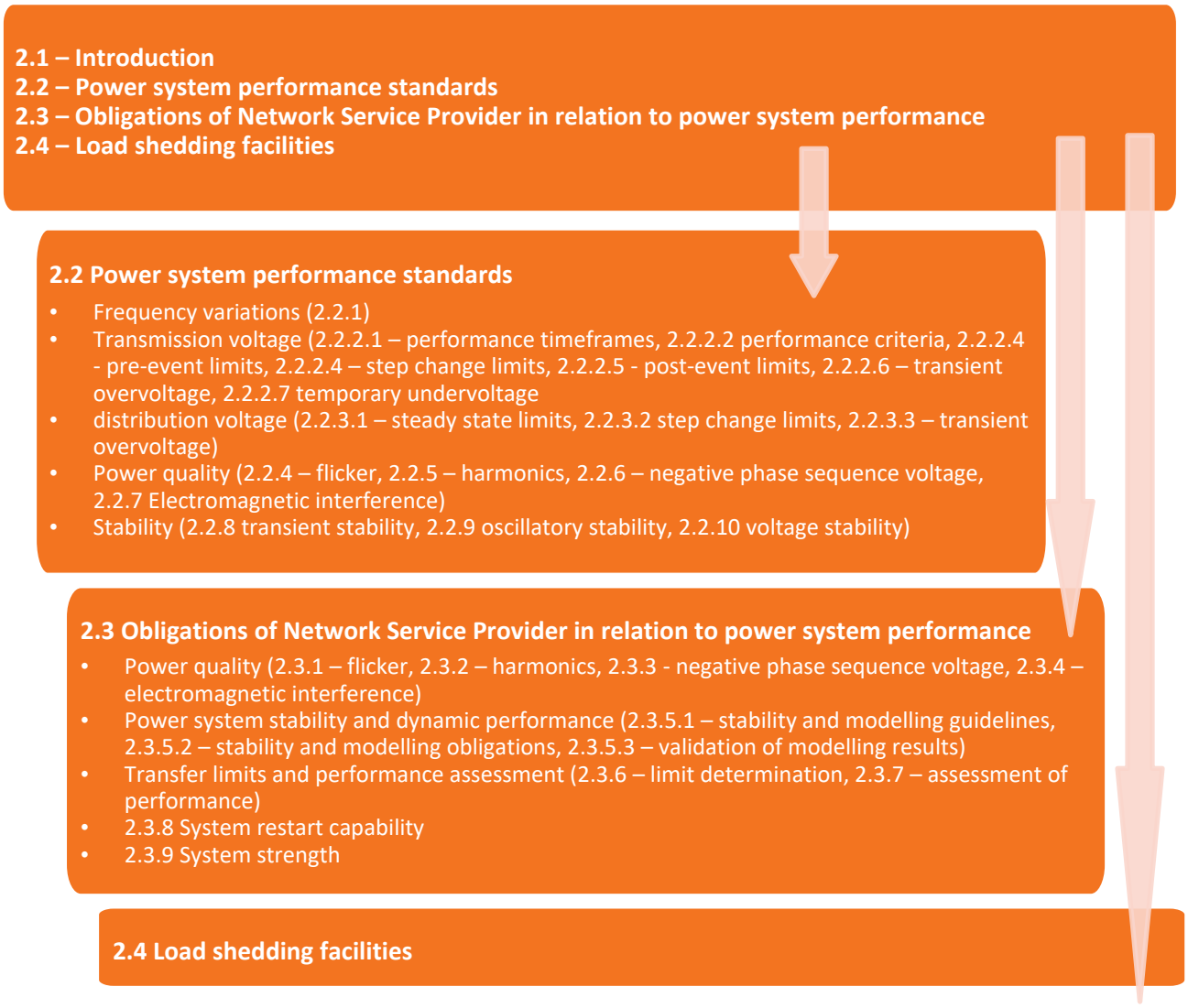


The limitations, issues and proposed solutions to address problems that have been identified through the Technical Rules review process are discussed in the sections that follow.

3.1 Structural revision of sections 2.1 to 2.4 of the Technical Rules

The proposed solutions to the issues identified through the Technical Rules maintain a similar high-level structure to these sections of the Technical Rules. However, they do necessitate some revision and rearrangement of the clauses within sections 2.1, 2.2, 2.3 and 2.4.

The revised structure is illustrated in the following diagram. The reasons for the changes are explained in the subsections that follow.



3.2 Purpose and applicability of the system performance standards

The introduction of chapter 2 of the Technical Rules (clause 2.1) describes the coverage of the section:

> *This section 2 describes the technical performance requirements of the power system, and the obligations of the Network Service Provider to provide the transmission and distribution systems that will allow these performance requirements to be achieved. In addition, it sets out criteria for the planning, design and construction of the transmission and distribution systems.*

Western Power has identified several issues with the purpose and applicability of the sections describing the power system performance standards. Specifically:

- The applicability of the system standards in operating and planning timeframes is not always adequately distinguished.
- It is currently unclear whether Users should expect the system performance standards to be continually achieved or under what conditions system performance may fall outside the limits specified in the standards.

- The option for Users connecting to the network to negotiate alternative system standards that might logically appear in this section of the Technical Rules does not appear.

These issues are addressed in turn in subsequent sections.

3.2.1 Applicability of systems standards in operational and planning environments

The applicability of power system performance standards is missing from the Technical Rules. As such, it is not possible to understand whether the standards are intended to be those Western Power seeks to achieve when planning the network or if they are the standards that should be delivered when operating the network.

The system standards used when planning a network may be different from the system standards that can be reasonably expected when operating the system. In some instances, the standards used to plan the network are tighter than those that apply in operational timeframes. This approach recognises that in planning timeframes it is not possible to anticipate the range of circumstances that may occur operationally. If more arduous conditions occur during operational timeframes than considered during planning timeframes it may not be possible to stay within the more stringent planning standards.

While the current version of the Technical Rules does not set out different system performance standards for operational and planning timeframes, Western Power typically applies margins when planning the power system to provide confidence that the specified system performance standards will be achieved during operational timeframes.

The provisions in chapter 2 of the Technical Rules should specify limits that are consistent with current practices. Clarifying the purpose of chapter 2 via amendments to clause 2.1 would help readers of the Technical Rules (including Users, AEMO, Western Power and the ERA) interpret subsequent clauses consistently.

In developing the options to address the lack of clear purpose for chapter 2, Western Power considered the following options:

a) The standards are those that Western Power seeks to achieve when planning the network.

b) The standards are those that Western Power seeks to achieve when planning and operating the network.

In selecting the preferred approach, Western Power considered approaches taken in other jurisdictions. For example, in the UK, the equivalent technical codes are prescriptive about planning and operational performance standards and treat these separate. The Grid Code that applies to the National Grid Electricity Transmission outlines the performance standards in the Planning Code, for example, in PC.4 (Planning Procedures) and PC.6 (Planning Standards), and the operational performance standards are outlined in the Operating Codes.

In the NEM, the NER provides both operational and planning standards together (i.e. there is no distinction). However, network planning standards are further articulated through licence conditions.

Western Power recommends option b) that the standards are those that Western Power seeks to achieve when planning and operating the network. A new paragraph has been added to clause 2.1 to enact this change. In addition, where appropriate, changes have been recommended to other clauses to:

- Differentiate between planning and operational limits, and
- More clearly define the boundary between distribution and transmission system standards.

3.2.2 Applicability of system standards to User connections

In the NEM, clause S5.1a.1 of the NER indicates to registered participants (i.e., parties connecting to the system) how the system standards set out in that section of the NER should be interpreted. That clause specifically clarifies that system standards may not be fully complied with at the connection point under all circumstances.[3]

The drafting of the NER arguably helps manage the expectations of connected and connecting parties regarding power system performance. It facilitates subsequent negotiations around the system standards at the connection point between the Network Service Provider and the connecting party.

In contrast, the Technical Rules are silent on how the system standards should be interpreted as applying across the network.

In reviewing the system standards in the Technical Rules, Western Power considered whether a similar clause to that which applies in the NEM should be adopted in the revised Technical Rules and under what conditions the system standards should be met.

On the basis that it would provide greater clarity for network users regarding the performance they should expect at the connection point, Western Power proposes revising section 2.1 of the Technical Rules to include an explicit statement that the network user should not rely on the system standards being achieved under all circumstances.

While the NER remains silent on the circumstances under which registered participants should not expect to rely on the system standards being fully complied with at a connection point, the clause S5.1a.1 of the NER does provide that:

> *"…a Registered Participant should expect to be reasonably informed of circumstances where the standard of supply at its connection points will not conform to the system standards."*[4]

Typically, Network Service Providers and AEMO discharge this responsibility through the connection agreement process.

Western Power has considered how network users may be afforded similar conditions under the Technical Rules. Network users are more likely to experience a standard of supply that does not conform to the system standards (as proposed in this Rule Change request) during system restarts and following contingency events. Therefore, the revisions proposed to clause 2.1 include the following statement:

> *A User should not rely on power system performance standards being fully complied with at a connection point under all circumstances. During the process of restoring the power system from a system shutdown or major supply disruption, the power system may not meet the power system performance standards defined in section 2.2.*

3.2.3 Negotiating alternative system standards

In other jurisdictions, there are provisions that allow connecting parties to negotiate standards at their connection point that differ from the system standards. For example, in the NEM clause S5.1a.1 of the NER states:

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[3] S5.1a.1 of the NER states: "A *Registered Participant* should not, by virtue of this schedule, rely on *system standards* being fully complied with at a *connection point* under all circumstances. However, a Registered Participant should expect to be reasonably informed of circumstances where the standard of *supply* at its *connection points* will not conform to the *system standards*."

[4] S5.1a.1 of the NER.

Except for standards of frequency and system stability, a Registered Participant should have the opportunity to negotiate or renegotiate relevant terms of a connection agreement (including relevant charges), to improve the standard of supply to the level of the system standard.

In the NEM, the negotiation of standards is typically done through the connection process.

While the technical requirements of User facilities are covered in chapter 3 of the Technical Rules, chapter 3 technical requirements aim to achieve the system standards set out in chapter 2. There is currently no explicit process included in the Technical Rules that allow a User to seek to negotiate a variation to the system standards at their connection point that differs from the system standards specified in chapter 2 of the Technical Rules. However, there is an exemption process defined in chapter 1 of the Technical Rules that could be used for this purpose.

Western Power considered the following options to clarify the potential to vary the system standards applicable to a particular User's connection:

a) Introducing a new sub-clause in clause 2.1 of the Technical Rules to allow users to negotiate a higher or lower standard provided this would not impact other network users. The cost associated with delivering a higher standard at the connection point should be borne by the User seeking the higher performance standard.

b) Reviewing the exemption provisions in clause 1.9.2 of the Technical Rules to confirm that the provisions provide an appropriate means of negotiating standards that differ from the system standards specified in chapter 2.

Option b) was identified as the preferred approach. A review of the exemption process did not identify any change was required to allow the existing exemption process to the utilised if needed to vary the system standard experienced by a User.

3.3 Frequency operating standards

The system performance frequency operating standards (FOS) are intended to describe the range within which Users can expect the frequency of the power system to remain. The FOS should include different ranges that indicate how frequency may vary following contingency events and the expected trajectory and timeline for recovery of the frequency following contingency events. Clause 2.2.1 of the Technical Rules specifies the frequency variations that may occur in the SWIS, with Table 2.1 specifying the FOS.

3.3.1 Current issue

The FOS are an important input for AEMO in its role as the System Operator. The limits specified in the FOS help define the actions that AEMO may need to take to ensure the secure operation of the SWIS. Actions could include deciding on the type and amount of essential system services required and whether there is a need to adjust generation dispatch to increase the amount of service available.

As part of the broader market reforms, AEMO has led a review of the FOS for the SWIS. The outcome is that the WEM FOS now appears in the WEM Rules. The WEM FOS applies for the intact SWIS and islands, excluding stand-alone power systems, embedded systems (not owned by Western Power) and disconnected microgrids.[5]

[5] Energy Transformation Taskforce, *Revising Operating Standards in the SWIS: Information Paper*, November 2019, p. 10.

If the frequency requirements in section 2.2.1 of the Technical Rules are not amended, there is a risk these requirements will not align with the new WEM FOS arrangements. The requirements would be duplicative and potentially cause confusion.

3.3.2 Solution options & preferred solution

Western Power has considered the following options to address these issues:

a) Amending clause 2.2.1 of the Technical Rules to refer to the FOS outlined in the WEM Rules.

b) Amending clause 2.2.1 of the Technical Rules to specify the same frequency requirements as applies in the WEM Rules.

Western Power recommends changes consistent with option a). Amending clause 2.2.1 of the Technical Rules to refer to the FOS outlined in the WEM Rules avoids duplication and any potential confusion. The WEM Rule FOS would apply to the power system when operating as a single interconnected system or as one or more islanded systems created by disconnecting one or more transmission elements.

3.4 Transmission voltage limits

Controlling the voltage on the transmission network to within acceptable limits is essential to maintaining power system security. It is, therefore, crucial that the acceptable transmission voltage limits are clearly defined to help guide efficient planning and operational decisions.

3.4.1 Current issues

Western Power identified the following issues with the definition of transmission voltage limits in the Technical Rules:

- Voltage limits for the transmission and distribution systems are specified in the same clauses of the Technical Rules making it harder to clearly identify the transmission voltage limits.
- Vague terminology is used that may lead to a lack of consistency in the way the limits are interpreted. Key concerns include:
  - The existing drafting leaves open to interpretation the timeframes over which particular voltage limits needed to be achieved, and over what timeframe the voltage should return to the steady state level following a contingency. For instance, the existing voltage step change limits do not specify the timeframe over which the step change should be measured and what control actions should be assumed to act to keep step changes within the specified limits. It is unclear how transformer tapping and switching of reactive plant is to be considered in assessing compliance with the voltage step change limits.
  - Limits are specified for temporary over-voltages, but there is a lack of information regarding acceptable limits for temporary under-voltages.
  - The specification of voltage step change limits contains superfluous information such as the switching frequencies that are unlikely to be experienced on the transmission system.
- The specification of the same voltage limits for operational and planning timeframes is inappropriate as it does not provide a sufficient incentive in planning timeframes to make prudent investments that will ensure voltage limits can be met in operations timeframes. The range of system conditions that can be experienced in operational timeframes is likely to be more diverse that the conditions studies when making planning decisions in planning timeframes. It is generally appropriate that the limits required to be achieved in planning timeframes are more arduous than those applicable in operational

timeframes. This approach builds sufficient capacity into the power system to cope with the range of conditions faced operationally.

Imprecise specification of voltage performance can impede the ability to monitor and compare actual performance against the system standards. A more precise definition of acceptable voltage limits will allow greater precision in the estimation of transfer limits and should help reduce the need for conservative transfer limits that build in margins that account for uncertainty in the performance requirements.

3.4.2 Solution options & preferred solution

The primary solution adopted was to restructure the Technical Rules, creating section 2.2.2 to specify the transmission system voltage performance standards. The various subsections within section 2.2.2 of the proposed Technical Rules incorporate revisions to address each of the identified issues:

- Section 2.2.2.1 of the proposed Technical Rules specifies the timeline from the occurrence of a disturbance to the return to steady state voltage conditions. The section includes information on the control actions that are likely to be active over each stage of the timeline. The information in this section is utilised in the remaining subsections of section 2.2.2 to provide better clarity regarding the specific voltage performance requirements.
- Section 2.2.2.2 of the proposed Technical Rules provides a definition of the criteria that collectively define unacceptable voltage conditions. The criteria consider both pre-event steady state conditions and conditions following disturbances and link to other subsections to provide additional details.
- Section 2.2.2.3 of the proposed Technical Rules specifies limits that should be achieved in steady state conditions prior to a switching event or credible contingency. This section also provides different steady state limits for planning and operational timeframes.
- Section 2.2.2.4 of the proposed Technical Rules specifies limits on the size of voltage step changes following switching or credible contingency. The voltage step change limits defined in this clause are similar to the voltage step change limits specified in the existing Technical Rules focussing on frequency of switching likely to be experienced on the transmission system. The step change limits specified are also consistent with the limits specified in revision 2 of the Technical Rules. The change removes ambiguity introduced in drafting changes between revisions 2 and 3 of the Technical Rules. This clause provides added clarity regarding how the voltage step change will be measured by referring to the timeframes defined in clause 2.2.2.1.
- Section 2.2.2.5 of the proposed Technical Rules specifies the voltage limits that apply in steady state conditions following a switching event or credible contingency. The pre-event limits are defined with reference to the timeframes defined in clause 2.2.2.1. The post-event steady state limits in planning timeframes are more arduous than those that apply in operational timeframes
- Section 2.2.2.6 and 2.2.2.7 of the proposed Technical Rules specify transient over and undervoltage limits respectively. These requirements are consistent with current practice, so the proposed changes formalise and make this practice more transparent.

The following subsections provide further elaboration of issues with the existing specification of voltage step change limits in the technical rules and how they have been addressed by the proposed revisions in clause 2.2.2.4.

Voltage step change

Section 2.2.2 of the existing Technical Rules sets out the criteria relating to steady state power frequency voltage fluctuations. Clause 2.2.2(b) sets out the limits for voltage step changes resulting from switching

operations. Table 3-1 (below) replicates Table 2.2 in the Technical Rules that sets out the voltage step-change limits that apply under clause 2.2.2(b).

Western Power has identified several issues with the current drafting of clause 2.2.2(b) and Table 2.2 related to:

- The structure of the table,
- Use of asymmetric voltage step-change limits, and
- The specification of voltage step-change limits.

The issues and proposed solutions are discussed below. Further, it is understood that the rows in the table for routine switching were originally extracted from an example in the 2001 version of AS/NZ 61000.3.7.[6] AS/NZ 61000.3.7 is a superseded voltage flicker standard[7], and hence the referenced example is not entirely relevant to clause 2.2.2 which addresses voltage step-change limits. Flicker requirements are outlined separately in clause 2.2.3 of the Technical Rules.

Table 3-1: Step-change voltage limits (Table 2.2. in the Technical Rules)

<table>
<tr><th rowspan="2">Cause</th><th colspan="3" rowspan="2">Pre-switching (quasi steady-state) and during tap-changing</th><th colspan="2">Post-switching (final steady-state)</th></tr>
<tr><th>Transmission</th><th>Distribution</th></tr>
<tr><td rowspan="5">Routine Switching(1)</td><td rowspan="2">r (hour^{-1})</td><td colspan="2">U_{dyn}(3)/U_N(4) (%)</td><td rowspan="4">Transmission voltages must be between 110% and 90% of nominal voltage</td><td rowspan="4">Must attain previous set point</td></tr>
<tr><td>Distribution</td><td>Transmission</td></tr>
<tr><td>r ≤ 1</td><td>±4.0%</td><td>±3.0%</td></tr>
<tr><td>1 < r ≤ 10</td><td>±3.0%</td><td>±2.5%</td></tr>
<tr><td>10 < r ≤ 100</td><td>±2.0%</td><td>±1.5%</td></tr>
<tr><td>Infrequent Switching(2)</td><td colspan="3">+6%, –10%</td><td>Transmission voltages must be between 110% and 9-% of nominal voltage</td><td>Must attain previous set point</td></tr>
</table>

Notes:
1. For example, capacitor switching, transformer tap action, motor starting, start-up and shutdown of generating units.
2. For example, tripping of generating units, loads, lines and other components.
3. U_{dyn} is the dynamic voltage change which has the same meaning as in AS/NZS 61000.3.7.
4. U_N is the nominal voltage.

Structure of Table 2.2 (step-change voltage limits)

The structure of Table 2.2 of the Technical Rules introduces the following concerns:

6 *AS/NZS 61000.3.7:2001*, Table 7 (Emission limits for voltage changes in function of the number of changes per hour), p. 14.
Table 7 gives the maximum voltage change ΔU_{dyn} / U_N for normal operating conditions (expressed in per cent of the actual voltage) a customer may cause, depending on the repetition frequency of these changes.

7 *AS/NZS 61000.3.7:2001 Electromagnetic Compatibility (EMC) Limits – Assessment of emission limits for fluctuating loads in MV and HV power systems (IEC 61000-3-7:1996, MOD)* "proposes a set of principles which are intended to be used to determine the requirements for connecting large fluctuating loads (producing flicker) to public power systems. This Standard provides guidance on engineering practices which will ensure service quality for all connected consumers."
Refer to: https://infostore.saiglobal.com/en-us/standards/as-nzs-61000-3-7-2001-115801_saig_as_as_241952/

- The specified voltage limits differentiate between limits that apply to frequent operational switching and infrequent operational switching. However, there is some ambiguity for contingency events with the current presentation.
- Does not define how the voltage step change is to be measured, specifically whether voltage step changes are measured by comparing the pre-event voltage with that immediately after the event but before transformer tapping. Previous versions of the Technical Rules provided greater clarity regarding the treatment of transformer tap changing.
- Specifies requirements for higher frequency switching events that could conflict with or duplicate requirements for flicker specified in other clauses of the Technical Rules. The current drafting provides limits for very high switching frequencies (up to 100 switching events per hour). Operating the transmission and distribution network seldom requires switching events that occur more frequently than once per hour.

Each of the above issues creates ambiguity, leading to confusion regarding the actual voltage step-change performance to be delivered under different scenarios.

Compared to the voltage step-change limits set out in the Technical Rules, the NER provisions are comparatively simple. Under the NER provisions:

- There is no specific voltage step change limit for routine switching. The voltage flicker standards are used to specify limits for voltage variations resulting from a range of activities including frequent variations in loading or frequent planned switching events.
- The voltage step change limits in the system standards have been considered in setting the voltage disturbance ride through automatic access standard for generators defined in S5.2.5.4 of the NER. The automatic access standard requires generators to ride through a voltage change that returns to within +15% of normal voltage within 20 seconds and -10% of normal voltage within 10 seconds.
- Symmetric step-change limits apply:
  - The maximum limit for voltage variation of +/-5% of the target voltage except as a consequence of a credible contingency event or protected event (NER S5.1.4(b)), and
  - Limits of +/- 10% apply at a connection point except as a consequent of a contingency event (NER S5.1a.4).
- Following contingency events, the voltage can vary to within the transient overvoltage limits that reduce to +10% of normal voltage as the time following the contingency increase to 900 ms. As a consequence of a contingency event, the voltage at a connection point may fall to zero for any period. (NER S5.1a.4)

In the UK, the Security and Quality of Supply Standards (SQSS) specify limits for the voltage step change on the transmission system. The SQSS defines the step change as the difference between the voltage immediately before an event and that at the end of the 'transient time phase' after the event. The 'transient time phase' spans the time taken for the fault to be cleared and for the transient voltage response. Typically, this phase extends from the time of the event for up to 5 seconds. During this time, it is expected that on-load transformer tap changes would not have operated.

The voltage change limits in the SQSS depend on whether the switching event is planned or unplanned. For planned events, the limits also vary with the frequency of the switching activity. The limits range from:

- +6 to -12% of the pre-event voltage for more severe unplanned contingency events,
- +6 to -6% of the pre-event voltage for less severe unplanned contingency events and planned but infrequent switching events, to

- +3 to -3% of the pre-event voltage for planned switching that occurs less frequently than once every 10 minutes, with lower limits applying for more frequent switching.

While the SQSS includes reduced limits for higher frequency voltage step changes, unlike the Technical Rules the SQSS does not specify flicker limits for the transmission system. Flicker limits are specified for connections to the grid through relevant sections of the UK Grid Code.

The Technical Rules for the Horizon Power network adopts similar wording to the current Technical Rules for the SWIS[8]. The voltage step change limits for the regulated power systems in the Northern Territory are specified in the Network Technical Code (NTC). The drafting in the NTC is similar to that which appeared in version 2 of the Technical Rules.

The proposed revisions to clause 2.2.2.4 of the Technical Rules address the issues associated with the structure of Table 2.2 in the current Technical Rules. The proposed revisions:

- operate in conjunction with the timeframes specified in clause 2.2.2.1 to provide greater clarity regarding how the voltage step change should be assessed.
- maintain limits consistent with those currently applied in by Western Power when planning and operating the transmission network[9], and
- specify limits that differentiate between frequent operational switching, infrequent operational switching and contingency events.

As discussed below the, proposed revisions retain asymmetrical step change limits.

Use of asymmetric voltage step-change limits in Table 2.2

Wester Power considered the following options regarding the asymmetric limits:

a) Adopt symmetrical limits for both frequent operational switching, infrequent operational switching and credible contingencies.

b) Retain the existing asymmetrical limits for infrequent operational switching and credible contingencies.

On balance, Western Power has decided to recommend option b). Option b) retains consistency between the Technical Rules for the SWIS and those applicable for the Horizon Power network. It also retains consistency with the historic practice adopted in planning the SWIS.

While symmetrical limits apply in the NEM (+/- 10% except where varied by jurisdictional regulations, e.g. Queensland[10]), the UK adopts asymmetrical limits (similar to the old CBEMA curves)[11]. As such retention of asymmetric voltage step change limits is not inconsistent with practice in other jurisdictions.

The original Computer Business Equipment Manufacturers Association (CBEMA) curve developed in the 1970s to indicate the sensitivity of computer equipment adopted asymmetrical limits (+6% and -13%)[12], indicating customer equipment was more susceptible to higher rather than lower voltages. The revised CBEMA curve published in 2000 adopts symmetrical limits (+/- 10%)[13], which suggests that modern

8 Horizon Power, Technical Rules, 5 August 2020, Table 2.3, p. 19.

9 For clarity, the current Technical Rules require the Network Service Provider to plan the network so that is operable, with the operating limits being those in section 2.2. To achieve compliance, Western Power typically plans the network to slightly tighter limits than required in section 2.2 so that operations can achieve the stated limits.

10 Clause 13 of the Queensland Electricity Regulations, 2006 require a voltage change of less than +/- 6%

11 Refer to Table 6.1 in Section 6.3 of the NETS SQSS, which outlines in pre-fault voltage steady state voltage limits and requirements in planning timescales that apply onshore transmission.

12 'CBEMA CURVE – THE POWER ACCEPTABILITY CURVE FOR COMPUTER BUSINESS EQUIPMENT', 3 April 2011, accessed 10 April 2020. Refer to: Refer to: http://www.powerqualityworld.com/2011/04/cbema-curve-power-quality-standard.html

13 'ITIC Curve', [undated[, accessed 10 April 2020. Refer to: http://voltage-disturbance.com/voltage-quality/itic-curve/

customer equipment may not be as susceptible to higher voltages. However, if there is doubt over the susceptibility of customer equipment, and in the absence of further analysis on the impact for customers, the existing asymmetrical limits should be retained to avoid any potential for adverse impact on customer equipment. Hence, option b), which keeps the asymmetric limits, is preferred.

Specification of voltage step-change limits

Voltage limits can be specified in several ways. The current drafting of the Technical Rules defines voltage step change limits with reference to the nominal voltage. In contrast, the limits are specified in the NEM are with respect to the 'normal' voltage[14], while those in the UK are with respect to the pre-event voltage.

In the NEM, the 'normal' voltage approach allows for different practices between different network operators regarding the typical voltage at a point in their network. That typical voltage is agreed with AEMO and defined as the normal voltage.

In revising the specification of voltage step-change limits in the Technical Rules, Western Power considered the following options for the presentation of voltage step change limits:

a) Limits specified with respect to nominal voltage.

b) Limits specified with respect to normal voltage (i.e., the NEM approach).

c) Steady state voltage range specified with respect to nominal voltage and voltage step change specified as the change from the pre-switching voltage, with the permissible threshold expressed as a percentage of the nominal voltage.

Option a) is recommended. This option aligns with the approach adopted historically by Western Power when planning the network and reflected in the current Technical Rules. Specifically, nominal voltage is used to specify limits for steady state voltage.

Changing from nominal to 'normal' voltage, as per option b), would have wide-ranging implications that need to be carefully considered, such as the potential impact on customer's equipment. While adopting this approach may allow for the voltage limits at connection points to be better aligned with the actual voltage at the connection point, Western Power does not recommend a change in terminology at this point.

In implementing option a), the voltage step change provisions will clarify that the voltage step change is measured by comparing the pre- and post-switching voltages. This will aid in consistent assessment of the voltage step change requirement. Specifying the required step change limit as a percentage of the nominal voltage means that the step change limit does not change as the even if the pre-event voltage varies. This is appropriate and provides a consistent threshold for all Users connected at the same voltage level. Retaining the limit for steady state voltage to be within a specified range of nominal voltage will mean that level of steady state voltage variation experienced by customers does not exceed historical levels.

3.5 Distribution voltage limits

Like for transmission voltage limits, distribution voltage limits play a role in ensuring the power system operates securely and reliably. The acceptable distribution voltage limits must be clearly defined to help guide efficient planning and operational decisions.

[14] In the NEM, 'normal voltage' means, in respect of a connection point, its nominal voltage or such other voltage up to 10% higher or lower than the nominal voltage, as approved by AEMO, for that connection point at the request of the Network Service Provider who provides the connection to the power system.

3.5.1 Current issues

Western Power identified the following issues with the definition of distribution voltage limits in the Technical Rules:

- Voltage limits for both the transmission and distribution network are specified in the same clauses of the Technical Rules which makes it harder to clearly identify the transmission voltage limits.
- Vague terminology that could be interpreted and applied in many ways leading to lack of consistency regarding the required level of performance.
- The specification of low voltage performance should allow for changes to relevant Australian Standards and the potential adoption of a 230 V nominal voltage on the low voltage distribution system.
- Adopting limits consistent with the relevant Australian Standard will allow a slightly wider variation in the voltages on the low voltage network. This should not adversely impact consumers as equipment is designed to operate with voltage consistent with the Australian Standard. This approach will, however, mean that some network investments can be deferred reducing costs for customers.
- Imprecise specification of voltage performance can impede the ability to monitor and compare actual performance against the system standards.

Other Australian jurisdictions have adopted wider limits including those specified in the Australian Standards (AS 61000.3.100) for voltages. A widening of the voltage range will allow Western Power to connect more residential scale solar PV systems.

3.5.2 Solution options & preferred solution

The primary solution adopted was to restructure the Technical Rules, creating section 2.2.3 of the proposed Technical Rules to specify the distribution system voltage performance standards. The various subsections with section 2.2.3 of the proposed Technical Rules incorporate revisions to address each of the identified issues:

- Section 2.2.3.1 of the proposed Technical Rules specifies the steady state voltage limits for the distribution network. This clause maintains consistency with the limits specified in the current Technical Rules for the distribution network voltage greater than 1 kV. A new table has been added which expresses the steady state voltage limits for the LV (<1 kV) distribution network. The specified limits align with those in the relevant Australian Standard AS 61000.3.100 (2011). This positions Western Power to migrate to 230 V as the nominal voltage for the low voltage distribution network.
- Section 2.2.3.2 of the proposed Technical Rules specifies limits on the size of voltage step changes following switching or contingency events. The voltage step change limits defined in this clause are similar to the voltage step change limits specified in the existing Technical Rules focussing on frequency of switching likely to be experienced on the distribution system and consistent with current practice. This clause provides added clarity regarding how the voltage step change will be measured by referring to the timeframes defined in clause 2.2.2.1.
- Section 2.2.2.4 of the proposed Technical Rules specifies the transient overvoltage limits for the distribution network. This section provides limits for the portions of the distribution network operating at greater than 1 kV and separate limits for the low voltage distribution network. A separate low voltage transient overvoltage limit is required to ensure consistency between that limit and the steady state voltage limit which each being expressed in volts rather than a percentage of nominal voltage. This approach allows for the eventual migration from a nominal voltage of 240 V to 230 V for the low voltage distribution network.

3.6 Transient stability

Rotor angle transient stability considers the ability of a synchronous generator to remain synchronised to the rest of the power system following a disturbance. Clause 2.2.7 of the Technical Rules specifies that all generating units with a rated capacity of 10 MW or more must not lose synchronism following a credible contingency event. This clause is focused on one aspect of transient stability that is particularly relevant to synchronous generators.

3.6.1 Current issues

With the majority of new generation connecting to the power system being non-synchronous renewable generating systems, it is important that the system standards consider all relevant forms of aspects of transient stability and not just rotor angle stability.

3.6.2 Solution options & preferred solution

Western Power considered the following options to address this issue:

a) Revise clause 2.2.8 of the Technical Rules by replacing the reference to rotor angle stability with a broader requirement that the power system must achieve transient stability for any disturbance resulting from a credible contingency. Noting that transient stability is achieved if the power system is able to reach an acceptable steady state condition following a disturbance.

b) Revising clause 2.2.8 of the Technical Rules to list various facets of transient stability and requiring the power system to avoid transient instability following a credible contingency event.

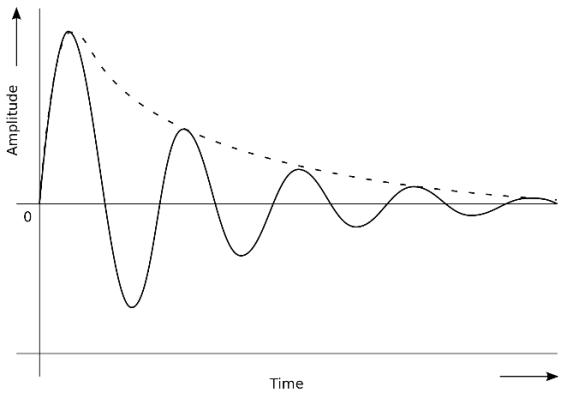
c) No change.

Option a) is recommended. Drafting consistent with this option expresses the underlying technical requirement in a more generalised manner, which means it is better able to capture current any emerging transient stability concerns.

3.7 Oscillatory stability and damping

The system performance oscillatory stability and damping requirements are set out in clause 2.2.8 of the Technical Rules. Damping in this context refers to the ability of control systems on generating systems to quickly reduce the magnitude of any oscillations in key system quantities such as active power, reactive power and voltage, following a disturbance and the ability for the system to return to a steady state free of oscillations, as illustrated in Figure 3-1.

Figure 3-1: Damping of oscillations

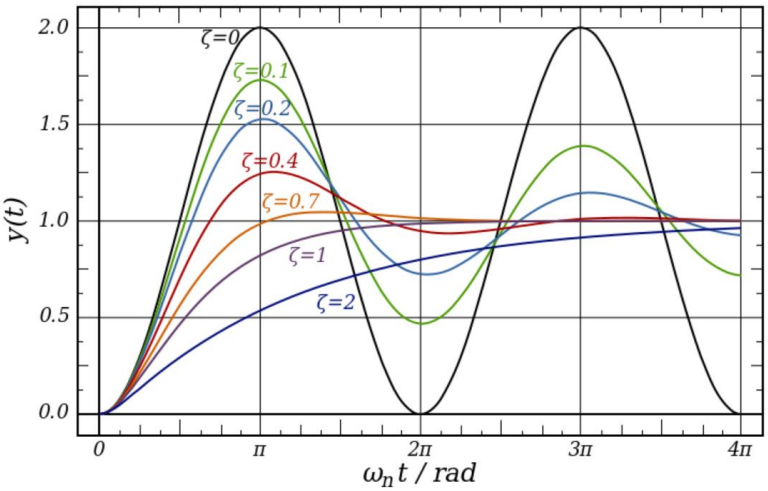


3.7.1 Current issue

The current drafting of the Technical Rules does not consider all forms of oscillations that could be present on a power system. The drafting focuses on system oscillation originating from electro-mechanical characteristics, electro-magnetic effects or the non-linearity of system components. The drafting does not consider other oscillations such as voltage oscillations that may arise through interactions between inverter connected renewable generators particularly in areas of low system strength.

The approach used in the Technical Rules defines adequate damping by specifying limits on the damping ratio for all electromechanical oscillations regardless of the frequency of the oscillation. Figure illustrated how the damping of a second-order system improves with increasing damping ratio.

Figure 3-2: Illustration of damping of a second-order system with different damping ratios[15]



This approach has created issues with several generators utilising gas turbine technology, as the fixed damping ratio limits are difficult to meet with these generators that have higher frequency modes of oscillation. To meet a fixed damping ratio, the time taken to reduce the magnitude of an oscillation by half is reduced as the natural frequency of the oscillatory mode increases.

In addition to the damping ratio requirement, the Technical Rules also require that the halving time of any electro-mechanical oscillation should not exceed 5 seconds.

In the NEM, a halving time is used to specify adequate damping requirements for frequencies of oscillation corresponding to electromechanical modes (Box 3-1). The advantage of using the halving time approach is it specifies a characteristic that can be readily observed via measurement. This is reflected in clause S5.1.8 of the NER that specifies how damping is to be assessed from measurements made on the power system.

The approach adopted in the National Electricity Transmission System (NETS) in the UK is different again. The NETS Security and Quality of Supply Standard (SQSS)[16] defines poor damping of electromechanical modes by the time constant of the slowest mode. Under the definition for system instability, poor damping is described as being where electromechanical oscillations of generating units are such that the resultant peak deviations in machine rotor angle and/or speed at the end of a 20 second period remain in excess of 15% of the peak deviations at the outset (i.e., the time constant of the slowest mode of oscillation exceeds 12 seconds).[17] While the approach in the SQSS is different to that in the NEM, both approaches provide a

[15] Refer to: https://en.m.wikipedia.org/wiki/File:2nd_Order_Damping_Ratios.svg

[16] The Security and Quality of Supply Standard (SQSS) sets out the criteria and methodology for planning and operating the National Electricity Transmission System (NETS). Refer to: https://www.nationalgrideso.com/industry-information/codes/security-and-quality-supply-standards

[17] *National Electricity Transmission System Security and Quality of Supply Standard*, Version 2.4, 1 April 2019, p. 72.

level of performance that is easily measured and related to the decay measured over time which is independent of the natural frequency of the oscillation.

Box 3-1: Damping in the NEM

In the NEM, the term 'adequately damped' is defined in the NER as follows.

> *In relation to a control system, when tested with a step change of a feedback input or corresponding reference, or otherwise observed, any oscillatory response at a frequency of:*
>
> *(a) 0.05 Hz or less, has a damping ratio of at least 0.4;*
>
> *(b) between 0.05 Hz and 0.6 Hz, has a halving time of 5 seconds or less (equivalent to a damping coefficient –0.14 nepers per second or less); and*
>
> *(c) 0.6 Hz or more, has a damping ratio of at least 0.05 in relation to a minimum access standard and a damping ratio of at least 0.1 otherwise.*

Clause S5.1.8 of the NER outlines the requirement for electromechanical mode damping. Clause S5.1.8 states:

> *In conforming with the requirements of the system standards, the following criteria must be used by Network Service Providers for both planning and operation:*
>
> *……*
>
> *Damping of power system oscillations must be assessed for planning purposes according to the design criteria which states that power system damping is considered adequate if after the most critical credible contingency event or any protected event, simulations calibrated against past performance indicate that the halving time of the least damped electromechanical mode of oscillation is not more than five seconds.*
>
> *To assess the damping of power system oscillations during operation, or when analysing results of tests such as those carried out under clause 5.7.7 of the Rules, the Network Service Provider must take into account statistical effects. Therefore, the power system damping operational performance criterion is that at a given operating point, real-time monitoring or available test results show that there is less than a 10 percent probability that the halving time of the least damped mode of oscillation will exceed ten seconds, and that the average halving time of the least damped mode of oscillation is not more than five seconds.*

Clause S5.1a.3 of the NER then sets out the system stability requirements as including the following:

> *The halving time of any inter-regional or intra-regional oscillation, being the time for the amplitude of an oscillation to reduce by half, should be less than 10 seconds. To allow for planning and operational uncertainties, the power system should be planned and operated to achieve a halving time of 5 seconds.*

3.7.2 Solution options & preferred solution

Western Power proposes revisions to the oscillatory stability requirements now specified in clause 2.2.9 of the Technical Rules to clarify that oscillatory stability requirements apply to all forms of power system oscillations, not just electromechanical oscillations. The requirement should be that all oscillations are adequately damped with the term "adequately damped" being defined in the glossary.

In addition, the following options were considered for improving the specification of the required damping of oscillations:

a) Adopt the NEM approach that specifies an electromechanical mode damping requirement as needing to be achieved in a 5-second halving time when planning the network, with a 10-second halving time used to assess whether actual damping of rotor-angle oscillations measured on the power system is sufficient.

b) Retain existing drafting for electro-mechanical modes but change the damping ratio limits to 0.1 to reflect quantities that generators connected to the SWIS can achieve[18], and introduce additional guidance requiring the use of statistical methods to assess damping from test results.

c) Adopt damping provisions similar to those in the UK SQSS that specify a level of damping required to be achieved in 20 seconds.

Western Power proposes amendments that reflect option b). This approach maintains consistency with historical practice by continuing to specify the required performance in terms of the minimum acceptable damping ratio. With the specified minimum damping ratio set a 0.1, generators connected to the SWIS should be able to meet the specified damping requirement.

The revised clause also specifies that test results used to assess damping must take into account statistical effects, which aligns with contemporary practice in the NEM. The revised drafting requires that to demonstrate compliance with the damping requirements, real time monitoring or test results must show that there is less than a 10 percent probability that the *halving time* of the least damped mode of oscillation will exceed ten seconds, and that the average *halving time* of the least damped mode of oscillation is not more than five seconds. The inclusion of this additional guidance will assist Users to understand how tests to demonstrate adequate damping should be conducted.

3.8 Voltage stability

Voltage stability is the ability of the power system to maintain or recover voltage magnitudes to acceptable levels following a contingency event. Instability would result in voltage magnitudes in part of the power system exhibiting an uncontrolled sustained increase or decrease over time (a “run-away” condition) or sustained or undamped oscillatory behaviour. Voltage instability can occur rapidly (over seconds) or slowly (over minutes).[19]

3.8.1 Current issue

Clause 2.2.9 the Technical Rules defines short-term voltage stability and requires that a stable voltage be maintained following the most severe credible contingency event. The current drafting provides no clear link between achieving voltage stability and operating within the voltage limits specified in the earlier clauses of chapter 2. This lack of alignment creates difficulty when assessing voltage stability.

3.8.2 Solution options & preferred solution

Clause 2.2.10 in the proposed Technical Rules addresses voltage stability requirements. Western Power has proposed revisions to this clause which identify that to achieve voltage stability, the voltage must be maintained within the limits specified in revised clauses 2.2.2 and 2.2.3. In addition, the proposed clause requires that sufficient static and dynamic reactive power capability be available to maintain steady state voltage control allowing for credible variations in load and generation patterns and reasonable variations in the availability of reactive equipment.

The proposed drafting of clause 2.2.10 provides sufficient specification of voltage stability requirements which means that it is no longer necessary to have separate clauses that articulate short-term and long-term voltage stability standards.

[18] Derogations granted that relax the damping ratio for generators include those for Muja D, Kwinana HEGTs, Kwinana Donaldson Road Power stations Units 1 and 2. For the full list of derogations refer to: https://www.erawa.com.au/cproot/21003/2/Western-Power-s-list-of-customer-exemptions---December-2019.PDF

[19] AEMO, *Power system stability guidelines* [for the NEM], version 1.0, 25 May 2012, p. 12.

3.9 Network Service Provider obligations – stability and modelling

The Network Service Provider obligations relating to the assessment of power system stability and dynamic performance are specified in clause 2.3.7 of the Technical Rules.

3.9.1 Current issue

Western Power identified the following issues with the drafting of clause 2.3.7 of the Technical Rules:

- The current drafting requires the Network Service Provider to use dynamic models of power system facilities to undertake the studies required to assess power system stability. However, it does not provide any clarity regarding the quality and functionality of the models. This lack of clarity can lead to uncertainty for Users in assessing the effort required to produce acceptable models for their facilities.
- The current drafting contains elaborate provisions that attempt to define how system stability studies should be undertaken by the Network Service Provider. The current drafting is difficult to interpret, does not reflect the complete set of studies that the Network Service Provider may need to undertake and is unnecessarily prescriptive.

3.9.2 Solution options & preferred solution

Western Power has considered the following options to address these issues:

a) Introduce two new clauses:

   i) Clause 2.3.5.1 that establishes requirements on the Network Service Provider to produce generator and load model guidelines and defines the high-level purpose for the guidelines. The guidelines should be consistent with the relevant generation system model procedure specified in the WEM Rules.

   ii) Clause 2.3.5.2 that specifies the stability and modelling obligations for the Network Service Provider including requirements to:

      A) plan design and construct the transmission and distribution system to meet the stability standards specified in section 2.2 of the Technical Rules.

      B) complete sufficient simulation studies to assess power system stability.

      C) utilise models developed in accordance with the generator load and model guidelines to assess system stability.

b) Option a) with the new clause 2.3.5.1 expanded to provide specific modelling requirements that need to be included in the guideline.

c) Option b) with the new clause 2.3.5.2 expanded significantly to provide more prescriptive and elaborate drafting of the approach the Network Service Provider should follow when undertaken system studies to assess power system stability.

Option a) is preferred. This approach provides a definite obligation from Western Power to maintain the existing load and generator modelling guidelines, which is an important document that helps Users understand the modelled requirements they need to meet. The approach also places clear obligations on the Western Power to make appropriate assessments of system stability while avoiding including unnecessarily prescriptive requirements regarding how the stability assessments are to be made.

Option a) is consistent with contemporary practice. In the NEM, the NER places a requirement on AEMO to develop power system modelling guidelines but avoids overly prescriptive drafting that would be required to define in detail the information that is included in the guidelines. The NER also places obligations of

transmission network service providers and AEMO to assess system stability but does not include prescriptive provisions defining in detail how such studies should be undertaken.

Options b) and c) do not fully address the issue regarding the unnecessary level of prescription in the current Technical Rules. Removal of this prescription retains the purpose of the Technical Rules and enables greater flexibility in approach where required.

3.10 Network Service Provider obligations – transfer limits

Clause 2.3.7 of the Technical Rules places obligations on the Network Service Provider to determine power transfer limits.

3.10.1 Current issue

The obligations to determine power transfer limits need to be revised to align with the requirements that have been added to the WEM Rules that address the requirement for the Western Power to supply AEMO with network transfer limits.

3.10.2 Solution options & preferred solution

Western Power has proposed revised drafting for clause 2.3.6. Proposed changes require the Network Service Provider to determine power transfer limits and further clarifies that the limits must be produced in accordance with the relevant procedure defined in the WEM Rules and provided to AEMO.

3.11 Network Service Provider obligations – power system performance

Clause 2.3.9 of the Technical Rules places obligations on the Network Service Provider to determine monitor the performance of the power system on an ongoing basis.

3.11.1 Current issue

While the current drafting requires the Network Service Provider to monitor power system performance, it does not include a specific obligation on the Network Service Provider to install sufficient monitoring systems to achieve the required monitoring of power system performance.

3.11.2 Solution options & preferred solution

Western Power has proposed revised drafting for this clause that places a specific obligation on the Network Service Provider to ensure sufficient monitoring is in place. This revision removes any ambiguity and clarifies that Western Power should install the monitoring equipment required to monitor power system performance.

3.12 Network Service Provider obligations – system restart

Sufficient facilities must exist at all times to restart the power system if required. A successful system restart requires having sufficient control and monitoring in place to be able to establish the necessary transmission corridors to connect generating systems providing restart services and enable those generators to restart the rest of the power system.

3.12.1 Current issue

The Technical Rules currently place no specific obligation on Western Power to support the restart of the power system. This creates potential uncertainty regarding the ability for Western Power to justify investment that might be required to maintain the ability of the transmission and distribution system to support the restart of the SWIS in accordance with the restart plan developed by AEMO.

3.12.2 Solution options & preferred solution

Consistent with obligation in section 3.7 of the WEM Rules, Western Power has proposed including a new clause that places clear obligations on the Network Service Provider to:

- Provide assistance to AEMO to develop the SWIS restart plan, and
- Plan the network to provide the capability required to restart the power system in accordance with the SWIS restart plan.

This is a prudent addition to the Technical Rules that helps ensure appropriate investment in the network is made to maintain expected levels of power system resilience.

3.13 Under-frequency load shedding requirements

Under-frequency load shedding (UFLS) schemes provide an important emergency system protection function design to act quickly to arrest frequency collapse following severe contingency events that result in the disconnection of generation.

In the Technical Rules, clause 2.3.1 and 2.3.2 place requirements on the Network Service Provider to design and install an appropriate UFLS scheme. Clause 2.4 provides prescriptive design requirements for the scheme specifying settings for each stage of the scheme.

3.13.1 Current issue

Table 2.8 of the Technical Rules (repeated below as Table 3-2) provides the required settings for the UFLS scheme and how switchable capacitor banks at substations must be shed.

Table 3-2: Under-frequency load shedding scheme settings for the South West Interconnected Network

Stage	Frequency (Hz)	Time Delay (sec)	Load Shed (%)	Cumulative Load Shed (%)	Capacitor shed (%)	Cumulative Capacitor Shed (%)
1	48.75	0.4	15	15	10	10
2	48.50	0.4	15	30	15	25
3	48.25	0.4	15	45	20	45
4	48.00	0.4	15	60	25	70
5	47.75	0.4	15	75	30	100

Source: Table 2.8 of the Technical Rules

The level of prescription in Technical Rules is much higher than similar provisions in the NER. The NER requirement is for market customers to make 60 per cent of expected demand available for load shedding. This can include load shedding offered as an ancillary service.

During the course of the Technical Rules review, the WEM Rules were also updated to include provisions addressing the design and specification of the SWIS UFLS scheme. The WEM Rules require:

- AEMO to prepare and publish an UFLS requirements document containing the aggregate requirements for the SWIS UFLS scheme taking into account the WEM FOS; and
- Western Power to develop an UFLS specification document setting out how it intends to design and implement an UFLS scheme that will meet the requirements specified in the UFLS requirements document.

In developing options to update the UFLS scheme provisions in the Technical Rules, Western Power considered:

- How the current requirements in the Technical Rules could be revised to provide the flexibility to address the needs of the evolving power system.
- The respective roles for the Network Service Provider and AEMO in designing UFLS schemes and the merit in a collaborative approach.
- How any UFLS settings should align the WEM FOS to provide an appropriate margin to avoid unnecessary load shedding if frequency does not move beyond the single contingency band.
- Changes being implemented in the WEM Rules that define roles for AEMO and Western Power in relation to UFLS.

3.13.2 Solution options & preferred solution

Western Power considered the following options for addressing the above concerns:

a) Replace the prescriptive arrangements in the Technical Rules with a high level obligation on the Network Service Provider to provide a UFLS scheme and coordinate the functional design with AEMO. This option aligns with the revisions implemented in the WEM Rules.

b) In addition to option a) include a clause specifying that the Network Service Provide may require a User to make a portion of their load available for UFLS.

Option b) is preferred as it aligns with the revisions to section 3.6 of the WEM Rules and adopts a more flexible set of requirements that will be better able to adapt to keep pace with changes to the SWIS such as the growing level of distributed energy resources. The clearer requirement for Users to make a portion of their load available for UFLS makes existing practice more transparent.

The provisions implemented in the WEM Rules allow Western Power and AEMO to agree on the functionality of the UFLS scheme. This approach is consistent with current contemporary practice.

In the NEM, work is proceeding to enhance the sophistication of the UFLS schemes to recognise that during daylight hours the location of embedded photovoltaic generation needs to be accounted for to avoid the UFLS scheme tripping generation rather than load. This requires a smarter system, i.e., IT and communications investment. Without this additional intelligence, UFLS schemes may not be effective in arresting under-frequency disturbances during daylight hours. These changes are being pursued by AEMO in collaboration with Network Service Providers without the need of prescriptive provisions in the NER.

Similar issues are emerging in the SWIS and the revised UFLS framework in the WEM rules will enable AEMO and Western Power to investigate and implement appropriate revisions to the SWIS UFLS scheme.

3.14 Network Service Provider Obligation - system strength

System strength is a way of describing how resilient the voltage waveform is to network disturbances such as those caused by a sudden change in load or, generation, the switching of a transmission element, tapping of transformers and various types of network faults.

If a network location is said to be “strong” in terms of system strength, the change in voltage at that location will be relatively unaffected by a nearby disturbance. However, if a location is said to be “weak” in terms of system strength the voltage at that location will be relatively sensitive to a disturbance, resulting in voltage dips that are deeper and more widespread.

Having a pliable voltage waveform is a precondition in which other problems are much more likely to emerge. This includes issues such as power quality and voltage instability, and unstable interactions between inverter-based generators. Thus, understanding the system strength in a network is a useful for understanding and proactively managing power system risks.

3.14.1 Current issue

The Technical Rules do not refer to system strength and do not allocate responsibility for planning the transmission and distribution system to provide sufficient system strength. Appropriate allocation of responsibility would allow the Network Service Provider to transparently assess proposed connections to weaker parts of the network and communicate whether adverse impacts are likely to emerge.

3.14.2 Solution options & preferred solution

The proposed revisions to chapter 3 of the Technical Rules (discussed in section 6 of this report) strengthen requirements for Users. They include an obligation for Users to provide suitable Electromagnetic Transient (EMT) models to assess whether the available system strength at a connection point is sufficient and for Users to operate their plant stably. As discussed in section 10.1 of this report, a number of revisions are also proposed to the Attachments to the Technical Rules to complement the changes proposed in the various chapters. One of those changes includes amending Attachments 4 and 9 to require Users to advise the minimum short circuit ratio large inverter connected generating systems and large inverter connected loads require for stable operation.

The proposed WEM Rule changes to introduce the generator performance standards (GPS) framework for transmission connected market generators do not introduce an obligation to manage system strength. As such, Western Power considered whether obligations similar to those in the NER should be introduced via changes to the Technical Rules. The NER provides for:

- Do no harm provisions for connecting generators (NER 5.3.4B) – where generators are assessed as connecting where there is insufficient system strength to support the connection, they are required to install system strength mitigation measures.
- AEMO’s periodic review of forecast fault levels at nominated points on the transmission network in each region. If AEMO identifies fault level are below minimum acceptable thresholds, they declare a system strength gap (NER 5.20C)
- Network Service Provider obligations to address declared system strength gaps (NER 5.20C.3)

There are issues with adopting the NEM approach. In practice, gaps have been identified in arrears rather than in advance. Detailed EMT simulations of the power system using models for generators validated via tests performed as part of the commissioning process are increasingly being used to identify system strength issues. These issues are identified in operational timeframes and have generally resulted in significant constraints being imposed on generators while longer term solutions are developed that often

involve investment in devices such as synchronous condensers or co-ordinated retuning of control system settings across a number of generating systems. Hence, there is a question as to what framework is best for the SWIS.

The connection process that applies to generators in the SWIS is split across various instruments (Technical Rules, WEM Rules, Applications and Queuing Policy (AQP) etc.). In the NEM, the entire connection process is defined in the NER. The separation of the different aspects of the connection process in the SWIS creates complications in implementing a NEM-style 'do no harm' process.

Western Power has identified two potential options to amend the Technical Rules that provide for the Network Service Provider to assess the system strength impacts of the proposed connection of a generator:

a) Introduce a new clause in section 2.3 of the Technical Rules that requires the Network Service Provider to plan the network to provide sufficient system strength to meet the stability requirements defined in the power system standards in section 2.2 and the transmission and distribution system protection requirements defined in section 2.9.

b) Implement a NEM-style framework with revisions to the WEM Rules and Technical Rules to:

   i) introduce a WEM system strength impact assessment guideline

   ii) require the Network Service Provider and AEMO to use that guideline to assess when a proposed generator connection will trigger the need for system strength remediation works, and

   iii) revise the generator connection process to include the negotiation of arrangements to implement the identified remediation works satisfying both AEMO and the Network Service Provider.

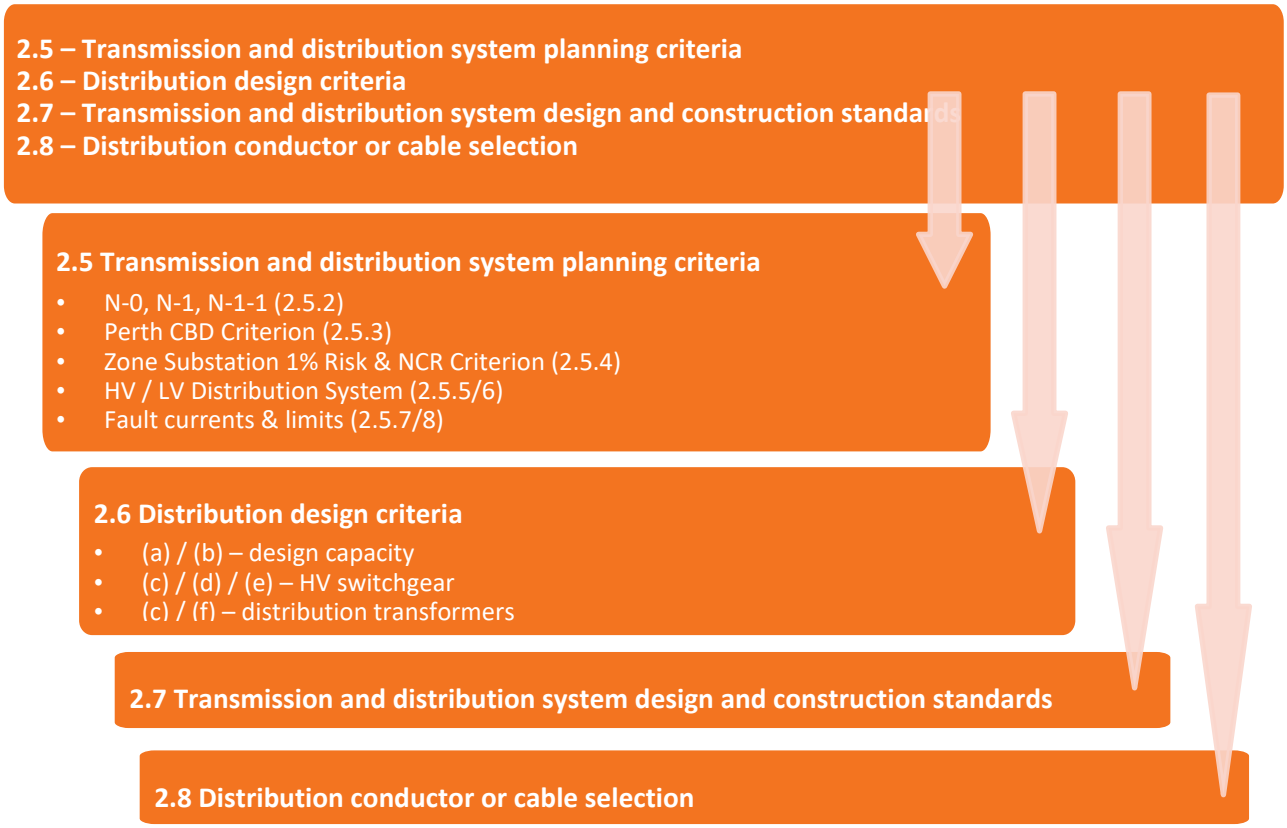
c) No change – remain silent on system strength obligations.

Western Power recommends option a) be implemented This option is most consistent with the existing framework for negotiating connection agreements with generators and agreeing and arrangements needed to fund augmentations necessary to facilitate the connection.

4. Transmission and distribution system planning criteria

The planning and design criteria that apply to Western Power's transmission and distribution network are defined in sections 2.5 to 2.8 of the Technical Rules.

The structure of these sections of the Technical Rules is illustrated in the following diagram.



The limitations, issues and proposed solutions to address issues that have been identified through the Technical Rules review process are discussed in the sub-sections that follow.

4.1 Transmission system planning criteria

The current transmission system planning criteria comprises of four criteria:

- A deterministic N-0, N-1 and N-1-1 criteria,
- The Perth CBD criteria,
- Normal Cyclic Rating (NCR) risk criterion, and
- 1% risk criterion.

The above criteria currently apply when planning and developing the transmission system and were originally adopted in 1996 in the Technical Code, which was developed in accordance with the *Electricity Transmission Regulations 1996,* and subsequently transferred to the Technical Rules in 2007.

The deterministic planning criterion defines acceptable loss of supply (or transfer capability) following the outage of a specified number of transmission elements. The current criterion permits a loss of supply to areas supplied by parts of the network based on the criterion that applies. Table 4-1 includes a summary of the deterministic criterion in the current Technical Rules.

The complete loss of supply to an area is recognised to be onerous for the affected community, especially if it affects essential services. The deterministic criteria are applied with this in mind and with consideration to the important parts of the network where a disturbance could have far reaching impacts across the customer base. The N-0 criterion applies to very small (lightly loaded) and remote parts of the transmission system, the N-1 criterion applies to the majority of the network, and the N-1-1 criterion, which provides a higher degree of security than the N-1 criterion, is applied to the most important parts of the network where an outage could put the system at risk or could affect a large proportion of customers. The N-1-1 criteria is considered when planning:

- all 330 kV transmission lines, substations and power stations;
- all 132 kV terminal stations in the Perth metropolitan area, and Muja power stations 132 kV substation;
- all 132 kV transmission lines that supply a sub-system of the transmission system comprising more than 5 zone substations with total peak load exceeding 400 MVA; and
- all power stations whose total rated export to the transmission system exceeds 600 MW.

A special criterion is specified for the Perth CBD area in recognition of the economic importance of loads located in this small area to the conduct of business throughout the state. This criterion requires that all loads must maintain full supply in the event of any of the following outage combinations:

- One or two transmission lines;
- One or two transformers; or
- One transmission line and one transformer.

As the CBD network does not operate as a paralleled network, it is recognised that load will be lost for a short duration following the unplanned outages. The Technical Rules require that in these circumstances load must be restored within 30 seconds if a single transformer trips. For outages of multiple items of plant, load must be restored within 2 hours.

To comply with the 30 second requirement following loss of a transformer, each substation supplying the Perth CBD area is equipped with an automatic load switching scheme. Feeders and busbars supplying the CBD area must have spare capacity retained to pick up any automatically switched load that can result from a transformer outage.

The 1% Risk and NCR criteria are modifications to the N-1 criterion that accept some additional risk to load security. Both of these criteria are reliant on the availability of spare transformers to be utilised in the event of a transformer failure within a substation.

The 1% Risk Criterion applies to zone substations outside of the Perth metropolitan area (where it is not practical to apply the NCR criterion). The criterion permits the loss of supply to a proportion of a substation's peak load that is demanded for up to 1% of time in a year (87 hours) following the unplanned outage of any supply transformer in the substation.

Historically, load duration curves have indicated that the top 10% of a substation's peak load is supplied during 1% of the time through the year and this figure has been used as a general rule in determining substation capacity for 1% risk substations. The capability to develop a probabilistic view of the load expected to be supplied from each individual substation allowed Western Power to apply the 1% Risk Criterion by assessing the load at risk for individual substations.

Both the NCR and 1% risk criteria rely on Western Power being able to share a common supply of spare transformers among a population of supply transformers located at zone substations within the same geographic area.

The NCR risk criterion may be applied by the Network Service Provider to zone substations in the Perth metropolitan area. This criterion is based upon the availability of a mobile rapid response spare transformer (RRST) to be transported to the affected substation and installed in the event of a transformer failure. The target time for installation of a mobile spare transformer is 12 hours. Given travel time, only substations within the Perth metropolitan area are suitable for application of the NCR criterion.

Application of the NCR risk criterion, as envisioned through the Technical Rules, considers the typical load profile seen by transformers within the zone substation where the criterion applies and defines a maximum power transfer level that should avoid premature aging of those transformers assuming that the load on the transformers varies across any day.[20] The variability in load across the day means that the transformers have the opportunity to cool-down during off-peak times and can therefore be loaded more during peak demand periods. Ratings determined taking into account the normal cyclic load pattern are referred to as normal cyclic ratings.

The NCR risk criterion, as defined in the current Technical Rules, attempt to provide for an appropriate level of redundancy in the transformation capacity available at zone substations. The NCR risk criterion requires transformer augmentations be considered once the peak demand on the substation exceeds 75% of the NCR rating. This trigger is delayed compared to that which would be required if the substation was planned to an N-1 criteria but is in advance of the augmentation trigger with an N-0 criteria.

The NCR risk criterion was originally set to 90% as the allowable transfer capacity before augmentation in the 1990's. The policy was introduced to manage capital restrictions[21]. Following the Fitzgerald Inquiry in Queensland (finalised in July 2004)[22], Western Power decided to change to the current 75% NCR trigger as they realised that the 90% trigger created a significant reliability risk under summer peak conditions. The 'NCR wind back' program phased in that change over 10 years to avoid a step change in capital expenditure[23].

A summary of the main elements of the existing transmission planning criteria detailed in sections 2.5.2.1 to 2.5.4.2 of the Technical Rules is presented in Table 4-1.

Table 4-1: Summary of existing transmission planning criteria

Criteria	Description
N-0 Clause 2.5.2.1	Loss of supply to sub-networks occurs following the loss of a transmission element until the failed element has been repaired or replaced.
N-1 Clause 2.5.2.2	No loss of supply to sub-networks occurs following the loss of a transmission element, other than in the case of a zone substation transformer where a brief switching period is allowed.

[20] The power transfer capacity of a zone substation (as referred to in clause 2.5.4(b)(2) of the existing Technical Rules) is generally the sum of the thermal ratings of the power transformers that transform from the transmission voltage (132kV) to the high voltage distribution voltage (33kV, 22kV or 11kV).

[21] Western Power, *Capital and operating expenditure 2009/10 to 20211/12*, September 2008, p. 73. Refer to: 20081008 AAI Appendix 1 - Capital and Operating Expenditure 2009-10 to 2011-12.pdf (erawa.com.au)

[22] Electricity Distribution and Service Delivery for the 21st century, prepared for the Queensland Government, July 2004. Refer to: https://www.parliament.qld.gov.au/documents/tableOffice/TabledPapers/2004/5104T1106.pdf

[23] Western Power, Appendix 7 - Substantiation of expenditure forecasts, 2006-2009 Access Arrangement, May 2006, p. 60. Available at: http://www.erawa.com.au/cproot/2638/2/AAI-Appendix_7-Expenditures_Report_Pt1-1.pdf

N-1-1 Clause 2.5.2.3	No loss of supply to sub-networks should occur following the loss of a transmission element during the planned outage of another transmission element, for system loads up to 80% of the peak system demand. Principally applies to 330 kV network assets and some high load 132 kV network assets.
Perth CBD Clause 2.5.3	No loss of supply should occur for sub-networks that transfer power to the Perth CBD following the loss of one or two transmission lines or supplying transformers (or combinations). For unplanned outages involving the loss of two transmission elements, an interruption time of 2 hours is allowed.
Zone Substations – 1% risk Clause 2.5.4.1	Permits the loss of supply to that portion of a substation's peak load that is demanded for up to 1% of the year (87 hours). Applies to zone substations outside of the Perth Metro area.
Zone Substations – NCR risk Clause 2.5.4.2	Permits a limited amount of substation demand to be lost until the Rapid Response Spare Transformer (RRST) is installed or the failed transmission element is repaired or replaced. Applies to zone substations in the Perth Metro area.

The current planning criteria is relatively simple and primarily focused on equipment (and equipment outages) rather than the load at risk or the expected value of that load at risk.

The criteria are intended to capture the minimum standards that should be achieved by the transmission system. However, where it is economic to invest beyond this standard, the Network Service Provider is able to justify this expenditure – including through techniques that value load at risk – though the regulatory test and new facilities investment test (NFIT) processes (Box 4-1).

Box 4-1: Summary of the Regulatory Test and New Investment Facilities Test (NFIT)

Regulatory test

In accordance with Chapter 9 of the Access Code, before committing to a major augmentation proposal, Western Power must satisfy the 'regulatory test'.

The regulatory test is satisfied if Western Power demonstrates it has considered all reasonable alternative options, including non-network solutions such as demand-side management or generation, and that its proposed option maximises the net benefit to those who generate, transport and consume energy in Western Power's network.

New facilities investment test (NFIT)

The NFIT is a separate test from the regulatory test and determines that portion of a project that can be financed through the regulated network tariff (i.e., the costs that may be rolled into the regulated capital base and therefore financed through network tariffs applying to all new work users).

Under section 6.52 of the Access Code, a new facilities investment satisfies the test if the proposed investment does not exceed the amount that would be invested by a service provider efficiently minimising costs and must satisfy at least one or more of the following benefit conditions:

- the investment generates enough revenue to cover the investment costs; or
- the investment provides a net benefit to justify higher network tariffs; or
- the investment is necessary to maintain the safety or reliability of the network or its ability to provide network services.

Any costs that did not meet the NFIT requirements need to be financed through some means other than through the regulated network tariff, typically through a capital contribution from specific network users. Hence, the NFIT is important in determining the amount of any capital contribution.

In this section, the transmission planning criteria as set out in the Technical Rules is considered. Changes are not proposed to the processes, which sit outside the Technical Rules, used to justify network

investments. However, this context is considered where it is appropriate to make links between these processes.

4.1.1 Current issues

Issues and opportunities for improvement identified through the Technical Rules review process ranged from more minor issues such as ambiguity of terms through to fundamental gaps, such as an inherent lack of flexibility in the current criterion to respond to changed load flows on the network. The main issues and opportunities are outlined below.

Lack of flexibility to respond to changes in demand

The Technical Rules provide for different parts of the transmission network to be designed to different levels of reliability. The intent is to provide higher integrity to the more important parts of the network where a failure could result in system collapse, or where a disturbance could have far reaching impacts across the customer base.

A concern with the current approach is that static measures are used to identify which groups of network assets are most important and should be planned to meet a particular criterion. Key examples of static measures include:

- The transmission voltage being relied on as a primary means of deciding which parts of the network are planned to the N-1-1 criteria, and
- The geographic location of substation being used to decide whether they are planned to an NCR or N-1 criteria.

Historically, the importance of parts of the network can change over time and this is not reflected in static measures. Over a long period of time, this results in less efficient investment than would overwise occur if demand levels were considered because:

- Some substations that supply a higher amount of demand are planned to a lower level of security than asset supplying a lower amount of demand. For example, some zone substations could be designed to a notionally lower standard using the NCR risk or 1% risk criterions despite supplying a higher load than some N-1 designed substations.
- Other assets are underutilised but still attract a higher security planning criterion. For example, the N-1-1 planning criteria is applied to 330 kV lines and typically requires that three overhead lines are built. In practice, the demand and power flows anticipated on some of the existing lines do not warrant this high security standard.

While some variation is expected in any planning criteria, other jurisdictions have adopted criteria that considers demand levels to provide a more direct measure of importance than relying on the static measures adopted in the Technical Rules[24]. For example, the planning standard[25] that applies to transmission and distribution system operators in Great Britain adopts ‘demand groups’ as a central theme.

Under the Great Britain planning standard, demand groups are a site or group of sites that collectively take power from the remainder of the system. The security afforded to a demand group varies by the size of the demand group. Higher group demand ranges have incremental and increased security and redundancy

[24] While there is some reference to demand load levels within the current N-0 criterion and N-1-1 criterion clauses of the Technical Rules, demand levels are not a central element of the transmission system planning criteria.

[25] Engineering Recommendation (ER) P2/6 Planning Standard

requirements. This approach recognises that, in general terms, portions of the network supplying larger amounts of load are more critical to system operation and have greater customer impacts.

Additionally, the UK requirements generally apply to group demands within the stipulated ranges whether the demand is located within an urban, rural or semi-urban environment. In other words, all customers receive the same level of supply security.

Unachievable restoration times

For clauses that outline supply restoration times there are concerns that the restoration times may not be achievable in all cases and hence are not reflective of current restoration actions and practices.

For example, the NCR risk criteria was introduced as a means of reducing substation augmentation costs compared to the application of a N-1 standard, while providing and acceptable reliability outcome. The reliability outcome is achieved by having a fleet of rapid response spare transformers (RRST) available. Since the NCR criteria was introduced, changes beyond Western Power's control have brought into question whether the RRST fleet can be rapidly deployed (Box 4-2). Hence, it is appropriate to rethink the criteria.

Box 4-2: Factors effecting Western Power's ability to achieve restoration times using RRSTs

Restrictions and reasonable time requirements for deployment of RRSTs are provided below:

- Operational restrictions imposed by Main Roads Western Australia that restrict travel of the RRSTs on public roads to between 9.30am to 3.30pm Monday to Friday, and to daylight hours on weekends.
- Contractor mobilisation to ready the trailers for deployment - The current contract terms provide for 24/7 availability, and a 1-hour response time.
- Deployment readiness, which may take up to 2.5 hours. This includes connection and disconnection of the trailers to and from the prime mover, routine checks and adjustments (required prior, during and after each trip) in accordance with the trailer manufacturer's manual and approved practices.
- Travel to substation sites built to NCR risk criteria, which may take up to three hours. This estimate is based on travel from Forrestfield (where the RRSTs are held when they are not deployed) to Yanchep substation, which is the furthest site from Forrestfield (2 hours in a passenger vehicle +50% factor for the prime mover).
- Site access, connection, commissioning and energisation is estimated to take up to 12 hours once the RRST is on site. This timeframe includes provision for outages that may be required to connect the transformer, including indoor switchboard outages and distribution off-load.

Based on the maximum timeframes specified above for permits, mobilisation, trailer readiness and travel time to site it could take up to 24.5 hours to have the RRST on site (not yet connected, commissioned or energised).

Further, while adoption of the NCR or 1% risk criterion may appear sensible on an individual transformer basis. If multiple transformers are relying on the RRST fleet, there is a risk this fleet is inadequate or not able to be deployed rapidly enough to reach all sites, some of which may be some distance from where the RRST fleet are stored. The available fleet of RRST transformers should therefore be a factor considered when assessing the acceptable number of substations to operate close to NCR limits.

Derogations required for appropriate changes to application of standards

The current requirements and wording do not provide sufficient flexibility to allow Western Power to tailor solution options and adopt a risk-based approach that varies from the Technical Rules, where necessary, without generally seeking a derogation from the Economic Regulation Authority.

While there is some reference to peak load within the N-1-1 criterion (i.e., for 132 kV transmission lines supplying more than five zone substations with total load > 400 MVA), there is no such considerations with respect to 330 kV overhead lines or transformers. For 330 kV overhead lines and transformers, the planning standard typically mandates building three overhead lines or transformers in order to meet the requirements, otherwise a derogation is required.

Since adoption of the current planning criteria, the 330 kV network has been extended into remote regions (including the North Country). The decision to extent the 330 kV network is often justified as the most cost-effective long-term solution taking into account the expected power transfer capacity which is likely to be required over time. In practice, it can take time for the utilisation of those newly constructed assets to reach a level where the added security inherent in an N-1-1 planning standard is appropriate. Western Power considers the suitability of the planning criteria to optimise expenditure in some of these higher voltage assets should be reconsidered.

One example of the need to relax the application of the planning criteria in the technical Rules to avoid inefficient investment is the Meadow Springs Substation exemption from the NCR risk criteria granted in July 2015. This exemption allowed Western Power to avoid inefficient investment recognising the potential uncertainty in the demand forecast and the ability to utilise operational measures to mitigate any supply interruption.

Box 4-3: Meadow Springs zone substation exemption experience

In May 2015, Western Power applied to the ERA for a temporary exemption from complying with NCR risk criteria specified clause 2.5.4(b) of the Technical Rules with respect to the capacity requirements at Meadow Springs zone substation.[26] Western Power sought the exemption from the 2015/16 financial year as it forecast the capacity available at Meadow Springs would be insufficient to meet the requirements specified in clause 2.5.4(b) from that year. The exemption was sought to avoid the cost of bringing forward the planned expansion of the Meadow Springs substation on the grounds that:

- For 2% of the year the forecast demand will be sufficiently high to breach the NCR risk criteria.
- Operational procedures exist to minimise the risk of load not being supplied during periods where the NCR risk criteria of forecast to be exceeded.
- Uncertainty regarding economic development in the area created a risk that demand may not develop as rapidly as forecast. Investing to meet the NCR risk criteria may be inefficient if demand growth does not achieve forecast levels.

On July 2015, the ERA approved an application from Western Power to be temporarily exempted from complying with the requirements of clause 2.5.4(b) (Normal Cyclic Rating Criterion) of the Transmission Planning Criteria in the Technical Rules at Meadow Springs zone substation until the completion of Stage 2 of the Mandurah load area investment strategy, or unless otherwise revoked under the provisions of the Electricity Networks Access Code 2004.

Lack of guidance on generator connections

Noting that the connection of User facilities is planned to enable the User requirements specified in Chapter 3 of the Technical Rules to be achieved, the current transmission planning criteria gives little consideration to the generator connections beyond the requirement to apply the N-1-1 criteria to sub networks for power stations whose total rated export to the transmission system exceeds 600 MW (clause 2.5.2.3(a)(4) of the current Technical Rules). For example, the current Technical Rules do not provide guidance on planning for the loss of generation that may be dispersed or the maximum generation that is

[26] Refer to: https://www.erawa.com.au/electricity/electricity-access/western-power-network/technical-rules/era-determinations-on-exemptions-from-the-technical-rules/meadow-springs-zone-substation-technical-rules-exemption

permissible to be supplied via a single transmission element and therefore at risk of being disconnected by a single contingency or how generation outages might be planned for.

Further, changes to the location of generation on the SWIS means that that the most critical transmission element from a generation connection perspective are changing. Traditionally, there has been little generation connected north of Perth but the development of large-scale renewable generation projects in the North Country region is changing that. In the future the transmission lines running north of Perth will connect a significant amount of generation. Outage of the transmission network north of Perth have the potential to result in a significant loss of generation.

Including appropriate consideration of generator connection requirements in the planning criteria will help ensure that sufficient transmission capacity is provided to efficiently connect new generation while managing power system security.

Lack of scope for risk-based approaches

Although there is a broad consideration and acceptance of differing levels of risk to customer supplies within the design of the current technical criteria, there is no explicit provision for the use of risk-based planning concepts. This could limit Western Power from planning the network in the most efficient manner, particularly when it comes to prioritising and optimising network investment budgets across multiple potential investment projects that have varying underlying risk considerations.

Additionally, if no consideration is given to such concepts, this can pose issues with respect to unplanned outage events that are not typically covered within the current definition of credible contingencies, i.e., High Impact Low Probability (HILP) events, such as the loss of single double circuit overhead tower line. Such events are unlikely to be explicitly considered within deterministic planning criteria given their low probability of occurrence and, therefore, network planners may not be incentivised to investigate whether there are prudent investment options that would help reduce the impact of HILP events. While it is unlikely that it would be economic to duplicate a transmission line to reduce the impact of a double circuit line outage, it may be economic to implement a wide-area control scheme that rapidly adjusts load and generation in response to such an event to prevent widespread supply disruption that might otherwise occur. Efficient investments that reduce the impact of HILP events are more easily justified if a defined process to identify and value such investments exists within business planning processes.

As part of the Technical Rules revisions, more explicit reference could be made to allow Western Power to adopt risk-based planning concepts. Such considerations would provide additional flexibility and allow Western Power to justify network investments that may not typically fit with the prescribed transmission planning criteria. Alternatively, these same techniques may be used by Western Power to demonstrate that minor deviations from the technical performance or planning criteria can be adequately managed through the proposed mitigation actions and thereby avoid unnecessary capital investment or the need to seek explicit derogations from the Economic Regulation Authority.

Western Power recognises adoption of more explicit risk-based approach to planning would add a level of complexity compared to the current approach. Of importance, the adoption relies on there being sufficient and adequate statistical information to support the required risk analysis. Otherwise, the calculated risks of events occurring could easily be under or over-estimated. In the case of the latter approach, by essentially avoiding any consideration of risk-based planning principles the issues outlined would remain and may continue to be overlooked.

Issues with specific clauses

In addition to the broader identified issues affecting particular elements of the existing transmission planning criteria, a number of specific issues were also identified with the current transmission planning criteria clause (clauses 2.5.2 to 2.5.4) as summarised in Table 4-2 below.

Table 4-2: Issues with specific transmission planning criteria clauses

Criteria	Principal issue(s)
N-0 Clause 2.5.2.1	• Application is unclear for zone substation with peak load > 10 MVA • Clarity is required over terminology definitions
N-1 Clause 2.5.2.2	• Application is unclear for transformer-feeder substation designs, which may lead to inconsistent outcomes. • Clarity is required over the definition of "brief switching period."
N-1-1 Clause 2.5.2.3	• No reference to load levels for 330 kV lines and connections means that all these lines must meet the requirements outlined unless a derogation is sought. • No demarcation in application between Metro and Country areas means some areas are supplied with this high standard when the investment is not necessarily justified based on the load at risk. • The outage conditions listed in Table 2.9 of the current Technical Rules, which lists a series of circumstances when the N-1-1 criteria does not need to be met during an outage, requires review to confirm these are still appropriate. • Clarification of the load levels that should be applied when assessing compliance with the criteria during planned outages.
Perth CBD Clause 2.5.3	• Clarity required around the defined Perth CBD boundary and application to ensure that this reflects current supply arrangements i.e., for substations and feeders supplying load part inside and outside defined boundary. • Review required restoration timeframe requirements to confirm these are still achievable and appropriate.
Zone Subs – 1% Risk Clause 2.5.4.1	• Application of 1% risk criterion questioned, and in particular whether some zone substations outside of the Perth metropolitan area, particularly urban areas, should also be designed to NCR requirements.
Zone Subs – NCR Clause 2.5.4.2	• Significant issues raised around deployment of RRST within defined 12 hour timescales required to apply NCR Criterion – timeframe in practice likely to be significantly longer. • Basis of criterion questioned including whether the standard should be N-1 with divergence to a lower standard based on economic, technical and reliability considerations on a specific case by case basis.

4.1.2 Solution options & preferred solution

There are two broad approaches that can be adopted to address the issues identified above. The first is to re-work and update the current clauses to remove the identified ambiguities, inconsistencies and update application restoration times as necessary to reflect current practice. The second approach is to revise the current planning criteria to make consideration of demand or customer load and its inherent value, the central element uses to select the appropriate planning criteria. The second approach can be achieved in two main ways:

- Using a structured demand or load group approach similar to Great Britain's Engineering Recommendation P2, revision 6 (ER P2/6) standard that stipulates the security requirements for

incremental demand values, with the inherent value of customer load being taken into consideration when setting the demand group thresholds.

- By explicitly valuing customer reliability through a value of lost load approach and using this value to determine the optimal technical and economic design of specific substations or sub-networks of the transmission system using risk based or probabilistic techniques.

Thus, Western Power considered the following options:

a) Revise the current transmission planning criteria to introduce a demand group structure to transmission system planning in a similar manner to the ER P2/6 standard that applies in Great Britain, albeit tailored to Western Australian considerations and requirements.

b) Revise the current transmission planning criteria to be fully or partly based on risk-based or probabilistic techniques and the use of value of customer reliability.

c) An approach that is a hybrid of option a) and b) whereby specific planning arrangements and demand groups are adopted akin to the Great Britain approach, but flexibility to deviate from the standard is provided for where economically justified.

d) Minimal change - Retain the existing transmission system planning criteria and update the Technical Rules to address the issues identified with clauses to remove ambiguities, inconsistencies and other out of date terminology and requirements.

Western Power has proposed changes consistent with option c) and the main characteristics of this approach are explained in section 4.1.3 of this report.

Option c) provides the appropriate balance between increasing the flexibility of approach to ensure efficient long-term investments, while retaining a structured approach that can be more readily adopted by transmission planners working in the SWIS context. The proposed approach:

- Removes the lack of clarity that was present in the current provisions.
- Aligns the updated drafting with the current intention of the Technical Rules to provide for higher security requirements for areas of the network that are more important.
- Is more flexible than the current approach because it allows for different planning standards to be applied as demand and generation locations alter power flows on the system.
- Can cater for known changes to the market including the change to a constrained (non-firm access) environment that is being introduced.

In developing the proposed drafting, Western Power considered the current network capability and considered future market changes. The proposed criteria move away from a planning system solely focusing on equipment types and historical geographic demand centres. The proposed approach will better optimise expenditure in the longer term as the security standards applicable to areas of the network can change as demand changes.

In considering the relative merits of options a), b) and c), Western Power considered the principal advantages and limitations of the demand group approach considered in option a) and a pure risk-based approach contemplated in option b). The advantages and limitations of each approach are summarised in Table 4-3.

Table 4-3: Summary of advantages and limitations of alternative demand based approaches

Approach	Advantages	Limitations
Structured demand groups	• Consistent application across individual demand groups • Clearly identifiable points at which higher security requirements apply • Avoids need to calculate value of customer load reliability in majority of cases • Avoids complex and bespoke risk or probabilistic calculations for which underlying data may not be available • Makes restoration activities in operational timescales easier as requirements are transparent	• Less flexibility to vary requirements within individual demand groups (although not impossible) • Step change in security requirements can occur when incremental movements across demand group scale • Can underestimate true value of customer load reliability, particularly for commercial and industrial customers
Customer reliability value	• Allows individual customer characteristics and load value to be explicitly included in the network design • Flexibility to adopt bespoke substation designs for loads • Avoids step change in security design requirements though small incremental load increases	• Basis for risk and probability calculations may not fully reflect operational considerations and may be less transparent • Requires detailed asset reliability and failure rate statistical data • Requires an explicit means of valuing reliability of supply • Investments for rural and remote areas may never pass economic test but are required to comply with licence conditions • More complex analysis results in investment decisions that are more difficult and costly to independently verify, which can lead to reduced transparency

Reviewing the characteristics outlined Table 4-3, it is evident that each approach has a number of advantages and limitations. However, on balance, Western Power considers the structured demand group approach offers the better starting basis for a planning criterion.

Structured demand groups offer a more transparent and simple starting point. Further, the limitations associated with a structured demand group style approach are easier to overcome than those where a customer reliability approach forms the basis the criteria.

The limitations of step change security requirement can be overcome by incorporating some risk based or reliability specific considerations into each demand group. For example, where a small increase in demand at a zone substation resulted in that substation's demand moving into the next demand group range triggering increased supply security requirements, a probabilistic criterion could be applied to defer the need to apply the higher supply security requirements if the considered risk exposure was limited. This could be used as a means to defer capital investment needed to enhance the security of supply for the substation or as a longer term solution if the period of exposure (time spend outside of security requirement) was not expected to increase i.e., if demand was stable or falling.

Based on the above, Western Power proposes changes that reflect a hybrid approach. The function specific planning arrangements and demand groups that form the basis of the proposed criteria are akin to the Great Britain approach, but flexibility is provided to deviate from the standard where there is technical or economic merit. The hybrid approach proposed by Western Power retains the main advantage of structured demand groups approach whilst negating the main limits.

Option d) was not considered sufficient to address issues with more fundamental concern with the current planning criteria. In particular, the continued lack of flexibility to adjust planning standards as use of the systems changes will become increasingly problematic. The transmission planning criteria has dated and requires significant revision.

4.1.3 Proposed transmission system planning criteria

The proposed transmission system planning criteria is based on the demand group structure to transmission system planning outlined in ER P2/6 standard that applies in Great Britain, albeit tailored to Western Australian considerations and requirements. The following sections outline the key components of the proposed criteria, namely:

- Planning is based on functional parts of the transmission system ensuring there are no gaps,
- A formulaic, transparent approach is used that speaks to a more clearly defined set of outages and contingencies,
- Ability to adapt to known future changes to the WEM, and
- Other elements of the planning criteria are maintained so that the approach does not result in a step-change.

These attributes are detailed in the subsequent sections.

Planning based on functional parts of the transmission system

The proposed transmission system planning criteria restructures the requirements for the system in terms of the functional parts of the system, namely:

- Main Interconnected System (MITS) and sub transmission system,
- Generation connections, and
- Demand connections.

This approach ensures there are no gaps and is consistent with the approach adopted in Great Britain.

The **MITS and sub transmission system criteria** applies to the most critical parts of the transmission system. The MITS comprises:

- all 330 kV terminal stations and transmission circuits connected to the 330 kV network by three or more 330 kV circuits;
- all terminal stations providing direct connection to generation in excess of 600 MW (consistent with the existing requirement in clause 2.5.2.3(a)(4)); and
- the transmission circuits connecting 330 kV terminal stations to the terminal stations providing direct connection to generation in excess of 600 MW.

The sub transmission system are the parts of the transmission system that are not part of the MITS.

For the MITS and sub transmission system, the security standard is applied recognises the importance of these parts of the network and that outages on these parts of the network could put the system at risk or could affect a large proportion of customers.

The MITS and sub transmission system require the Network Service Provider to consider the security of power transfers across large portions of the network. For this reason, when outages or faults occur, the potential loss in demand considered naturally results in criteria applicable to the larger demand groups generally being used.[27]

Two background conditions are stipulated in a new Attachment to the proposed Technical Rules that outline the background conditions applicable when planning the MIST and sub transmission systems:

- The System Security Background represents the typical planning assumptions used when applying the planning criteria, such as a worst case demand forecast and a security constrained economic dispatch that is then modified to represent a credible worst case dispatch scenario for the area of the network being investigated. The intent of the System Security Background is to allow the planning of the transmission system to consider a range of credible but challenging future system conditions to ensure that there is sufficient transmission capacity to meet demand reliably and securely across a range of disparate outcomes.
- The System Economy Background is intended to represent the most likely network assumptions and the lowest cost dispatch ignoring any network transfer constraints. This approach is used to identify boundaries that have the potential to lower overall system cost through augmentation. Under the System Economy Background condition, all boundaries identified as constraining the most efficient dispatch outcome must be investigated and monitored to ensure the most efficient outcome between market constraint cost and network transfer capacity augmentation.

Several additional requirements are provided for in the MITS and sub transmission criteria (clause 2.5.5.6 of the proposed Technical Rules) that allow the Network Service Provider to consider constraints[28] as alternative solutions to network and non-network solutions. The role of these provisions in assisting with the transition to a constrained market is discussed below, in the section titled, “Ability to adapt to known future change to the WEM”.

The **demand connection criteria** apply to areas of the system that support demand groups, where demand groups are a site or group of sites that collectively take power from the remainder of the system. The criteria do not replace those Chapter 3 requirements that might require specific design of connection assets to achieve the User’s requirements.

The criteria proposed for demand connections replicate the intention of the original Technical Rules. However, the proposed changes allow for the security standard to flex as the demand on the system changes, leading to more efficient investment outcomes in the long term.

The proposed permitted loss of demand groupings broadly aligns to the existing approach. Rural, Urban and Perth CBD requirements are retained with the security requirements increasing within these broad classifications as the quantity of demand at risk increases. For example, for rural parts of the network and under intact system conditions, the allowable time period for a loss of demand <20 MVA due to a loss of

[27] Some areas of the sub transmission system supply regional areas where load is relatively small and the revised planning criteria adapts appropriately for these smaller demand groups.

[28] ‘Constraint’ has the meaning given the WEM Rules. As at 1 July 2021, this definition was “(a) a Network Constraint; and (b) a limitation or requirement affecting the capability of a Load or generating system such that it would represent a risk to Power System Security or Power System Reliability if the limitation or requirement was removed.”

transmission circuit credible contingency is the repair time. Whereas the same circumstance but for groups of demand greater than 20 MVA there is no should be no loss of demand.

For the Perth CBD area, the existing restoration times of 2 hours is retained for a contingency event following an existing planned or unplanned local outage and 30 seconds for the outage of a single transformer. As with other functional parts of the network, the contingencies that need to be considered for each demand group is clearly specified so that the system can be efficiently planned and subsequently operated with a clearer understanding of has been catered for. Contingencies defined in the proposed planning criteria are outlined further in sections 4.1.3 and 4.2 of this report.

There are newly defined time periods for which permitted demand losses are acceptable:

- repair time is the time taken to repair the fault and restore supply to the area.
- remote switching time is the time it would typically take to carry out remote switching from the Network Service Provider's control centre.
- emergency return to service time is the pre-agreed time to recall a planned outage following an unplanned event.

Where the permitted loss of demand time is stated as 'None', the system should be planned so that no demand is lost. For clarity, this is different from load shedding that may occur if the UFLS scheme is triggered. UFLS scheme load shedding should occur as a last resort and in emergency events, whereas permitted demand losses specified in the proposed transmission system planning criteria are intended to reflect the value of the lost load compared to the costs of avoiding that loss in demand. Group demands have been developed to align with the existing standards and with consideration to the network configurations.

When planning the network, two types of demand losses are considered depending on the level of security to be achieved:

- group demand is used for assessments of the system capability with intact system conditions, and
- maintenance period demand is used for assessments of the system capability with planned and unplanned outage conditions.

The maintenance period demand is, by definition lower than group demand, consistent with the current practices.

The **generation connection criteria** apply to areas of the system that support generation. These areas of the system may support the connection of one or more generators to the remainder of the system and included embedded generation. The criteria do not replace the Chapter 3 requirements that apply to connection assets.

In planning generation connections, the criteria require the Network Service Provider to look at the loss of power infeed that may occur under the set of defined scenarios. The loss of power infeed calculation included in clause 2.5.3.1 of the proposed Technical Rules is intended to calculate the net loss of power during a forecast minimum demand period. In this way, the planning takes an appropriately conservative approach to the risks the system may be exposed to from a network outage that results in a loss of generation.

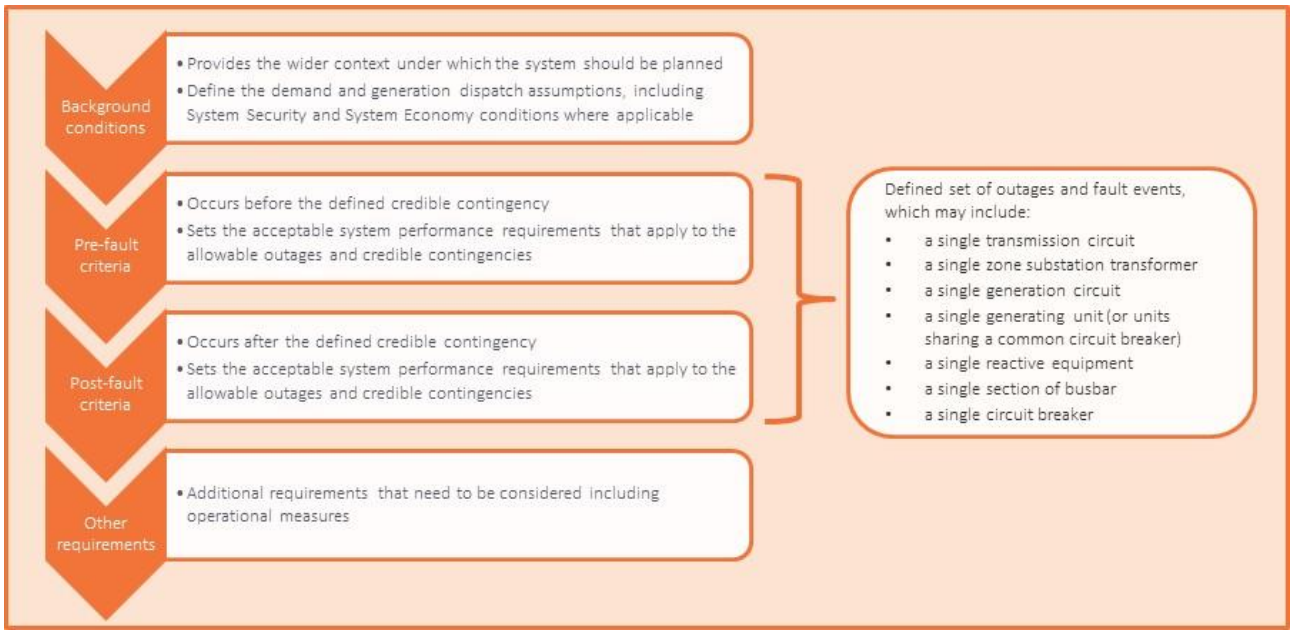
The maximum infeed loss limit permitted for any part of the transmission system is 400 MW (clause 2.5.3.1(b) of the proposed Technical Rules). This value is lower than the export limit of 600 MW specified in the existing N-1-1 planning criteria (refer to clause 2.5.2.3(a)(4) of the current Technical Rules and clause 2.5.2(b) of the proposed Technical Rules). However, the value of 400 MW is in line with the size of

generation contingency which is likely to be able to be accommodated by essential system service available in the WEM. Currently AEMO procures spinning reserve services sufficient to cater for the loss of the largest generating unit. Setting the maximum infeed loss at 400 MW is therefore unlikely to impose an unrealistic expectation of the amount of essential system service required.

Further, Western Power proposes the maximum reduction of generation capacity at any single section of busbar during a planned outage should be limited to 150 MW (clause 2.5.3.1(d) of the proposed Technical Rules). This figure is consistent with the current network configuration and is considered a reasonable upper limit given the size of the SWIS.

Formulaic, transparent approach to planning

The proposed transmission system planning criteria provides for a formulaic approach to planning the system. For each functional part of the system (MITS and sub transmission, generation connection, demand connection), background conditions are established, then pre- and post-fault criteria are set out that consider the intact system and the system with a local outage[29]. The outage and contingencies that need to be considered are also clearly articulated.



In each case, the functional part of the system must be planned such that when that part of the system is intact (and pre-fault) there are no:

- equipment loadings exceeding the pre-fault rating;
- unacceptable voltage conditions; or
- system instability.

Following any credible contingency of the types identified in the proposed Technical Rules, the same requirements (no equipment overloading, no unacceptable voltage conditions and no system instability) must also be meet. However, loss of demand is permitted to the extent provided for in specified demand group. As described in the section above, the time period and conditions under which demand losses are permitted vary based on the size of the demand group at risk.

[29] The exception is generation connections for which local system outage conditions are not applicable.

As discussed further in section 4.2 of this report, the proposed transmission system planning criteria provides for a more clearly defined set of outages and credible contingencies. The outages and contingencies listed in in the proposed criteria vary between clauses.

The proposed approach, when implemented, will be consistent with the way the system is being planned. That is Western Power already studies for the above list of outages and faults. However, the revised drafting brings a significantly enhanced level of transparency compared to the previous drafting. This transparency is important as it will enable better consistency across planners, particularly with strategic longer term plans developed through the Whole of System Plan. Enhanced transparency also better allows interested stakeholders to understand the reasons for proposed transmission system investments, which in turn may create opportunities for providers of non-network services to work with Western Power to develop options capability of addressing identified needs.

Flexibility to respond to demand and more efficiently manage the network

Table 2-11 in the proposed Technical Rules outlines the permitted loss of demand following specified credible contingencies. While the table sits within the demand connection section, the table is used when planning all functional aspects of the network when it forms one of the conditions that must be met.

Previously the equipment and geographic specific criteria meant the system was inflexible to changes in demand. With the adoption of the demand groups in Table 2-11, changes in the potential loss of demand being considered for an area will naturally alter the criteria that is applied. For example, if the loss of demand from a contingency event during the planned outage of a transmission circuit in an urban area is greater than 90 MVA but less than 250 MVA, the planner must ensure the maintenance period demand is only unsupplied for the emergency repair return to service time. However, if there was demand growth such that the loss was likely to be greater than 250 MVA, steps would need to be taken to avoid that loss entirely.

The flexibility in responding to demand works in both directions. As the load at risk falls for particular parts of the network, the security planned for naturally adjusts so that when existing assets reach the end of their life these are replaced or managed to achieve the standard appropriate for that new lower demand profile. Importantly, the process allows the planner to manage the network and transfer of demand between groups during outages to make better utilisation of plant and equipment. In this way, consideration of demand transfer capability allows for more efficient outcomes.

The adoption of demand groups provides additional transparency with respect to future network design and investment requirements. Specifically, incremental security and redundancy requirements when moving between demand or load groups can be more easily tied to capital investment plans and an evaluation of the technical (reliability) and economic benefits of doing so to determine if the investment is appropriate.

Ability to adapt to known future change to the WEM

Reforms being progressed by the Western Australian Government are expected to introduce a constrained access regime for the WEM. Users will be allowed to use the access that is available and, should they wish to relieve any of the constraints, they will have the opportunity to do so or the option to be constrained.

The System Economy Background conditions provided for in the proposed Technical Rules directly provides for a future constrained dispatch market environment. This set of background conditions represent the most likely network assumptions and the lowest cost dispatch ignoring any network transfer constraints.

This approach is used to identify boundaries that have the potential to lower overall system cost through augmentation. The changes will enable the Network Service Provider to consider the value of imposing

constraints where this is more economically efficient than alternative network and non-network solutions. Consequently, the Technical Rules need to cater for these circumstances.

Other requirements in the MITS and sub transmission criteria have been designed with the move to constrained dispatch in mind. Clause 2.5.5.6(c) of the proposed Technical Rules allows the Network Service Provider to consider network and non-network solutions except where operational measures, including constraints, suffice to meet the criteria.

MITS and the sub transmission criteria are designed to ensure efficient levels of network transfer capability are delivered in a way that minimises the costs to users of the system, while ensuring reliability, adequacy supply. These additional clauses ensure the full range of available options are considered.

4.2 Definition of credible contingency

Credible contingencies are used in electricity network planning to define the set of circumstances that are reasonably foreseeable and should be planned for. The same terms are used in operational timeframes to define circumstances when the operator should reasonably be able to manage the system within acceptable, pre-defined limits. These circumstances can be distinguished from emergency operating states, where unforeseeable (or uncontrollable) events must be handled.

Credible contingencies applicable to the SWIS are defined in the WEM Rules and the Technical Rules. The current definition used in the Technical Rules are outlined in Table 4-4 below. The term 'Credible Contingency Event', is used throughout the Technical Rules, including in clause 2.5.2.3 (N-1-1 Criterion) and clause 2.5.8 (Maximum Fault Currents) within the transmission and distribution system planning criteria (section 2.5).

Table 4-4: Credible contingency definitions

Term	Definition
contingency event	An event affecting the power system which the Network Service Provider expects would be likely to involve the failure or removal from operational service of a generating unit or transmission/distribution element.
credible contingency event	A single contingency event of one of the following types: a. for voltages at or below 66kV, a three phase to earth fault cleared by disconnection of the faulted component, with the fastest main protection scheme out of service; b. for voltages above 66kV: i. a two-phase to earth fault cleared by disconnection of the faulted component, with the fastest main protection scheme out of service; or ii. a three-phase to earth fault cleared by disconnection of the faulted component, with the fastest main protection scheme out of service. This criterion is to be applied only to transmission elements where the Network Service Provider can demonstrate that the design type, environmental conditions, historic performance or operational parameters results in a material increase in the likelihood of a three-phase to earth fault occurring. c. a single-phase to earth fault cleared by the disconnection of the faulted component, with the fastest main protection scheme out of service; d. a single-phase to earth fault cleared after unsuccessful high-speed single-phase auto-reclosure onto a persistent fault;

	e. a single-phase to earth small zone fault or a single-phase to earth fault followed by a circuit breaker failure, in either case cleared by the operation of the fastest available protection scheme; or f. a sudden disconnection of a system component, e.g. a transmission line or a generation unit.

4.2.1 Current issue

Credible contingencies are well understood as a concept and there is agreement on how these should be planned for and managed in operational timeframes. However, several points of clarification were raised through the Technical Rules review. These included:

- Incorrect labelling of definitions – the current definition for credible contingency events is a list of faults with exception of the final item in the list, which is a disconnection. None of items listed is a contingency.[30]
- Potential confusion as to the treatment of particular plant when the timeframe under which credible contingencies can occur is considered.

  Contingencies within an operating timeframe may differ from those that can reasonably (and economically) be considered and catered for in a planning timeframe. That is, the contingency that is "credible" may necessarily differ across the time frames. In the planning timeframe, a lack of definition either exposes the operator to significant risk or is very costly if the range of credible contingencies that might arise in the operational timeframe are planned for. An example where this difference plays out is secondary systems. These systems need to be appropriately considered as credible continencies and more holistically where there is a risk of cascading effects due to outages or faults in these systems. Western Power has experienced difficulty in obtaining permission to take protection elements and other secondary systems out of service for maintenance due to the application of an expanded contingency definitions during the outage. This scenario may not have been considered in the design and specification of the secondary systems.
- Lack of clarity on the treatment of specific circumstances as contingencies, for example:
  - Loss of an entire busbar or bus section being classed as a credible contingency event and therefore the need for this to be considered from network planning, operations and outage scheduling purposes. A related concern is whether the decision about what is credible takes into account the probability of the contingency or the consequence of the contingency if it occurred.
  - That the scope of power system elements that need to be considered is unclear when applying the N-1-1 criteria.
  - Whether contingencies are limited to single events or if they also contemplate multiples events. If the definition is narrowly considered, the risks posed by building multiple circuits in the one easement are not captured.[31]

Additionally, during the Technical Rules review, the operating states and contingency events outlined in the WEM Rules have been updated (note operating states are discussed further in section 10.5 of this report). The changes include:

[30] A contingency is a future event or circumstance which is possible but cannot be predicted with certainty.

[31] This network arrangement can present operability issues, for example, if during extreme weather conditions, the loss of multiple circuits is reclassified as a credible contingency event. Securing the network for that reclassified contingency can be difficult if the network was not designed to provide the necessary levels of redundancy.

- Moving to an operating state framework that defines a satisfactory operating state and a secure operating state and an expectation of restoring the system to a secure state as soon as possible and within a time frame defined in the power system security principles.
- Adopting a secure operating state definition that requires the system to be able to sustain a credible single contingency events and return to in a satisfactory operating state following power system security principles. The definition of credible contingency event is an important aspect of the framework as are the power system security principles.
- Introducing a requirement that to the extent practicable, the SWIS should be operating such that it is in a reliable operating state.
- Introducing definition for credible contingency event and a reclassification framework allowing AEMO to decide when to treat non-credible events as credible.

While there is a benefit in aligning the framework for operating states and contingency events defined in the WEM Rules and Technical Rules, there is a risk that the Technical Rules and WEM Rules will become duplicative or become misaligned over time. Western Power also considers a further level of specificity is possible within the Technical Rules because the main function of the definitions is to drive outcomes in planning timeframes. Nevertheless, the two regulations should align to the extent practicable.

In other jurisdictions, the size or impact of the contingency is considered when deciding whether a particular contingency needs to be considered when planning and operating the transmission network. This approach is used in the Middle East and the UK, where the size of the demand group or generation impacted by an event is considered as well as the definition of the event or contingency. This approach allows, for example, a contingency that removes a bus section from service to be considered if there is a sufficiently large amount of load or generation impacted by the contingency. The advantage of this approach is that it clarifies which contingencies need to be consider in planning and operating the network as well as helping to prioritise what is reasonable given the relative impacts.

4.2.2 Solution options & preferred solution

In developing options to address the issues associated with the existing credible contingency definition, Western Power considered the proposed changes to the transmission system planning criteria discussed in section 4.1 of this report. Included in those proposed changes are a more clearly defined set of outage and contingencies that should be considered credible within a planning timeframe.

Options considered include:

a) Revising the credible contingency definition in planning timeframes to align with an updated definition used in operational timeframe (and broad principles of WEM Rules outcomes).

b) Updating the credible contingency definition in planning timeframes only.

c) Clarifying the terminology used in definitions and adopting clearly specified credible contingency circumstances in the updated transmission planning criteria.

d) No change.

Of the considered options, option c) is recommended. The term credible contingency is used in several areas through the Technical Rules, including for distribution system requirements where the WEM Rule definitions may not be directly applicable. The approach drives appropriate alignment between the definitions in the WEM Rules and Technical Rules but recognises the benefit of more explicit contingency definitions be specified in the Technical Rules as this allow better clarity and transparency regarding the transmission planning criteria.

Alignment with the WEM Rules was strongly considered. However, the range of circumstances that can be considered credible in operating timeframes is necessarily different from those that should prudently be considered within planning timeframes. The proposed changes for the transmission system planning criteria adequately cover the range of credible faults and outages that are currently being planned for and provide a more transparent solution.

4.3 Use of alternative plant ratings within planning timescales

Plant ratings are the limits given by manufacturers to equipment used in the power system. Long term ratings are those ratings that can be maintained under most circumstances. Equipment can be operated at the long term ratings without risk of the asset life being shortened or other adverse effects occurring.

Alternative and short term ratings are typically greater than long term ratings for the same equipment. These ratings consider conditions such as temperature or the time period over which the equipment can safely be run at the specified rating. Alternative ratings in a planning context can include short-term permissible thermal ratings for overhead lines or substation transformers for minutes or potentially hours to facilitate load transfers during outage conditions, or alternative ratings for adoption within the planning timescales beyond typical summer, spring/autumn, winter ratings commonly used. Equipment is often able to run safely at alternative or short term ratings for a period of time. However, operation at these limits for longer period risks stressing the equipment to the point of failure.

The difference between long term and alternative or short term ratings provides operators of the power system a degree of flexibility in the way they manage the system. Knowledge of these ratings enables them to safely demand more from equipment when needed to provide for short term requirements or in an emergency.

The adoption of alternative ratings by planners of the system can lead to deferral of upgrades. For example, the planner may determine that is appropriate to use short term ratings in some scenarios rather than applying the stricter long term rating. Often an additional margin is added to ratings to account for uncertainties that might arise in operational timeframes. It is important when choosing ratings in planning timeframes that the network planner preserves sufficient margin to cater for uncertainty. This is particularly important if the planner is considering adopting short term ratings in order to defer investment. Failure to preserve sufficient margin risk under-investment resulting in operational difficulties particularly under unexpected conditions.

4.3.1 Current issue

The Technical Rules do not reference or make explicit allowance for short-term or other plant and equipment ratings in a planning context. As such, it is not clear how these alternative ratings may be adopted to meet the transmission and distribution planning criteria. Nevertheless, the use of long term and short term emergency ratings for underground cables, in addition to normal cyclical ratings, is detailed in the Western Power Distribution Planning Guidelines including use in potentially deferring projects due economic inefficiencies, financial or deliverability constraints.

There may be advantages in clarifying in the Technical Rules how and when alternative ratings may be used when planning the transmission and distribution system. Benefits of using these ratings in planning timeframes include:

- providing additional flexibility in relation to the development of future network capital investments,
- optimisation across a portfolio of projects, and
- potentially allowing some projects to be deferred.

However, as highlighted above, a balance needs to be stuck between planning allowance and the need to leave operational and control system engineers with some “headroom” to operate the system.

Additionally, the application of alternative and short-term plant and equipment ratings may require investment in equipment to measure ambient conditions in real time. Up to date information on the condition of assets is also required to facilitate the specification of appropriate equipment ratings. To implement alternative ratings in an operational timeframe it may also be necessary to adjust protection settings. The cost of the measures necessary to facilitate the use of alternative ratings should be considered carefully and may limit the scope for applying alternative ratings to just those instances where doing so will avoid material network augmentations or upgrades.

4.3.2 Solution options & preferred solution

Western Power considered the following options that would address the above issue:

a) Update the transmission planning criteria to explicitly allow the use of alternative or short-term ratings when determining compliance with planning criteria, including detailing specific requirements for individual plant types and voltage levels.

b) Update the transmission planning criteria to explicitly allow the use of alternative or short-term ratings when determining compliance with planning criteria, but only include high level description.

a) No change.

Of the considered options, option b) is preferred. The revised transmission planning criteria includes a general requirement that clarifies the arrangements for when short-term and other alternative plant are used. The updated drafting requires the Network Service Provider to maintain up to date, functional and deliverable outcomes in operational timescales when using these ratings.

The preferred option recognises that there may be limited cases where such approaches can be useful applied, but also recognises that underlying asset condition data may not be perfect in all instances and also that some flexibility in plant capacity is needed in operational timeframes and during contingencies i.e., cannot be used in planning timescales.

Option a) is not recommended at this stage. Detailing requirements for specific plant types, demand groups or voltage levels for the transmission system is a potentially resource intensive exercise. Western Power considers developing an approach as needs arise is appropriate in the first instance following this change.

Option c) is also not recommended. Remaining silent on the use of alternative ratings within the transmission system planning criteria risks leaving consideration of this flexibility and subsequently the use of the flexibility unclear. There is therefore a risk that planning and operational outcomes are less coordinated than they would be with an explicit reference and link.

4.4 Perth CBD planning criterion & definition

The Technical Rules sets out a defined planning criterion that applies to “sub-networks of the transmission system that transfer power to the Perth CBD and zone substations …”. The requirements are detailed in clauses 2.5.3 and these provisions are complimented by requirements in clause 2.5.5.2 (distribution feeders). Perth CBD is defined in the Glossary with reference to a geographic area within the City of Perth and the zone substations suppling that area (Table 4-5).

Table 4-5: Current Technical Rules definition for Perth CBD

Term	Current definition
Perth CBD	The geographical area in the City of Perth bound by Hill Street (East), Havelock Street (West), Wellington Street (North) and Riverside Drive and Kings Park Road (South) and supplied (exclusively or in part) from the following *zone substations*: Hay Street, Milligan Street, Wellington Street, Cook Street and Forrest Avenue[(1)]. [(1)] Subject to a periodic review

4.4.1 Current issue

During the review process Western Power considered the role of the Perth CBD criterion and whether it should be updated. Consideration was given to the following:

- Whether the security requirement should be retained for the Perth CBD.
- The geographic boundary as outlined in the Glossary was developed based on the location of government and other high importance loads. However, since then new developments have arisen (e.g., Elizabeth Quay, Metro Arena area) as well developments just outside and on the fringes the defined boundary area. Additionally, there is significant interconnection at distribution system level and between substations both within and outside the CBD. Collectively, this demonstrates the difficulty in drawing a geographic boundary that fully captures issues associated with supply to, and security of customers within the Perth CBD.
- Forrest Avenue zone substation has been decommissioned.

4.4.2 Solution options & preferred solution

Western Power considered the following options that would address the above issue:

a) Update the current defined geographic boundary Perth CBD area to account for new load area developments and update substation references.

b) Remove the geographic boundary element from the Perth CBD definition and leave the definition based on reference to particular substations (updated if necessary). Incorporate the current Perth CBD requirements into a specific demand group within the proposed transmission system planning criteria

c) Remove references to zone substation supplying load from the Perth CBD definition and incorporate the Perth CBD requirements into a specific demand group within the proposed transmission system planning criteria.

d) Remove references to the Perth CBD boundary from the transmission system planning criteria and rely on the demand groups within the proposed criteria to provide for suitable requirements based on the load for that area. Update the Perth CBD definition to enable references in the Technical Rules function appropriately.

e) No change.

Of the considered options, option c) is preferred. There was broad agreement throughout Western Power and representatives at AEMO and Energy Policy WA that were consulted during the development of the proposed Technical Rules that there remains a need for a higher planning security standard for the Perth CBD area, which is something that also applies in other jurisdictions.

Option c) will allow a defined CBD area to be maintained for the purpose of the planning standard. The change in definition to refer only to a geographic boundary allows for the more efficient supply of that area and removes the need to make upgrades for a wider and less critical areas supplied by the named

substations. Reference to the Perth CBD area and particular requirements have been incorporated in the proposed transmission planning criteria outlined in section 0 of this report. In the proposed changes, the Perth CBD is called out in the demand group table and given an N-2 criterion consistent with current arrangements.

Option a) was discounted as it is considered a temporary fix and would need to be further adjusted if and when new load developed close to the revised new boundary.

Options a), b) and e) all retain references to substations. As seen following the retirement of the Forrest Avenue substation, associating definitions with fixed substations risks the definition becoming out of date. Several of the substations listed in the current definition will need to be upgraded or modified in the next 10 to 15 years. Further, labelling substations provides a degree of inflexibility. As the network changes over time, the loads supplied by the substations can change and leading to coverage becoming unclear.

Option d) is conceptually appealing, particularly as the proposed transmission system planning criteria naturally adapts as demand moves across the power system. Under this option, if load were to move away from the CBD, the requirement to maintain the highest levels of security would automatically fall away leading to reduced network expenditure in the longer run. However, this would be a fundamental change to the supply reliability provided for the Perth CBD, which would be inconsistent with other jurisdictions.

4.5 Distribution system planning criteria

Like the current transmission system planning criteria, the planning criteria for the distribution system is deterministic in nature. It applies specified redundancy levels for substations or network types and is largely based on geographic boundaries. Areas that have historically experience higher load typically have higher redundancy requirements.

The main elements of the current distribution planning criteria detailed in sections 2.5.5.1 to 2.5.6.2 of the Technical Rules are presented in Table 4-6.

The distribution system planning criteria is supported by the Distribution Network Planning Guideline. This guideline provides comprehensive guidance on the detailed application of the distribution planning criteria considering the various factors that can change across the different parts of the distribution network.

Table 4-6: Summary of existing distribution planning criteria

Criteria	Description
N-0	Loss of supply occurs following a fault outage until the failed equipment has been repaired or replaced. This general criterion applies to the whole distribution system.
HV feeders in the Perth CBD	Distribution feeders in the Perth CBD must be designed such that during an outage, supply can be restored using remote controlled switching.
HV urban feeders (outside the Perth CBD)	Distribution feeders must be designed such that during an outage, supply can be restored using manual switching. Applies outside of the designated Perth CBD boundary.
HV radial feeders (within Perth metro area)	Distribution feeders should be designed to limit the number of customers on a switchable feeder section to 860 if the feeder section cannot be energised through a backup interconnection. Applies within the Perth Metro area.
HV rural feeders	Distribution feeders are normally designed without interconnection unless such interconnection is technical and economically feasible.

Criteria	Description
LV feeders	Designed to the N-0 criteria unless interconnection is technically and economically feasible. For underground residential subdivisions, a switching point must be provided for every 16 connection points.

4.5.1 Current issue

Given the proposed changes to the transmission system planning criteria, where a more structured approach based around demand groups is proposed, there is an opportunity to similarly revise the distribution planning criteria.

A variety of more minor issues have been identified with the current distribution planning criteria. Several of these are addressed in the remainder of this section.

In addition, the current distribution requirements are largely fragmented and detailed within individual clauses, with some requirements detailed in the Distribution Planning Guideline.

4.5.2 Solution options & preferred solution

Western Power considered the following options that would address the above issue:

a) Update and amend existing clauses related to the HV and LV distribution system to address current know issues and limitations (as outlined in sections 4.6 and 4.7 in this report).

b) Provide a comprehensive update of the LV and HV distribution system planning criteria to introduce a structured approach more in keeping with the revised transmission planning criteria and with the planning security standards that apply in other jurisdictions.

c) No change.

Western Power proposes changes consistent with option a). This option addresses the immediate issues related to the distribution system planning criteria.

Option b) was considered in-depth and is expected to be preferred in the longer term as it will enable more flexible planning of the system. However, Western Power considers taking a staged approach to reform of the system planning criteria appropriate given the type of changes being considered. The staged reform of transmission first and then distribution system planning at a later date will make better use of scarce planning resources and enables learnings from the adoption of reforms to transmission system planning to be feed into future distribution system planning changes.

As part of the Technical Rules review, Western Power developed draft demand groups for distribution that aligned with those proposed for the transmission planning criteria. Western Power considered a restructure based on the demand size and security requirements (similar to the transmission planning criteria). However, Western Power also considered an approach structured around voltage levels and urban and rural area definitions. This second option is likely to be more appropriate as it allows the key difference that arise between the longer rural and short metropolitan distribution feeders to be considered.

If adopted, these changes would align with the format adopted in other jurisdictions, e.g., Essential Energy, where distribution network planning and design requirements are structured based on regional or area classification with population references.

A staged approach to reform will also allow Western Power to consider and revisit the balance of prescription across the Technical Rules and in the Distribution Network Planning Guidelines.

In addition to implementing changes consistent with option a), structural changes are proposed for the distribution system planning criteria that separate the transmission and distribution planning criteria. This includes giving some existing criteria a lower heading level within the Technical Rules, so all clauses related to the distribution system planning criteria are contained within a single section.

4.6 Distribution feeders in the Perth CBD

Clause 2.5.5.2 of the Technical Rules sets out the requirements for distribution feeders in the Perth CBD. It states:

> *Distribution feeders in the Perth CBD must be designed so that in the event of an unplanned loss of supply due to the failure of equipment on a high voltage distribution system, the Network Service Provider can use remotely controlled switching to restore supply to those sections of the distribution feeder not directly affected by the fault.*

Redundancy in the feeders in the Perth CBD is required because these feeders supply critical load. Consistent with the status of this load, remote control is used to ensure the timely operation and control of switching needed to maintain supply to this area.

4.6.1 Current issue

The current wording places remote control switching requirements only on feeders *in* the Perth CBD and is not clear on coverage for sections of feeders that sit outside of the defined Perth CBD boundary but originate from within the Perth CBD boundary. A strict interpretation of the drafting may result in inefficient expenditure relative the desired objective of securing load within the Perth CBD.

For example, if half of a feeder lies within the Perth CBD and half outside, a narrow interpretation would result in only half of that feeder being considered for remote switching (the part that falls within the Perth CBD). However, installations on the second half of the feeder (outside the Perth CBD), which still controls the whole feeder, may be a more efficient means of achieving the CBD requirements.

As discussed in section 4.4 of this report, the definition for Perth CBD is problematic and requires revision. Even with the proposed revision clause 2.5.5 of the Technical Rules should be clarified so that drafting better aligns with the likely objective of the clause.

4.6.2 Solution options & preferred solution

Western Power considered the following options that would address the above issue:

a) Update drafting of clause 2.5.5.5 of the Technical Rules to clarify requirements so that the critical load is treated as such.

b) No change.

Option a) is preferred. Proposed drafting aligns with the intended purpose of the clause and avoids boundaries that are arbitrary from an electrical systems perspective. The preferred solution clarifies the requirement to make investments to apply the requirements to load supply by zone substations in the Perth CBD as well as feeders within the Perth CBD. This also aligns with updates to the definition of Perth CBD discussed in section 4.4 of this report to ensure the combined changes maintain the existing planning standards for this area.

4.7 Distribution visibility

Distributed energy resources, including electric vehicles, household battery storage and solar rooftop PV, are changing the way the distribution system is used. Historically, visibility was required at transmission levels and introduced by exception at distribution voltages. However, improved visibility over the distribution system is needed to understand and, where appropriate, manage these changed flows. Improved visibility also allows adoption of less conservative limits improving the ability to host renewable generation connected to the distribution network.

Visibility over power system flows can come from a range of data points across the system. However, transformers are a critical part of the distribution system infrastructure and it's critical to understand the power flows over these assets so that these assets are not overloaded and unable to perform their functions optimally. Measurements taken at distribution transformer locations also help the Network Service Provider better understand and estimate the power flows across the upstream and downstream networks and the voltage performance.

Clause 2.6(f) of the Technical Rules relates to the provision of load monitoring equipment on distribution transformers. The clauses states:

> *"Distribution transformers rated at 300 kVA or above must be fitted with load monitoring equipment. This must provide a local indication of actual and peak load and must be capable of being modified in the future to enable remote monitoring of the transformer load".*

Load monitoring equipment collects a range of data depending on specifications and may facilitate local and remote readings. The key parameters needed to understand power flows and power quality at a distribution level include:

- Actual and peak load
- Signed (i.e., positive or negative) active power (kW) and reactive power (KVAr), voltage and current.

Remote monitoring enables timely collection and analysis of data leading to faster response times where operational controls are needed in real time. Remote monitoring provides more accurate assessment of the state of the distribution network, which assists Western Power to operate assets closer to their rated capacity, which in turn improves the ability to host distributed energy resources such as roof top PV systems.

4.7.1 Current issue

The current wording of clause 2.6(f) of the Technical Rules limits Western Power's ability to install *remote* load monitoring equipment on distribution transformers during initial construction and development by requiring only that the transformer has the capability to be modified in the future. While it is possible to retrofit remote load monitoring equipment to larger distribution transformers and Western Power has done this in the past, the practical issues associated with fitting monitoring to already installed transformers often make this option less attractive and therefore less preferred.

A more efficient and effective approach that achieves greater visibility over time is to enable new transformers to be fitted with remote load monitoring equipment as they are installed. This approach provides the monitoring at a much lower cost as it avoids the expense of a brownfield retrofit.

Going forward Western Power requires greater visibility and remote monitoring of the distribution network to effectively manage the power system, maximise the ability to connect DER and optimise expenditure. In particular, greater visibility at the distribution level will allow Western Power to:

- more readily identify and manage emerging system issues,
- more confidently identify available network capability reducing the need to limit renewable generation or distributed energy resources, and
- understand where and what type of network management or control options are required to achieve the greatest benefit more quickly.

This view aligns with that of AEMO and Energy Networks Australia, who identified defining enhanced network visibility as a key capability for any future Distribution System Operator and Distribution Market Operator role.[32]

Other jurisdictions have found direct benefits in installing improved monitoring and remote control on low voltage transformers. Box 4-4 provides case studies from Scottish and Southern Energy Networks in the UK and SA Power Networks in South Australia.

In the UK, the Distribution Network Operators have a separate budget for conducting innovative trials for new technologies, processes and commercial arrangements. This has helped roll-out active network management and intelligent voltage control across the distribution network, resulting in savings to customers and faster connections. The innovative projects are reported on through the Open Networks Portal, managed by Energy Networks Association (UK), to enable shared learnings[33].

Box 4-4: Case studies for installation of remote monitoring control on LV transformers

Scottish and Southern Energy Networks - Low Cost LV Substation Monitoring

An LV substation monitoring project undertaken by Scottish and Southern Energy Networks in the UK involved a trialling low-cost retrofit monitoring solutions for LV feeder pillars. The £1.1 million project enabled data from the equipment to be transmitted via cellular network to a data portal.

The data collected through the project provided much greater visibility of the LV network and valuable details on electric vehicle hotspots and network imbalances.

The study has helped Scottish and Southern Energy Networks understand where DER, including electric vehicles, is growing and the level of reinforcement required. Of note, the data can be used to manage and control the network more efficiently and consequently defer augmentations.

SA Power Networks – LV Transformer Monitoring[34]

SA Power Network's LV monitoring program involves installing and commissioning permeant remote monitoring at a sample set of approximately 1,300 multi-customer LV distribution transformers in the metropolitan area to improve capacity and planning in the LV network.

In the longer term, the permanent monitoring sites established through this program will enable the current practice of undertaking around 500 transformer load surveys each year using temporary loggers to be phased out, giving a permanent reduction in operating costs. As a consequence, SA Power Network estimates over the 15-year life of the transformer monitors the program has positive net present value under all sensitivity cases considered in the business case.

The Australian Energy Regulator approved $5.2 million for this program (of which $1.3 million is operating expenditure) in its final decision.[35]

[32] AEMO and Energy Networks Australia, Interim Report: Required Capabilities and Recommended Actions, report for the Open Energy Network Project, July 2019. Available here.

[33] Refer to: https://www.energynetworks.org/creating-tomorrows-networks/open-networks/

[34] SA Power Networks, LV transformer monitoring business case (supporting document 5.15), 2020-25 Revised Regulatory Proposal, 27 November 2019.

[35] Australian Energy Regulator, *Attachment 5: Capital expenditure, Final decision SA Power Networks 2020-25*, June 2020, p. 5-40. Available here.

4.7.2 Solution options & preferred solution

Western Power considered the following options that would address this issue:

a) Modify clause 2.6(f) of the Technical Rules to require all new distribution transformers >300 kVA to be capable of remote load monitoring. Continue to allow existing transformers >300 kVA to be retrofit, where reasonable.

b) Modify clause 2.6(f) of the Technical Rules to require all new distribution transformers >300 kVA to be capable of remote load monitoring. Allow all existing transformers to be retrofit, where reasonable, and provide guidance examples in a drafting note.

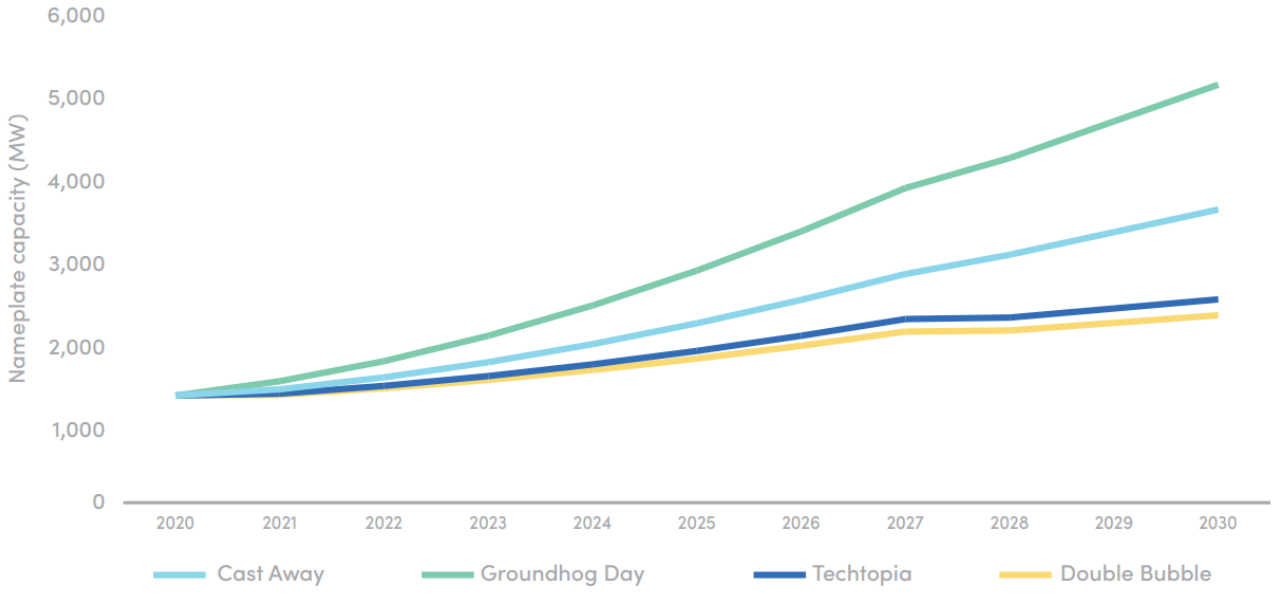
c) Keep existing clause 2.6(f) wording but detail the acceptable conditions under which the modifications should take place and the economic and technical arguments that would support this. This detail may be outside of the Technical Rules i.e., in the Distribution Network Planning Guideline or another procedural document.

d) No change.

Of the considered options, option b) is recommended. This is the most efficient option to provide the necessary increase in visibility to manage the increasing level of distributed energy resources being connected to the distribution network.

The need for improved visibility is evident from the projected increase in distributed energy resources, mainly rooftop PV systems assumed in the 2020 Whole of System Plan.[36] The four scenarios in the Whole of System Plan project continued growth in the capacity of installed roof top PV systems connected to the SWIS. For example, the Groundhog Day scenario assumes rooftop PV capacity increases from 1,291 MW in 2020 to 5,037 MW by 2030 (Figure 4-1).

Figure 4-1: Cumulative rooftop PV capacity 2020 to 2030



Source: Energy Transformation Taskforce, *Whole of System Plan 2020*, August 2020, Figure 4.13, p. 59.

[36] Energy Transformation Taskforce, *Whole of System Plan 2020*, August 2020. Available at: https://www.wa.gov.au/government/document-collections/whole-of-system-plan

The requirements for small generating systems are specified in sections 3.6, 3.7 and 3.8 of the proposed Technical Rules. As discussed in section 6.4.2 of this report, the revised User requirements place an obligation on all generating systems to be able to operate to an export limit set by the Network Service Provider. This change is necessary to provide Western Power with the ability to impose export limits where required to ensure the capability of the distribution system is not exceeded.

The improved visibility provided by option b) will help Western Power set appropriate export limits that maximise the opportunity for embedded generators to export power while managing the security of the distribution system.

Option b) is a prudent approach to providing increase visibility. The option allows for the installation of remote load monitoring on transformers >300 kVA when these are installed (or replaced) – when it is most cost effective to install equipment.

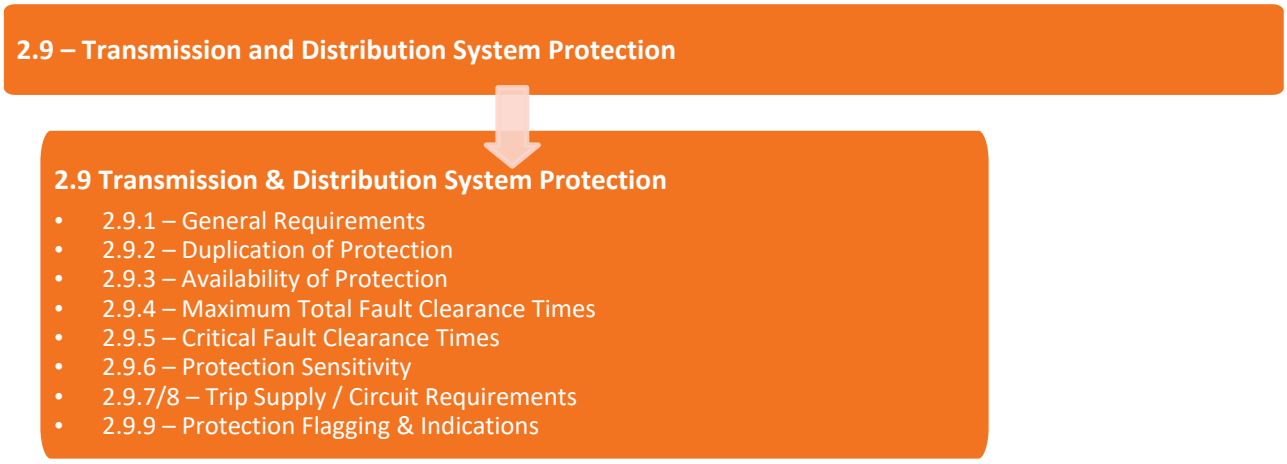
For other transformers, the option does not mandate that remote monitoring is enabled, instead it provides the discretion for Western Power to do so where warranted. This will allow Western Power to only activate remote monitoring on new transformers where there is an assessed need to do so. In situations where there is insufficient need for remote monitoring (i.e., there is forecast to be very low penetration of embedded generation) Western Power can avoid activating remote monitoring at the time of commissioning thereby avoiding the cost of providing the communications facility to transmit the monitored quantities back to the Western Power control centre.

The proposed option will allow Western Power to add remote monitoring when new transformers are commissioned in areas of the network where there is a strong need for improved visibility. These are likely to be areas of the network project to experience growth in distributed energy resources.

5. Transmission and distribution system protection

The transmission and distribution system protection requirements that apply to Western Power's networks are contained in section 2.9 of the Technical Rules.

The structure of these sections of the Technical Rules is illustrated in the following diagram.



The limitations, issues and proposed solution to address issues that have been identified through the Technical Rules review process are discussed in the sub-sections that follow.

5.1 Clarity on duplication of protection requirements

The role of protection schemes in a power system is to keep the power system stable by rapidly isolating all components that are under fault, but also ensure that the sections of the network that have no fault will continue to operate (protection discrimination). Protection systems should also remain unaffected by conditions external to the protected zone (protection stability). The reliable operation of these schemes is therefore critical for power system stability and security.

Due to the critical role protection schemes play, it is common for these schemes to be duplicated to provide independent schemes which provide reliable clearing of a fault even if one of the primary protection scheme fails. For duplication to provide a robust protection system, the two schemes must be capable of operating fully independently (i.e., no shared communications or power supply), and they should not be vulnerable to the same equipment failures.

Power systems rules commonly require network operators to install two fully independent protection schemes of different principles or manufactured by different organisations, if these use the same principles, to minimise the risk that both protection schemes fail to operate as a consequence of either the principle failing to detect the fault or a failure of the protection relay.

5.1.1 Issue

Several clauses in the Technical Rules require "two fully independent protection schemes of differing principles[37]" to be implemented. However, there are situations when this may not represent the best solution and having two protection systems with the same operating principle would be preferred. For example, where the speed of the protection system is critical, and the use of two different methods results in inadequate primary protection because the second method is not sufficiently quick.

[37] In this context, the principle refers to the way that the protection system detects or measures the faults.

The Glossary defines the term 'two fully independent protection schemes of differing principles' and makes it clear that the same method of operation for both schemes is permitted if the two schemes have "been designed and manufactured by different organisations" (Table 5-1). However, there is currently no reference to this exception within the clause drafting. As such, it is only indirectly discoverable that this exception applies and the requirement around when to use schemes of differing principles may be ambiguous.

Table 5-1: Relevant protection scheme definition in the Technical Rules

Term	Current definition
two fully independent protection schemes of differing principle	*Protection schemes* having differing principles of operation and which, in combination, provide dependable detection of faults on the protected *primary equipment* and operate within a specified time, despite any single failure to operate of the *secondary equipment*. To achieve this, complete secondary *equipment* redundancy is required, including *current transformer* and *voltage transformer* secondaries, auxiliary supplies, signalling systems, cabling, wiring, and circuit breaker trip coils. Auxiliary supplies include DC supplies for *protection* purposes. Therefore, to satisfy the redundancy requirements, each *protection scheme* would need to have its own independent battery and battery charger system supplying all that *protection scheme's* trip functions. In addition, the relays of each *protection scheme* must be grouped in separate physical locations (which need not be in different panels). Furthermore, the two *protection schemes* must either use different methods of operation or, alternatively, have been designed and manufactured by different organisations.

5.1.2 Solution Options

Western Power considered the following options that would address this issue:

a) Amend clauses that refer to "*two fully independent protection schemes of differing principle*" to remove "of differing principle". Update the Glossary definition accordingly.

a) Amend clauses that refer to "*two fully independent protection schemes of differing principle"* to say, "two fully independent protection schemes of differing principle or have been designed and manufactured by different organisations."

b) No change.

Western Power considers both options achieve the same aim. However, option a) is slighter simpler to implement as the term "two fully independent protection schemes of differing principle" is defined in the Glossary and used in a number of clauses of the Technical Rules. As such, Western Power recommends changes consistent with option a) be implement revisions to six clauses in the revised Technical Rules [38].

5.2 Duplication of protection where fuses are used

Protection systems are duplicated in a power system because of the critical role they play in avoiding situations that would overwise pose a significant risk to human and system safety. The duplication requirement acknowledges that technology and equipment involved is typically not fail safe. Should the primary protection system fail for any reason, a secondary system is available that preforms the same protective function.

[38] Clauses 2.9.2(a)(1), 2.9.2(a)(2), 2.9.2(b)(2), 3.5.2(c), 3.5.2(d), 3.5.3.6.

However, some protection equipment is designed to be fail-safe. That is, the design inherently responds in a way that will cause minimum or no harm to other equipment, to the environment or to people. Fail-safe in this context does not mean that failure is impossible or improbable, but rather that the system's design prevents or mitigate unsafe consequences of the system's failure.

5.2.1 Issue

Clause 2.9.2(b)(1) of the Technical Rules requires that "primary equipment forming part of the distribution system must be protected by two independent protection systems". Fuses, which form part of the distribution protection systems, are considered under Western Power's distribution design policy to be inherently failsafe. Consistent with this view, there is not typically a requirement to duplicate this part of the protection systems in other jurisdictions, such as Great Britain.

Western Power has historically exercised judgement in interpreting the Technical Rules and not installed duplicate protection systems on parts of the high voltage distribution network that are protected by fuses. Installing additional fuses to fulfil the requirements for a second protection system would incur unnecessary equipment duplication and be uneconomic.

5.2.2 Solution options & preferred solution

Western Power considered the following options that would address this issue:

a) Amend the existing clause wording to make clear where Western Power design policies apply and where deviation from the duplicate protection system requirement is acceptable.

b) No change.

Western Power recommends option a) is implemented. This option reflects practice in other jurisdictions and avoids the situation where Western Power is in breach of the Technical Rules or otherwise required to incur additional uneconomic costs by installing duplicate protection systems where fuses are used in the distribution system.

The recommended drafting for clause 2.9.2(b)(1) makes clear that parts of the distribution systems protected by fuses do not need to meet the duplicate requirements.

5.3 Availability of protection systems

Similar to other equipment on the power system, protection systems (and schemes) need to be taken out of service from time to time for upgrades, maintenance and repair.

5.3.1 Issue

Clause 2.9.3(a) of the Technical Rules allows protection schemes to be taken out of service for up to 48 hours every 6 months without necessarily removing the protected primary equipment from service. However, there is no differentiation between unplanned and planned outages.

For unplanned outages, 48 hours is considered an acceptable time period to replace the majority of failed components. However, for planned outages, the complexity involved in undertaking full protection system replacements or significant upgrades can require an outage of a significantly longer duration. So long as there are no unreasonable risks to the power system from allowing an outage of protection schemes, enabling a longer period for planned protection system outages should support more efficient outcomes.

Further, under clauses 2.9.3(b) and 2.9.3(c) of the Technical Rules, the protected element must be removed from service (in addition to the protection scheme) unless instructed otherwise by AEMO in the case of

transmission system protection, or in the case of distribution protection, the Network Service Provider assesses the distribution system elements must remain in services to maintain power system stability.

There are circumstances whereby protection needs to be taken out of service longer than 48 hours to facility critical maintenance work. In these circumstances, it may not be possible to take a primary plant outage. However, changes could be introduced that allow for a mechanism to assess the risk of the protection outage and have an appropriate approval process in place. This would ensure the risk of taking the protection out for longer than 48 hours while keeping primary plant in service is managed.

The allowed outage duration of 48 hours is limited to one period every 6 months. Western Power understands the purpose the 6 monthly limit is to put some bounds around taking multiple consecutive outages for the same equipment. This ensures customers that might otherwise be affected do not experience more or longer outages than needed. However, the 6-month limitation:

- can make scheduling of upgrades and maintenance difficult,
- is impractical as the 6-month period is difficult to track, and
- may be unnecessary where protection is duplicate and outages leaving one protection scheme in service are acceptable.

Further, the protection outages taken in alignment with the current Technical Rules are done to improve the conditions of assets and Western Power does not consider this limit should hinder the ability to make these improvements.

If the Technical Rules were updated to allow outages beyond 48 hours (subject to appropriate risk-assessment and approvals) the need to take multiple outages within a 6-month period is likely to reduce.

5.3.2 Solution options & preferred solution

Western Power considered the following options to address the above issue:

c) Amend clauses 2.9.3(a) to 2.9.3(c) of the Technical Rules to provide for an updated risk-based approach to allowing equipment outages where protection system outages are planned.

a) Remove the reference to 6 months in clause 2.9.3(a) of the Technical Rules.

b) Options a) & b).

c) No change.

Option c) is preferred. Removal of the six month limit on outages will enable appropriate and timely upgrade and maintenance of protection schemes and systems. The risks associated with outages of protected equipment can be managed through the updated clauses that require the Network Service Provider to conduct a risk-assessment and put in place risk-mitigation for equipment outages associated with planned protection system outages. The requirement to keep protected transmission equipment in service if required by AEMO is maintained. As outlined above, the changes are similar to the practice already adopted by Western Power for construction work activities where a detailed risk assessment and mitigation paper is routinely compiled before undertaking planned outages.

5.4 Application of maximum total fault clearance times for ‘new’ and ‘existing’ equipment

Maximum total fault clearance times are maximum allowed time in which a fault should be cleared. As outlined in the Glossary for the Technical Rules, this is the time from fault inception to the time of complete

fault interruption by a circuit breaker or circuit breakers. The total fault clearance times take into consideration the time taken for both circuit breakers and protection equipment to operate.

The ability for equipment to meet maximum total fault clearance times depends on the nature of technology and when it was developed as well as the range of equipment that, together, dictate the clearance time.

Technology changes mean that newer equipment tends to operate significantly faster than equipment that was installed prior to the Technical Rules commencement (in 2007). However, as the total time achievable is limited by all equipment that together results in the clearance of a fault, the operating times of equipment involved in each system must be considered in setting an appropriate maximum total fault clearance time. For example, where a protection relay detects a fault and sends a signal to a circuit breaker to open, the time to clear a fault is the time to detect the fault (dictated by the relay logic process and response) plus the time it takes to open the circuit breaker (i.e., receive and respond to the signal). A very small amount of time is also included in the total times that reflects operation of communication equipment.

5.4.1 Issue

Clause 2.9.4 of the Technical Rules sets out the maximum applicable fault clearance times for zero impedance short circuits faults at different voltage levels across the SWIS. Two sets of applicable maximum clearance times are detailed in Tables 2.10 and 2.11 of the Technical Rules, those that apply to Existing Equipment and those that apply to New Equipment. With the times that apply for Existing Equipment are typically longer than those that apply for New Equipment.

As per sub-clause 2.9.4(i), the term “existing equipment” refers to equipment in service at the Rules commencement date, which for the current version is defined as 1 July 2007. Accordingly, equipment that forms part of protection systems that was installed prior to 1 July 2007 is only required to meet the Existing Equipment times.

Given there are multiple pieces of equipment that together comprise a protection system, in some instances, it is unclear exactly what equipment is being referred to and how the term “Existing Equipment” should be interpreted in practice.

There is also no differentiation between primary and secondary equipment with regards to “existing” or “new”. In practice, this lack of clarity creates confusion as to which definition applies when, for example, a partial replacement of protection relays and other secondary equipment is carried out, but related switchgear (primary equipment) is not upgraded.

5.4.2 Solution options & preferred solution

Western Power considered the following options to address the above issue:

a) Amend existing clause wording by removing column labels “Existing Equipment” from Tables 2.10 and 2.11 and adopt either the ‘New Equipment’ or the ‘Existing Equipment’ times for all equipment covered by the tables.

b) Clarify the definition of “existing equipment” under sub-clause 2.9.4(i) to refer to a defined ‘material changes’ such that the correct and appropriate maximum fault clearance times that apply under partial component upgrade conditions are clear.

c) No change to drafting of clause 2.9.4 but use the guideline introduced under clause 1.9.4 of the proposed Technical Rules to capture appropriate guidance.

Option c) is the preferred option. The guideline proposed under changes to clause 1.9.4 (discussed in section 2.6 of this report) provides an efficient and flexible mechanism for capturing useful examples that demonstrate when modifications should result in the application of 'New Equipment' times. The grouping of similar topics in this guidelines avoids several definitions being introduced for bespoke circumstances and thus prevents the Technical Rules from becoming over complicated.

While both options a) and b) were considered appropriate to address the confusion, for the reasons outlined below neither offered a perfect solution. The persistence of the issue will naturally decrease as more of the relevant equipment reaches the end of its life and is replaced. Until such time, Western Power is considering alternative non-Technical Rules solutions such as capturing details in internal guidelines.

Option a) is not considered appropriate or viable at this point in time. Numerous components of Western Power's protection systems were installed prior to 2007. It is not economically prudent to require Western Power to upgrade these components, nor would it be realistic to apply the New Equipment times to these older systems. While applying the longer Existing Equipment times to components that were installed after 2007 would be feasible and active the option a) outcome of removing the New and Existing Equipment distinction, Western Power does not consider this a prudent outcome. As such, option a) is not considered viable.

Option b) is also not recommended. The introduction of a defined term 'material change or upgrade' that is designed to be specific to the equipment covered in clause 2.9.4 of the Technical Rules is potentially confusing. Western Power considered various definitions that could be adopted. However, in each case, judgement continues to be needed in understanding whether the existing or new times should apply. As such, the introduction of a definition, even when supported by examples, does not resolve the issue sufficiently to justify amendments to the Technical Rules.

Western Power will continue to apply the current practice whereby the new equipment times are required to be meet only where all upgrades of all or part of the system enable these stricter times to be met.

5.5 Weak infeed fault conditions

Transmission protection equipment relies on a level of fault current existing on the system to function. Under weak infeed fault conditions, generating units connected to the distribution system supply a fault current that is significantly below normal load current of the installed transmission protection scheme.

In recognition of this issue, the Technical Rules were updated in March 2016 so that under weak infeed fault conditions, total fault clearance times of one of the transmission protection schemes meets the remote end total fault clearance times set out in the Rules.

5.5.1 Issue

Users connecting to the distribution system are required to fund weak infeed assessments and provide for mitigation where studies indicate investment is needed remedy issues arising from their connection i.e. where investments are requirement to satisfy the clause 2.9.4(j) of the Technical Rules.

Several refinements to the weak infeed fault condition provision were identified that would benefit Users if adopted and allow for appropriate assessment that consider the risks posed by a weak infeed:

1. Assessment should only be required where there is a high risk of sustained islanding. Weak infeed fault conditions as described in the Technical Rules only occur when there is a sustained islanding of the relevant part of the distribution system. Under normal circumstances, an island will not be sustained and this will clear and fault contribution from generators embedded in the distribution network.

The Technical Rules requires assessment in all circumstances. This is more conservative than necessary given the nature of the problem.

2. Assessments should exclude circuit breaker failures. It is rare for sustained islanding to coincide with circuit breaker failure. The inclusion of this scenario in current assessments therefore adds an unnecessary level of complexity.
3. Clarity is needed regarding the practicable point of assessment. The Technical Rules do not specify how deep into the distribution network the assessment should consider. The lack of clarity has potential to drive inconsistent approaches and for some assessments to be more detailed than others. Western Power considers assessments that do not go beyond the remote end of the transmission line isolator are acceptable.

5.5.2 Solution options & preferred solution

Western Power proposes changes to address and clarify each of the issues outlined above. The changes proposed provide for a more reasonable and practicable approach to weak infeed assessments.

The clarifications allow for risks for be appropriately assessed and reduce the cost of assessments for Users. For new connections the changes should reduce the time needed for connection studies.

5.6 Critical fault clearance times

The maximum total fault clearance times specify the maximum fault clearance times which the transmission and distribution protection systems are designed to achieve. The maximum total fault clearance times are considered when specifying the ratings for plant and equipment as equipment may be required to safely carry fault currents for these times.

In some situations, a fault must be cleared more quickly than the maximum total fault clearance times in order to maintain power system stability. In these circumstances the Network Service Provider will identify Critical fault clearance times which are the maximum time interval by which faults must be cleared in order to preserve power system stability.

5.6.1 Issue

Clause 2.9.5(b) of the Technical Rules relates to main protection requirements and critical fault clearance times. The clause requires the main protection systems meet all of the relevant requirements under clause 2.9.2(a). Clause 2.9.5(a) states that the Network service Provider may apply critical clearance times to a part of the transmission or distribution system but the referenced clause 2.9.2(a) applies only to transmission protection system, not distribution protection system. The distribution system requirements for duplication of protection are detailed in clause 2.9.2(b).

In practice, Western Power considers applies the main protection requirements specified in clause 2.9.2 for transmission and distribution protection when assessing the ability of the main protection systems to meet critical clearing times. The reference under sub-clause 2.9.5(b) should be revised to include 2.9.2 generally (transmission and distribution) in line with clause 2.9.5(a).

5.6.2 Solution options & preferred solution

Western Power considered the following options to address the referencing issue above:

a) Change the reference to in clause 2.9.5(b) from clause 2.9.2(a) to clause 2.9.2 such that distribution system requirements are also picked up (rather than transmission only under 2.9.2(a)).

a) No change.

Western Power recommends changes consistent with option a). This is a simple change to improve consistency between related Technical Rule clause requirements.

6. User requirements

The technical requirements that Users must satisfy to connect equipment to the transmission or distribution systems are specified in chapter 3 of the Technical Rules. The chapter is separated into sections that provide technical requirements differentiated by:

- whether the User facility consumes power (i.e., is a load) or produces power (i.e., is a generating system),
- the rated capacity of the facility, and
- how the facility is connected (i.e., transmission or distribution connected).

The figure below shows the current structure of chapter 3 of the Technical Rules and the proposed structure. The structure retains a similar differentiation of requirements with adjustments made to help Users identify the requirements applicable to their facilities.

Current structure for chapter 3:
3.1 Introduction
3.2 Requirements for all Users
3.3 Requirements for connection of generating units
3.4 Requirements for connection of loads
3.5 User's protection requirements
3.6 requirements for connection of small generating units to the distribution network
3.7 Requirements for the connection of energy systems to the LV distribution system via inverters

Proposed structure for chapter 3:
3.1 Introduction
3.2 Requirements for all Users
3.3 Requirements for connection of large generating systems to the transmission system or HV distribution system
3.4 Requirements for connection of loads
3.5 User's protection requirements
3.6 requirements for connection of small generating systems to the transmission system or HV distribution system
3.7 Requirements for the connection of small generating systems to the LV distribution system
3.8 Requirements for the connection of inverter energy systems connected to the LV distribution system via a standard connection service

The following sections of this report consider the limitations, issues and proposed solutions to address identified issues relevant to chapter 3 of the Technical Rules.

6.1 Introduction

Section 3.1 of the Technical Rules provides guidance to assist Users to understand which of the technical requirements specified in chapter 3 apply to their facility.

Western Power has identified revisions to the introduction section of chapter 3 that could:

- Provide enhanced navigation assisting Users to identify applicable requirements.

- Simply drafting by consolidating information defining generating system modes of operation.

These issues are addressed in turn in the following two sections.

6.1.1 Navigation

Current issue

The introduction section provides insufficient guidance for Users to understand which technical requirements apply, particularly where their facilities include a combination of generating systems, loads and electricity storage facilities.

The problem is further exacerbated by the existing drafting of the Technical Rules, which can be ambiguous about the technical requirements applicable to particular generating systems. For example, the provisions appliable to a small generating system connected to the transmission system with a rating < 10 MW is unclear as clause 3.3.1(c) suggests that such a generator may fall beyond the scope of clause 3.3, 3.6 and 3.7 leaving the technical requirements undefined.

Existing and potential new navigational issues were considered in the context of the revised technical requirements proposed in the remainder of this chapter.

Solution options & preferred solution

Western Power considered the following options to address the above concern:

a) Extensive restructuring of chapter 3 of the Technical Rules including introduction of sections that provide specific technical requirements for electricity storage facilities and for facilities that combine load and generating systems.

b) Include additional information in section 3.1 of the Technical Rules that helps Users identify which of the technical requirements expresses in other sections of the chapter apply to their facilities.

c) No change.

Western Power proposes changes consistent with option b). The revisions introduce a new clause 3.1(d) that includes two tables identifying the technical requirements applicable to transmission and distribution connected facilities. The tables provide further differentiation by type of facility so that requirements applicable to loads, generating systems, and electricity storage facilities are clear. In addition, the subsections in chapter 3 specifying technical requirements for different types of facilities have been renamed to better describe the types of facilities they apply to. An introductory section in each of those sections further clarifies the facilities covered by the technical requirements in that section.

In the proposed changes, generating system requirements are differentiated based on the size of the generating systems. A 5 MVA threshold is used to differentiate between large and small generating systems. The 5 MVA threshold is lower than the 10 MW threshold adopted in the current Technical Rules. However, a review of contemporary practice supports adopting the lower threshold. The 5 MVA thresholds aligns with practices in the NEM specifically:

- Section 11(1)(a) of the National Electricity Law requires that any person engaged in the activity of owning, controlling or operating a generating system in the NEM must be registered as a Generator, unless exempt. AEMO has allowed a standing exemption for generating systems with a nameplate rating of less than 5 MW[39];

[39] AEMO, *Guide to generator exemptions and classification of generating units, National Electricity Market*, 1 February 2021, p. 5. Available at: External Procedures Template Mar 2015 (aemo.com.au)

- AEMO requires that all battery energy systems with a nameplate capacity of 5 MW or more must register as both a scheduled generator and a market customer[40], and
- Registration as a generator in the NEM means that generating system and battery energy storage systems need to meet the generator performance requirements specified in the NER, including the requirements to negotiate generating performance standards.

The proposed clause clarifies that electricity storage facilities must adhere to:

- the technical requirements for loads when they are consuming active power i.e., charging, and
- the technical for generating systems when they are producing active power i.e., discharging.

The proposed changes will assist Users to identify which technical requirements apply to their facility and better account for emerging technology where electricity storage facilities are concerned.

6.1.2 Modes of operation

Current issue

The existing requirements for generating systems vary depending on the mode of operation of the generating system. For example, some requirements depend on whether the generating system operates continuously in parallel to the transmission or distribution system, occasionally operates in parallel to the transmission or distribution system or only operates in parallel for short term tests.

Several revisions are proposed to clarify the requirements applicable to generating systems. Those revisions address gaps in the existing Technical Rules that create ambiguity regarding the technical requirements that apply to particular generating systems. The solution proposed involves using four subsections in chapter 3 to specify technical requirements applicable to different types of generating systems:

- Clause 3.3 of the proposed Technical Rules specifies requirements for large generating systems connected to either the transmission or high voltage distribution system.
- Clause 3.6 of the proposed Technical Rules specifies requirements for small generating systems connected to either the transmission or high voltage distribution systems.
- Clause 3.7 of the proposed Technical Rules specifies requirements for small generating systems connected to the low voltage distribution systems.
- Clause 3.8 of the proposed Technical Rules specifies requirements for inverter energy systems connected to the low voltage distribution system via a standard connection service.

The modes of operation are defined in clause 3.6.2(d) of the Technical Rules. If this same approach was repeated in the revised Technical Rules it would result in the definition of modes being repeated in various sections specifying technical requirements for generators. This approach increases the length of the Technical Rules and risks inconsistent specification of operating modes.

Solution options & preferred solution

Western Power considered the following options to address the above concern:

a) Move the clause defining operating modes to section 3.1 of the Technical Rules.

[40] AEMO, *Fact sheet – Registering a Battery System in the NEM*, November 2018, p. 1. Available at registering-a-battery-system-in-the-nem.pdf (aemo.com.au)

b) No change - resulting in operating mode definition being repeated in generating system sub-sections of chapter 3.

Western Power proposes changes consistent with option a). The revisions propose introducing a new clause 3.1(e) which retains the same definition of operating modes as appears as clause 3.6.2(d) of the current Technical Rules. This allows for more efficient drafting and reduces the risk of inconsistent definitions of operating modes for different types of generating systems across the revised Technical Rules.

6.2 Requirements for all users

Section 3.2 of the chapter 3 specifies requirements that apply to all Users. The figure below compares the structure for this section in the current Technical Rules and the revised structure recommended by Western Power. The revisions:

- Consolidate the requirements for Users to control fault current contributions and to keep fault currents within the limits specified in the transmission and distribution planning criteria.
- Clarify the main switch requirements to reduce the need for future exemptions.
- Clarify the modelling requirements.
- Include generator performance standards in the list of technical matters to be coordinated.
- Include a requirement to maintain a User performance register.
- Include an explicit provision allowing the Network Service Provider to review control and protection settings for User facilities and arrange for modification of settings where necessary to improve power system security, reliability and quality of supply.
- Require Users to ensure the design of their facilities comply with the WA Service and Installation Requirements.

The rational for each of the key revisions are presented in the subsequent sections of this report.

Current structure of scetion 3.2 of the Technical Rules:
3.2.1 Power system performance standards
3.2.2 Main switch
3.2.3 User's power quality monitoring equipment
3.2.4 Power system simulation studies
3.2.5 Technical matters to be coordinated

Proposed structure for section 3.2 - Requirements of all users
3.2.1 Power system performance standards
3.2.2 Main switch
3.2.3 User's power quality monitoring equipment
3.2.4 Modelling data for power system simulation studies
3.2.5 Technical matters to be coordinated
3.2.6 Register of performance requirements
3.2.7 Changes to control and protection settings
3.2.8 Other installation requirements

6.2.1 Power system performance standards - Fault contribution

The power system performance standards require that fault levels on the transmission and distribution system stay within equipment fault ratings. This requirement appears in clause 2.5.6 and 2.6.4 in the proposed Technical Rules, which reflect a similar requirement that appears as clause 2.5.7 in the current Technical Rules.

Current issue

Clause 3.6.6 of the current Technical Rules places obligations on small generators to manage the additional fault current they inject into the distribution system. With the restructure of chapter 3 there is an opportunity to reposition this requirement as a general requirement for all generating systems. This approach does not change the obligations on Users connecting generating systems but expresses those obligations more clearly. This is achieved by specifying the obligations for both transmission and distribution connected generation in the same clause.

Solution options & preferred solution

Western Power recommends including new clauses 3.2.1(f)(4) and (5) that express the requirements for all generating systems to manage their contribution to fault currents. Specifying the requirement within section 3.2.1 is preferable to the alternative of replicating the requirement within each of the sub-sections in chapter 3 that define technical requirements for different types of generating systems as it allows for more efficient and consistent specification of requirements.

6.2.2 Main switch requirements

User are required to have an appropriate means of disconnecting their facilities from the transmission or distribution system. These requirements are specified as main switch requirements in the Technical Rules.

In the current Technical Rules clause 3.2.2 specifies that all Users apart from large generators must be able to de-energise its own equipment without reliance on the Network Service Provider. The various sub-clauses in chapter 3 provide additional main switch requirements that apply to the different types of User facilities:

- Clause 3.3.3.10 specifies conditions under which a Network Service Provider's circuit breaker can be used as a point of de-energisation for large transmission connected generating systems avoiding the cost of an additional transmission circuit breaker,
- Clause 3.6.7.2 specifies additional main switch requirements for small generating systems connected to the distribution system, and
- Clause 3.7.6.2(a) specifies additional main switch requirements for inverter energy systems connected to the low voltage distribution system.

Current issue

Western Power identified the following issues with the main switch requirements specified in Chapter 3:

- The proposed addition of sub-sections into chapter 3 that provide greater clarity on the technical requirements for different types of generators requires revision of how the main switch requirements are specified.
- The main switch requirements for distribution system connected generators have been the source of many exemption requests. Over 170 exemptions have been processed since the Technical Rules commenced. The majority of these were associated with low voltage distribution connections.

Clarifying the main switch requirements for these generators would minimise the need for future exemptions.

Solution options & preferred solution

Western Power considered the following options to address the identified issues:

a) Expand the main switch requirements for all Users to include common provisions that apply to any User connecting to the low voltage distribution network and introduce a requirement for all User facilities connected to the low voltage distribution network to comply with AS/NZS 3000. This should substantially reduce the need for future exemptions as arrangements that comply with AS/NZS 3000 will now meet the requirements in the Technical Rules.

b) In addition to option a) introduce clauses that specify additional main switch requirements applicable to different types of generating systems:

   i) new clause 3.3.12.2 specifying additional main switch requirements for large generating system based on the requirements in clause 3.3.3.10 in the current Technical Rules with appropriate modifications to allow for the possibility of a distribution connected large generating system.

   ii) new clause 3.6.6.2 specifying additional main switch requirements for small generating systems connected to the high voltage distribution system or the transmission system. The requirements are based on those appearing in clause 3.6.7.2 in the current Technical Rules.

   iii) new clause 3.7.6.1 specifying additional main switch requirements for small generating systems connected to the low voltage distribution system.

   iv) new clause 3.8.5.1 specifying additional main switch requirements for inverter energy system connected to the low voltage distribution system via a standard connection service.

c) Remove the main switch requirements for all Users and introduce new clauses into the various subsections in chapter 3 to independently specify the main switch requirements for the different types of Users.

Western Power proposes changes consistent with option b). This approach provides more efficient drafting and reduces the risk of introducing inadvertent inconsistencies between the main switch requirements that are common to all User facilities. It also allows for differences within the relevant dedicated subsection as appropriate.

Adopting the proposed revisions should reduce the need for exemptions to the main switch requirement, by clarifying the requirements applicable to Users connecting generating systems to the distribution system.

6.2.3 Modelling data for power system simulation studies

Current issue

As noted in section 3.9 of this report, Western Power proposes introducing a requirement for the Network Service Provider to maintain a generator and load model guideline that defines the requirements Users must satisfy when providing modelling information for their facilities. Adopting the proposed revisions requires amendments to the User modelling requirements specified in chapter 3 of the Technical Rules.

Solution options & preferred solution

Western Power proposes revisions to clause 3.2.3 of the Technical Rules that simplify the specification of modelling requirements. The proposed drafting clarifies that all Users must supply modelling information as specified in the generator load and model guidelines.

Additional details regarding the model provision requirements for large generating systems are specified in clause 3.3.11 of the proposed Technical Rules.

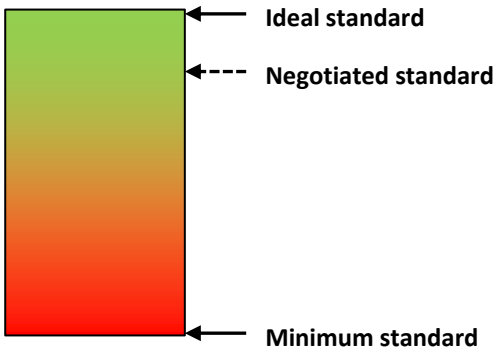
6.2.4 Extend technical matters to be coordinated to include generator performance standards

Section 3.2.5 in the current Technical Rules lists matters that the User and the Network Service Provider must agree upon.

Current issue

The existing list of matters does not include the generator performance standards for large generating systems, which creates an inconsistency with the proposed requirement for Users to negotiate generator performance standards for all large generating systems (see section 6.3.1 of this report for the proposed requirement).

The revisions to section 3.3.4 of the proposed Technical Rules introduce a framework allowing the Users connecting large generating systems to negotiate a set of generator performance standards. The negotiation process reflects that specified in the WEM Rules for transmission connected generators participating in the WEM. Each performance standard addresses a particular technical requirement, and the level of performance must be as close to the specified ideal performance standards as is practicable and must not fall below the minimum standard as illustrated in the following diagram.



Solution options & preferred solution

Western Power recommends extending the list of matters to be coordinated to include generator performance standards for large generating systems.

6.2.5 User performance register

As discussed in section 6.3 of this report, revisions have been proposed to the requirements for generating systems to ensure these systems support the ongoing maintenance of system security. The proposed revisions to the generating system requirements in chapter 3 work in tandem with the enhanced compliance arrangements proposed for chapter 4 of the Technical Rules (as discussed in section 7.4 of this report) to provide ongoing confidence that generators will contribute the technical requirements necessary to maintain power system security.

Given the importance of generators meeting their technical requirements, it is critical that those requirements are well documented and readily accessible to the Network Service Provider, AEMO and the relevant generator.

Current issue

The current version of the Technical Rules does not place any explicit obligation on the Network Service Provider to document generator technical requirements. Failure to address this gap could lead to confusion regarding the technical requirements applicable to individual generating systems.

As part of the connection process, the Western Power requires Users to produce a Technical Rules Compliance Report that contains content demonstrating the User is complying with the relevant areas of the Technical Rules. The final version of a Technical Rules Compliance Report for particular connection works must be accompanied by certification from a Chartered Professional Engineer with National Professional Engineers' Register Standing that the plant is ready for commissioning.[41] Currently, information and evidence, including compliance test plans and results that demonstrates User compliance with the condition of connection are included within the Technical Rules Compliance Report. Hence the relevant information is already being captured and there is an opportunity to formalise the process within the Technical Rules.

Solution options & preferred solution

Western Power considered the following options to address the identified issue:

a) Create new clauses in section 3.2 of the Technical Rules that requires the Network Service Provider to:
   i) maintain a User Performance Register capturing the performance standards negotiated for large generating systems, relevant generating system models, compliance monitoring plans and records produced by User to demonstrate ongoing compliance of larger generating systems with their generator performance standards,
   ii) provide AEMO and the Authority with access to the register on request, and
   iii) provide Users with access to the information in the register for their larger generating system on request.

b) In addition to option a), extend the User Performance Register to also capture key technical requirements for large loads.

c) In addition to option b), extend the User Performance Register to capture technical requirements for all generating systems and loads.

d) No change – rely on existing approaches to capture information.

Western Power proposes changes consistent with option b). This approach captures information in the User Performance Register for those facilities that are likely to have the most significant impact on power system security. It is particularly important that the information for large generating systems is captured as Users controlling large generating systems have the opportunity to negotiate performance standards for their generating systems by applying the negotiation processes defined in either the WEM Rules or the Technical Rules (as discussed in section 6.3.1 of this report).

Extending the scope of the User Performance Register to capture technical requirements for smaller generators is not recommended. Those generators all face with a common set of performance

[41] Western Power, *Technical compliance report (TCR) and guidelines,* 3 August 2017. Available at: https://westernpower.com.au/media/2457/technical-compliance-report-and-guidelines-20170726.pdf

requirements and do not have the opportunities to negotiate performance standards. This means these bespoke performance requirements will not exist, which lessens the need to capture individual performance requirements in the User Performance Register.

Option b) is also preferred as it will allow for alignment between the User Performance Register required by the Technical Rules and the GPS register required under clause 3A of the WEM Rules.

6.2.6 Review of User control and protection settings

Various clauses in chapter 3 specify technical requirements that must be met by User facilities. Satisfying those requirements will generally require specific settings be applied to control and protection systems at User facilities. Those settings can have a significant impact on the performance of the User facilities and the impact those facilities have of the ability to maintain power system security and to meet the power system performance standards.

Consistent with the potential power system security impact, Chapter 4 of the Technical Rules includes provisions that require the Network Service Provider to approve any changes to control and protection settings.

Current issue

As the power system evolves it may become necessary to adjust control and protection settings to optimise the performance of the power system and to maintain power system security. The Technical Rules currently do not provide any explicit provisions allowing the Network Service Provider to review control and protection setting and, where necessary, request changes to settings to improve power system security, reliability or quality of supply to other Users.

Solution options & preferred solution

Western Power has proposed introducing a new clause 3.2.7 to address this issue. The new clause:

- Recognises that the Network Service Provider may review the control and protection system settings within for a User's facility and, where necessary, may require the User to implement setting changes to improve power system security, reliability or quality of supply to other Users.
- Requires the User to implement any recommended changes to settings.

6.2.7 System design and construction standards

Current issue

Clause 2.7 of the Technical Rules requires the Network Service Provider ensure that the transmission and distribution systems comply with key requirements including:

- the Technical Rules,
- Electricity (Network Safety) Regulations 2015,
- relevant codes, standards and regulations such as the Access Code, Australian and International Electricity Commission (IEC) Standards, and
- relevant Electricity Networks Association Guides.

To ensure the distribution system complies with these technical requirements, Western Power requires that Users facilities must comply with the requirements of the WA Service and Installation Requirements. The Technical Rules however do not explicitly express this requirement.

Solution options & preferred solution

Western Power has proposed introducing a new clause 3.2.8 to address this issue. The new clause requires that Users connecting to the distribution system must ensure that the design of their facilities complies with the WA Service and Installation Requirements. This approach reinforces existing practice[42] and should not add any additional cost to Users seeking to connect to the distribution system.

6.3 Large generators

Section 3.3 in Chapter 3 of the Technical Rules specifies requirements that apply to large generating systems. The figure below compares the structure for this section in the current Technical Rules and revised structure recommended by Western Power.

Structure in the current Technical Rules:
3.3.1 General
3.3.2 Provision of information
3.3.3 Detailed technical requirements requiring ongoing verification
3.3.4 Monitoring and control requirements
3.3.5 Power station auxiliary transformers
3.3.6 Synchronising
3.3.7 Secure electricity supplies
3.3.8 Design requirements for generator's substations
3.3.9 Computer model

Proposed structure for section 3.3 - Requirements for connection of large generators
3.3.1 Overview
3.3.2 General requirements
3.3.3 Provision of information
3.3.4 Establishing generator performance standards
3.3.5 Potential relevant generator modifications to existing generating systems
3.3.6 Relevant generator modifications to existing generating systems
3.3.7 Technical requirements addressed by generator performance standards
3.3.8 Remote monitoring requirements
3.3.9 Remote control requirements
3.3.10 Communication equipment requirements Other installation requirements
3.3.11 Generation system model
3.3.12 Safe shutdown without external electricity supply
3.3.13 Restart following restoration of external electricity supply
3.3.14 Generating unit transformer
3.3.15 De-energisation of Generator circuits
3.3.16 Power station auxiliary transformers
3.3.17 Synchronising
3.3.18 Secure electricity supplies
3.3.19 Design requirements for generator's substations

The key revisions include:

- Introducing generator performance standards to clarify Users technical performance requirements, support maintenance of power system security and align with changes to WEM Rules. These changes

[42] User connecting to the distribution system are currently required to meet requirements in the Western Australian Distribution Connection Manual. The WA Service and Installation Requirements documents is the updated name for this Manual.

also allow negotiation of bespoke performance requirements, which should reduce the need for exemptions.

- Clarifying the treatment of modifications to generating systems that impact their ability to achieve technical requirements.
- Clarifying remote control and monitoring requirements.
- Clarifying protection requirements.
- Revisions required to ensure the technical requirements are applicable both distribution and transmission connected large generators.

The rational for each of the key revisions are presented in the subsequent sections.

6.3.1 Generator performance standards framework

Individually, large generating systems have the ability to impact the performance of the power system. It is important that the technical requirements for these generating systems are set appropriately to maintain power system security, reliability and the ability to meet the power system performance standards.

Recent revisions to the WEM Rules have introduced a generator performance standards (GPS) framework, which aims to provide a more appropriate specification of technical performance requirements for large transmission connected generators that participate in the WEM.

Current issue

Western Power has identified a number of concerns with the specification of technical requirements for large generating systems in section 3.3 of the current Technical Rules:

- The existing specification of technical requirements is biased toward a power system dominated by large synchronous generators, with many requirements not specified in a manner suitable for large inverter connected generating systems.
- The specification of the same technical performance requirement for all large generating system limits the ability to optimise performance requirements taking into account the characteristics of proposed generating systems and the transmission system at the proposed point of connection. This gives rise to a less efficient connection process forcing connecting parties through an exemption process to negotiate bespoke performance requirements.
- The technical requirements for large generating systems do not always cater for large distribution connected generating systems.
- The requirements in the current Technical Rules differ significantly from the requirements encapsulated in the GPS framework introduced in the WEM Rules. This creates the potential for significant misalignment of the requirements that a larger generating system faces depending on whether those requirements are established via the process in the WEM Rules or the Technical Rules.

Solution options & preferred solution

Western Power considered the following options to address the above issues:

a) Implement a GPS framework in the Technical Rules that replicates the requirements in the WEM Rules and that applies to large generating systems not covered by the WEM Rules (see section 6.3.2 of this report). The performance standards specified in the WEM Rules are consistent with contemporary practice in the NEM and address the technology bias in the existing Technical Rules. The framework allows for Users to be able to negotiate a bespoke set of generator performance standards for each of

their large generating systems. A generator performance standard is negotiated for each of the following 11 technical requirements:

- Active power capability
- Reactive power capability
- Voltage and reactive power control
- Active power control
- Inertia and frequency control
- Frequency disturbance ride through
- Voltage disturbance ride through
- Multiple disturbance ride through
- Disturbance ride through for partial load rejection
- Disturbance ride through for quality of supply
- Quality of electricity generated

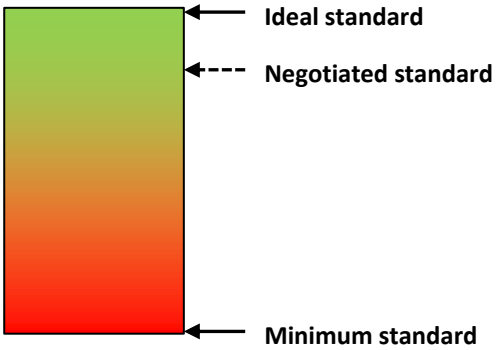
Each performance standard must be set as close as practicable to the level of performance specified in the ideal generator performance standard and can be set no lower than the level of performance specified in the minimum generator performance standard.

b) In addition to option a), make appropriate adjustments to the specification of minimum and ideal generator performance standards to accommodate connections to the high voltage distribution system.

c) No change - Maintain arrangements in the Technical Rules that are not aligned with those in the WEM Rules.

Western Power proposes changes consistent with option b). This approach best addresses the identified issues.

Option b establishes a process for negotiating GPS, with the negotiated standard set at a level of performance no less onerous than the minimum standard and as close as practicable to the ideal standard.



This option means that large generating systems face a consistent set of performance requirements regardless of whether they are negotiated through the process in the WEM Rules or the Technical Rules. The proposed changes implement revisions to the Technical Rules that align with the GPS provisions in the WEM Rules as of 30 July 2021 (or a later date if there are delays)[43]. To ensure consistency moving forward,

[43] The Technical Rules have been drafted to align with WEM Rules that are in the process of being approved for gazettal. At the time of writing the most recent minor changes were expected to be finalized on 30 July 2021. Given the minor nature of these changes, Western Power considered it prudent to adopt the draft changes now rather than updating the Technical Rules to re-align at a later date.

any revisions to the generator performance standards in the WEM Rules should be reflected as changes to the Technical Rules.

The proposed negotiating framework should help limit the need for exemptions in the future particularly given that the minimum generator performance standard generally captures the relaxation of technical requirements previously granted to generators through the Technical Rules exemptions process.

Option b) is implemented via the following revisions to section 3.3 of the proposed Technical Rules:

- Clause 3.3.4 of the proposed Technical Rules specifies the process to be followed to negotiate GPS via the Technical Rules. As noted in section 6.3.2 generator must follow the process in the Technical Rules unless performance standards have been negotiated via the process in the WEM Rules or an exemption granted via the mechanism in the WEM Rules.
- Clauses 3.3.5 and 3.3.6 of the proposed Technical Rules specify processes for identify relevant modifications to large generating systems and assessing requests to undertake those modifications including the need for potential renegotiation of generator performance standards. These provision as discussed further in section 6.3.3.
- Clause 3.3.7 of the proposed Technical Rules specify the requirements than must be satisfied by each of the 11 generator performance standards.

6.3.2 Exemptions for generators with GPS by the WEM Rules

The GPS provisions proposed for large generators in the Technical Rules are intended to align with the GPS arrangements in the WEM Rules. Large generators play a critical role in power system security and so it is appropriate to ensure they are adequately covered via the WEM Rules process or in Technical Rules.

Current issue

In the absence of clarity, there may be confusion about the need to apply both the WEM Rule and Technical Rule GPS processes. Applying both processes would be duplicative and unnecessary as they are designed to cover the same power system risks.

Further, the need to apply or not apply for an exemption from the Technical Rules where a GPS process is agreed under the WEM Rules may be unclear. The intention of the changes to avoid exemptions should be made clear in the changes.

Solution options & preferred solution

Western Power considered the following solutions:

a) Introduce clauses in Chapters 1, 3 and 4[44] and drafting notes in relevant sections of the Technical Rules that clarifying that the Technical Rules GPS process does not apply, and no exemption is required from the Technical Rules where a generator has agreed GPS or received an exemption from GPS in accordance with the WEM Rules. Clarify in notes that generators must comply with all other relevant provisions in the Technical Rules.

b) Rely on the hierarchy established through the lead legislation and regulations to inform generators of the precedence of the WEM Rules over the Technical Rules. Revisions to the Access Code included a new clause A6.2 that states “Technical Rules are not required to address the matters listed in clause

[44] Refer to clauses 1.9.1(f), 3.3.4.1 and 4.2.2(d) of the proposed Technical Rules.

A6.1 to the extent that these matters are dealt with in Chapter 3A or Appendix 12 of the Market Rules."[45]

Option a) is preferred as it make the application of the WEM Rules and Technical Rules clearer for generators that need to meet requirements in the documents.

Generators who negotiate GPS or receive an exemption from requiring GPS under the WEM Rules should not have to go through a similar process under the Technical Rules as the risks being addressed are adequately covered by the WEM Rules. The preferred option clarifies that no exemption is needed from the Technical Rules if the generator has agreed GPS under the WEM Rules or has been exempted from the WEM Rules GPS process. It avoids confusion and potential duplication.

6.3.3 Treatment of relevant generator modifications

Current issue

The changes in clause 3.3 of the Technical Rules introduce similar GPS arrangements to those in the WEM Rules for large generators (>5 MVA) both transmission and distribution connected. The WEM Rules also introduce a relevant generator modification framework. The framework requires that when generators undertake relevant changes to their equipment, they face an obligation to meet the current GPS. Where appropriate, a relevant generator modification can also give rise to the need for compliance testing and commissioning to verify the required performance is achieved.

A relevant generator modification framework is not adequately covered in the current Technical Rules[46], which creates the potential for ambiguity regarding the technical requirements that need to be met by a modified generator. Developing a relevant generator modification framework for the Technical Rules would help address this concern and would provide the opportunity to clarify the testing requirements following commissioning of a relevant generator modification. Aligning the relevant generator modification framework in the Technical Rules with that in the WEM Rules will also benefit Users by ensuring a consistent approach for all large generating systems.

Solution options & preferred solution

Western Power considered the following solutions:

a) Revise chapter 3 of the Technical Rules to implement a relevant generator modification framework reflecting that adopted in the WEM Rules and ensure that relevant generator modification requires compliance testing in accordance with chapter 4. Modify chapter 4 to ensure AEMO is notified of any identified non-compliances and informed regarding any rectification processes (i.e., reciprocal arrangements to those in the WEM Rules). With this approach, the WEM Rules definition for relevant generator modification is adopted in the Technical Rules.

b) In addition to Option a), extend the scope of the guideline produced by the Network Service Provider in accordance with clause 1.9.4(d) to provide examples relevant generator modifications.

Option b) is preferred. Larger generators captured by the Technical Rules may not be participating in the WEM and may be either transmission or distribution connected. It is therefore appropriate that the Technical Rules include a relevant generator modification framework similar to that in the WEM Rules.

[45] Energy Policy WA, *Draft Changes to the Electricity Networks Access Code*, 14 May 2020. Available at: https://www.wa.gov.au/government/publications/energy-transformation-strategy-proposed-access-code-changes

[46] Clause 1.9.4 of the Technical Rules considers some modifications and upgrades.

The key revisions proposed to implement the relevant generator modifications framework in the Technical Rules are:

- Introduction of a new clause 3.3.5 defining the process followed to assess whether a potential relevant generator modification should be treated as a relevant generator modification,
- Introduction of a new clause 3.3.5 defining the process to seek approval from the Network Service Provider prior to undertaking any relevant generator modification,
- Revision of clause 1.9.4(d) to extend the scope of the guideline to include relevant generator modifications, and
- Revisions to chapter 4 to address compliance testing required as a result of undertaking a relevant generator modification.

The alignment with updated clause 1.9.4(d) of the Technical Rules (discussed in section 2.6 of this report), links guidance on related requirements in the Technical Rules – both clause 1.9.4 and the relevant generator modification framework consider upgrades and modifications that trigger a requirement to comply with the current Technical Rules.

6.3.4 Remote control and monitoring

It is important to ensure appropriate remote control, monitoring and communication facilities are provided for each large generating system. Appropriate remote control and monitoring assist the Network Service Provider and AEMO to manage system security by providing appropriate visibility of the status of large generating systems and their ability to provide technical performance consistent with their GPS.

Current issue

Western Power identified the following issues with the remote control, monitoring and communication requirements for large generators defined in clause 3.3.4 in the current Technical Rules:

- There is a lack of clarity regarding the standards that Users should comply with in designing their remote control, monitoring and communication requirements.
- The existing drafting suggests that provision of remote monitoring may not be required in all instances. Western Power considers that remote monitoring of all large generating systems is required to manage power system security.
- The list of signals to be monitored is explicitly specified in the Technical Rules, which creates the risk that the list may not cater for all technologies or be appropriate for all large generating systems.
- The requirements for a backup speech communication channel outlined in clause 3.3.4.3(d) of the current Technical Rules are no-longer necessary given the variety of electronic communications options available today.

Solution options & preferred solution

Western Power propose the following changes to address the identified issues:

- Introduce new clauses 3.3.8, 3.3.9 and 3.3.10 that specify requirement for remote monitoring, remote control and communication systems respectively.
- Introduce a requirement via clause 5.8.1(b) of the proposed Technical Rules for the Network Service Provider to develop a generating system control and monitoring guideline (as discussed in section 8.6 of this report)

- Including in clauses 3.3.8, 3.3.9 and 3.3.10 of the proposed Technical Rules the requirement to provide remote control, monitoring and communication systems consistent with the generating system control and monitoring guideline. This allows the explicit list of signals to be retained so that User have clarity on the requirements but removes the list from the Technical Rules to the guideline where the list can be more readily monitored maintained.
- Delete the requirement for a backup speech communication channel.

These changes benefit Users by providing greater clarity regarding the requirements for remote monitoring, control and communication systems and remove the outdated requirement for a back-up speech communications channel. Utilising the guideline to provide detailed guidance provide a more efficient means of providing updated information by avoiding the need for amendment of the Technical Rules.

6.3.5 Protection requirements

As noted in section 6.8.1 of this report, Western Power recommends consolidating the User protection requirements in section 3.5 of the Technical Rules to address issues identified with the existing fragmented definition of User protection requirements. To support this change, two new subclauses are proposed for clause 3.3.2 that link the protection requirements to relevant parts of the new section 3.5:

- A large generating system connected to the transmission system (3.3.2 (g) of the proposed Technical Rules), and
- A large generating system connected to the high voltage distribution system (3.3.2 (h) of the proposed Technical Rules).

6.3.6 Accommodating distribution connected large generating systems

As outlined in section 6.3.1 in this report, the proposed requirements for section 3.3 of proposed Technical Rules are based on WEM Rule requirements that apply to transmission connected generators that are Market Participants (under the WEM Rules).

Current issue

Several of the existing technical requirements in section 3.3 of the current Technical Rules need revision to ensure that they expressed appropriate requirements for connection to the transmission system or the high voltage distribution system.

Solution options & preferred solution

Western Power proposed various revisions across section 3.3 of the Technical Rules to ensure that the requirements for both transmission and high voltage distribution connections are clearly defined. In many instances this involved replacing references to the transmission system with references to the transmission and high voltage distribution system.

For the following technical requirements, additional clauses were added where it was necessary to vary the requirements for a transmission or distribution connection:

- Clause 3.3.15.1 of the proposed Technical Rules specifies main switch requirements for transmission connected large generating systems, while the requirements for those large generating systems connected to the high voltage distribution system are specified in clause 3.3.15.2.
- The specification of voltage ride through performance standards in clause 3.3.7.8 were extended beyond those specified in the WEM Rules to provide ride through requirements for the transmission

and distribution system. The requirements expressed in the WEM Rules are applicable for transmission connected generating systems participating in the WEM. The requirements needed to be extended to include voltage ride through requirements applicable to generating systems connected to the distribution system.

6.4 Small generators connected to the transmission or high voltage distribution system

Section 3.6 in the proposed Technical Rules specifies the requirements that Users must meet for small generating systems (aggregate rated capacity ≤ 5 MVA) connected to the transmission system or the high voltage distribution system. The requirements in this clause have been developed by implementing a series of revisions to the requirements specified in section 3.6 of the current Technical Rules.

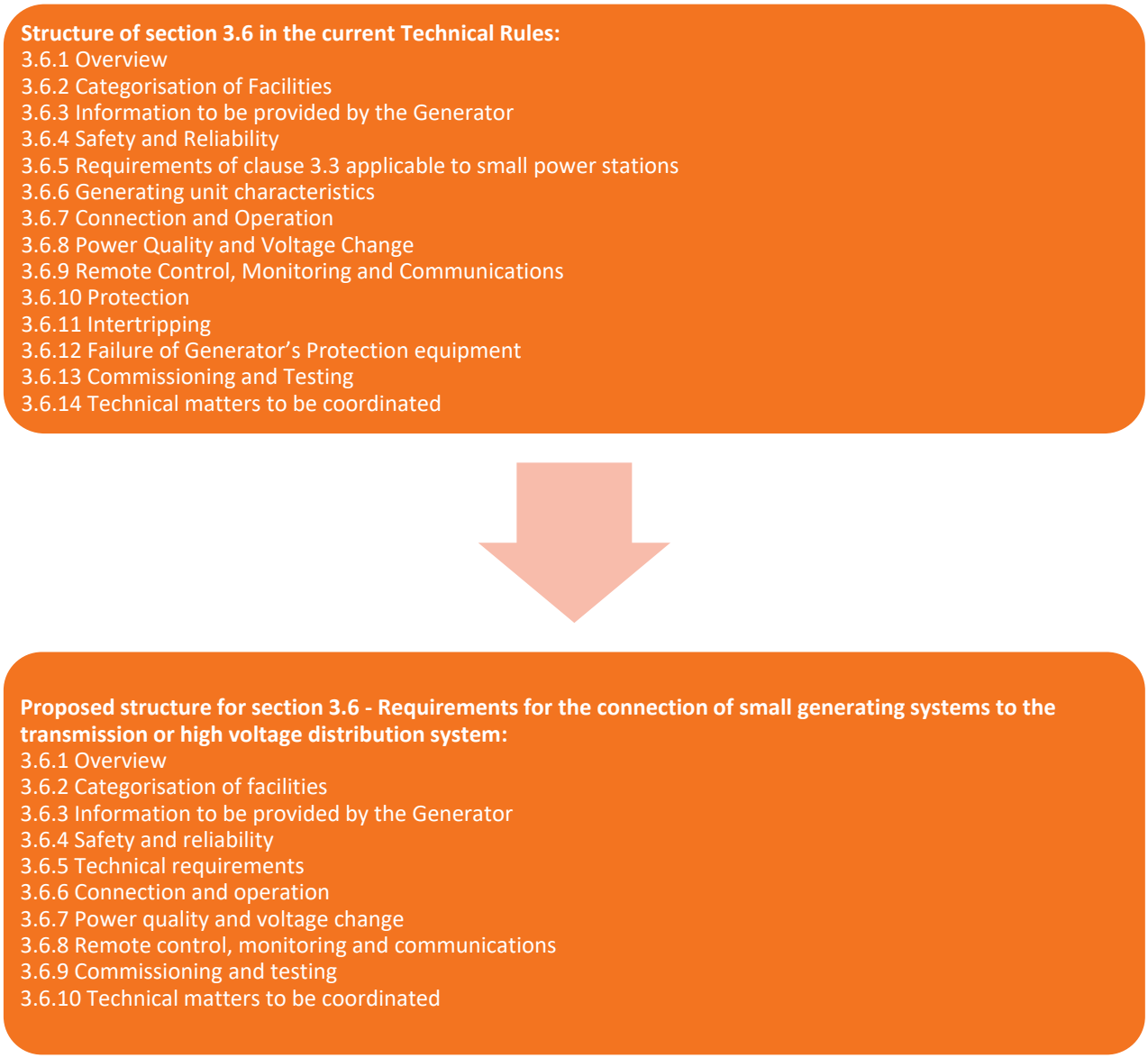
Western Power proposes changes to the structure of section 3.6 to reflect the revised focus of the section and to align with other structural changes implemented across chapter 3. Figure 6-1 illustrates the key structural changes proposed for section 3.6. The main changes result from the consolidation of the protection requirements into section 3.5 (as discussed in section 6.8.1 of this report).

The key revisions proposed to the requirements for the connection of small generating systems to the transmission or high voltage distribution system include:

- Adopting appropriate technical requirements that cater for all generation technologies, appropriately leveraging the GPS requirements for large generators and providing appropriate alignment with the requirements in the most recent inverter standard AS/NZS 4777.2.
- Clarifying main switch requirements as discussed in section 6.2.2 of this report.
- Introducing requirements to allow the Network Service Provide to specify export limits that should help maximise embedded generation hosting capacity and avoid more restrictive connection arrangements.
- Adjusting requirements to ensure they are applicable to all small generators connected to either the transmission system or the high voltage distribution system.
- Clarifying communication system requirements.

The rational for each of the key revisions are presented in the subsequent sections.

Figure 6-1: Overview of small generating system requirements specified in section 3.6



6.4.1 Appropriate technical requirements for small generating systems connected to the transmission or distribution system

Section 3.6 in the current Technical Rules specifies requirements for distribution connected small generating systems. Many of the technical requirements specified in this section of the Technical Rules leverage the requirements for large generating systems specified in section 3.3 in the current Technical Rules.

Current issue

The technical requirements for small generating systems need revision to address the following issues:

- Some of the technical requirements are specified in a manner that is biased toward synchronous generation technology. Given that the majority of new generation being connected to the power system is inverter based non-synchronous generation, requirements need to be expressed in a manner which is equally applicable to inverter based generation technology.

- The provisions in section 3.6 in current Technical Rules fail to address some of the important technical requirements covered by the GPS introduced for large generating systems. Key gaps include limited specification of disturbance ride through requirements and inequitable requirements for primary frequency response.
- The latest version of AS/NZS 4777.2 specifies significantly improved functional requirements for inverters used to connect generator the power system. The existing provision in section 3.6 should be revised to take advantage of the additional capability provided by AS/NZS 4777.2 compliant inverters.

Solution options & preferred solution

Western Power considered the following solutions to address these issues:

a) Revise the technical requirements in section 3.6 of the Technical Rules to implement technical requirements for small generating systems that are equivalent to those specified for large generating systems, requiring negotiation of generator performance standards for all small generating systems.

b) Where appropriate align the technical requirements for small generating systems with minimum performance standards specified for larger generating systems.

c) In addition to b) incorporate revisions into the technical requirements that leverage capability available in AS/NZS compliant inverters.

Option c) is preferred. This option addresses all the identified concerns:

- Leveraging the minimum performance standards developed for the large generating systems will address the technology bias concerns. The minimum performance standards have been developed considering those used in the NEM with appropriate variations adopted to suit the characteristics of the SWIS. The NEM requirements have been developed and reviewed by the Australian Energy Market Commission and are generally free of technology bias.
- The adoption of the minimum standard to set the requirement for small generating systems is appropriate and reflects that these systems are less likely to impact power system security compared to larger generating systems. Requiring alignment with the more onerous ideal generator performance standard is therefore unnecessary.
- Leveraging the generator performance standards addresses gaps in the existing technical requirements for small generating systems.
- Adopting appropriate revisions to leverage the capability of AS/NZS 4777.2 compliant inverters will reduce the cost for Users while maintaining the security of the power system. The revisions recognise that the capability provided by inverters which comply with the latest standard is in many cases sufficient to meet performance requirements thereby avoiding unnecessary additional investment.

Option a) is not currently recommended as it would require a significant increase in the level of effort required from Users and Western Power to manage the connection of small generating systems. The more complex process for negotiating performance standards does not providing the appropriate balance between the complexity and cost of the connection process and the potential system security issues that could result from the connection of individual small generating systems.

The following key revisions are proposed to implement option c):

- Clause 3.6.5 specifies the technical requirements that small generating systems connected to the transmission or the high voltage distribution system must meet. The drafting efficiently references the minimum performance standards in section 3.3.7 to specify the requirements.

- The aggregate capacity of the small generating system dictates which minimum performance standards they need to meet. Small generating systems with an aggregate capacity >150 kVA are required to meet a broader set of minimum performance standards than other small generating systems. This approach adopts a similar threshold to clause 3.6.5 in the current Technical Rules.
- The relaxation to disturbance ride through requirements for small generating systems with an aggregate rated capacity ≤ 150 kVA allowed in clause 3.6.5 aligns required performance with that specified in AS/NZS 4777.2

6.4.2 Export limits for transmission and distribution connected small generating systems

The ability to host renewable generation on the power system can be enhanced if Western Power is able to impose export limits on all generating systems. In the absence of export limits more restrictive limits may need to be applied via the connection process to avoid connected generation exceeding available network capacity. The ability to impose export limits allows greater hosting capacity by using the actual power system conditions to adjust the notified export limits.

In the absence of the ability to specify export limits that can be adjusted to cater for actual system conditions, Western Power may need to impose restrictions on the connection of embedded generation to prevent insecure or unsafe operation of the distribution system.

Current issue

The Technical Rules currently lack explicit provisions allowing the Network Service Provider to specify an export limit for small generating systems and requiring the Users to operate to within those limits. The existing provisions for small generating systems include export limits as a protection rather than a control measure.

The proposed performance standards for larger generating system provide the ability to set active power limits and thereby enforce an export limit.

Solution options & preferred solution

Western Power considered the following options to address the issue:

a) Introduce new clauses that allow the Network Service Provider to specify an export limit where necessary to ensure safe, reliable and secure operation of the power system; and require the User to control the active power from their small generating system to remain below the export limit.

b) Option a) with the application of export limits restricted to only small generating systems connected to the transmission system or the high voltage distribution system (i.e., User facilities covered by clause 3.6 of the proposed Technical Rules).

Option a) is preferred as this approach addresses all the identified concerns and provides an approach which is best able to maximise hosting capacity at all voltage levels in the distribution network. Allowing the Network Service Provider to specify export limits should help maximise embedded generation hosting capacity and avoid more restrictive connection arrangements. The latest version of AS 4777.2 requires that inverters are able to receive and operate to stay within specified export limits, as such export limits can readily be accommodated by Users that install inverters compliance with the latest Australian Standard. The proposed changes are therefore unlikely to increase connection costs for Users.

The recommended option is implemented through the following new clauses added to sections 3.6, 3.7 and 3.8 of the proposed Technical Rules:

- Clause 3.6.6.5 – export limit control, which applies to small generators connecting to the transmission and high voltage distribution systems,
- Clause 3.7.6.4 – export limit control, which applies to small generators connecting to the low voltage distribution system, and
- Clause 3.8.5.2 – export limit control, which applies inverter energy systems connecting to the low voltage distribution system.

6.4.3 Accommodating transmission and distribution connected small generating systems

As outlined in section 6.4.1 in this report, the proposed requirements and therefore the drafting for section 3.6 of proposed Technical Rules mirrors that adopted for section 3.3 of the proposed Technical Rules.

Current issue

Several of the existing technical requirements in section 3.6 of the current Technical Rules need revision to ensure that they expressed appropriate requirements for connection to the transmission system or the high voltage distribution system.

Solution options & preferred solution

Western Power proposed various revisions across section 3.3 of the Technical Rules to ensure that the requirements for both transmission and high voltage distribution connections are clearly defined. In many instances this involved replacing references to the transmission system with references to the transmission and high voltage distribution system.

For the following technical requirements, additional clauses were added where it was necessary to vary the requirements for a transmission or distribution connection:

- Clause 3.6.2(c) of the proposed Technical Rules was revised to list applicable voltage level for the transmission and high voltage distribution system.
- Clause 3.6.8(a) of the proposed Technical Rules was revised to remove references to the low voltage distribution system.

6.4.4 Communication system requirements for small generating systems

The requirements for remote monitoring, control and communications systems for small generating systems are outlined in section 3.6.9 of the current Technical Rules.

Current issue

The requirements section 3.6.9 concerning the communication system requirements for small generating systems are outdated and require amendment to reflect the capability of modern communication systems and to reflect the reduced importance of back-up speech communication channels for enabling power system operations.

Further, the current requirements for installation of remote monitoring, control and communications systems are triggered based on aggregate export limits. Setting requirements based on generator capacity would be consistent with the requirements in other Australia jurisdictions.

The lack of appropriate triggers to require remote monitoring, control and communications systems, including on smaller system, means that Western Power does not have visibility of how some generators are interacting with the power system including during critical minimum load periods. Going forward, as

the minimum load continues to fall, there is an increasing need to monitor and potentially control smaller generators to ensure system security including where the Network Service Provider is directed by AEMO.

Solution options & preferred solution

Western Power recommends the following revisions to address the identifies issues and provide communication system requirements that are aligned with modern requirements and meet operational requirements:

- Update clauses in 3.6.8 of the proposed Technical Rules to specify requirements for remote monitoring, control and communications systems are triggered based on generating system capacity rather than an export limit.
- Introduce revisions to clauses 3.6.8(c) of the proposed Technical Rules requiring Generators to provide a continuous communications link to the Network service Provider's control centre where the Generators are required (in accordance with other clauses) to implement remote monitoring and control.
- Introduce revisions to clauses 3.6.8(d) of the proposed Technical Rules that remove the requirement for a back-up speech communications channel.
- Introduce clauses 3.7.8 and 3.8.6(b) of the proposed Technical Rules, which make the requirements in clause 3.6.8 apply to all small generating systems connected to the low voltage distribution system.

The removal of obsolete requirements should reduce costs to Users and the change to specify requirements based on generating system capacity aligns with practice in other jurisdictions. The revised clauses will enable the Transmission Network Operator and Distribution Network Operator to perform roles as outlined in Chapter 5 of the proposed Technical Rules.

6.5 Small generators connected to the low voltage distribution system

Current issue

The current Technical Rules do not explicitly differentiate the technical requirements for small generating systems connecting to the low voltage distribution system from the requirements for small generating systems connected to the high voltage distribution system. This approach has made it difficult for Users connecting at different distribution voltage levels to understand the specific requirements that apply to their generating system.

Solution options & preferred solution

Western Power considered the following options to address this issue:

a) Introduce a new section 3.7 to separately identify the requirements for all small generating systems connected to the lower voltage distribution network.

b) In addition to option a) ensure the structure of the new section mirrors that in section 3.6 of the proposed Technical Rules (discussed in section 6.4 of this report) with changes to subsections and clauses made to express appropriate requirements for low voltage connected generating systems.

c) Option b) with the requirements for inverter energy systems connected via a standard connection service moved to a separate section within Chapter 3.

Option c) is preferred as this approach provides a structure that clearly distinguishes requirements for:

- Small generating systems connected to the **high** voltage distribution system,

- Small generating systems connected to the **low** voltage distribution system, and
- Inverter energy systems connect to the low voltage distribution system.

The new structure allows for technical requirements to be varied between these different voltages and systems as appropriated.

The recommended option is implemented through the following new clauses added to sections 3.6 and 3.7. The revised section 3.7 specifies the requirements that Users must meet for small generating systems (aggregate rated capacity ≤ 5 MVA) connected to the low voltage distribution system. The requirements in this section have been developed by implementing a series of revisions to the requirements specified in section 3.6 of the Technical Rules to customise requirements to suit connection to the low voltage distribution system. Consequently, the structure of section 3.7 and 3.6 in the revised Technical Rules are aligned. Alignment of the two sections will simply navigation of technical requirements, particularly for Users who operate generating systems connected to the high voltage and low voltage distribution systems.

The key changes made between the clauses in section 3.6 and 3.7 include:

- Clause 3.7.1 of the proposed Technical Rules provides an overview of section 3.7 and states that the section present requirements for small generating systems connected to the low voltage distribution network. Drafting in this clause clarifies that the requirements for inverter energy systems connected the low voltage distribution network via a standards connection service are specified in section 3.8.
- Clause 3.7.2(c) of the proposed Technical Rules includes the same provision that appears as clause 2.6.2(c)(3) in the current Technical Rules. This clause allows Users to elect to have their facility assessed for compliance against the requirements for a connection to the high voltage distribution system.
- Various clauses of the proposed Technical Rules recognise that a sufficient technical requirement for the generating systems connected via inverters is that the inverters comply with the relevant Australian Standard AS/NZS 4777.2. For example, this is reflected in clause 3.7.5(a) of the proposed Technical Rules.
- Adjustment of wording throughout section 3.7 to only refer to connection to the distribution system not the transmission and distribution systems
- Adjustment to the power quality and voltage change requirements to allow the Network Service Provider to permit a voltage step changes of up to 5% on low voltage feeders in some circumstances.

Western Power considers that the recommended option will deliver benefits to Users seeking to develop a small generating system connected to the low voltage distribution system because:

- The clarified technical requirements are presented in a manner that is very similar to that adopted for high voltage connected small generating systems enabling consistent navigation by Users.
- The technical requirements implement appropriate refinements allow Users to leverage the capability available in inverters that are compliant with SA/NZS 4777.2 to reduce connection costs.

6.6 Inverter energy systems connected to the low voltage distribution system via a standard connection service

Section 3.7 in the current Technical Rules specifies the requirements for inverter energy systems connected to the low voltage distribution system.

Current issue

The existing Technical Rules do not appropriately leverage the capability provided by inverters that comply with AS/NZS 4777.2. Recognising that capability has the potential to clarify the specification of technical requirements and reduce compliance costs for Users.

The current drafting also includes some detailed information, such as schematic diagrams and metering information, that is inconsistent with the level of detail provided in the remainder of the Technical Rules and is better provided through the connection standards maintained by Western Power. Moving this information from the Technical Rules to a connection standard is consistent with contemporary practice as recommended by the Electricity Network Association and implemented by distribution network service providers operating in the NEM and by Horizon Power.

Solution options & preferred solution

Western Power considered the following options to address the above issues:

a) Introduce a new section 3.8 to identify the requirements for inverter energy system connected via a standard connection service.

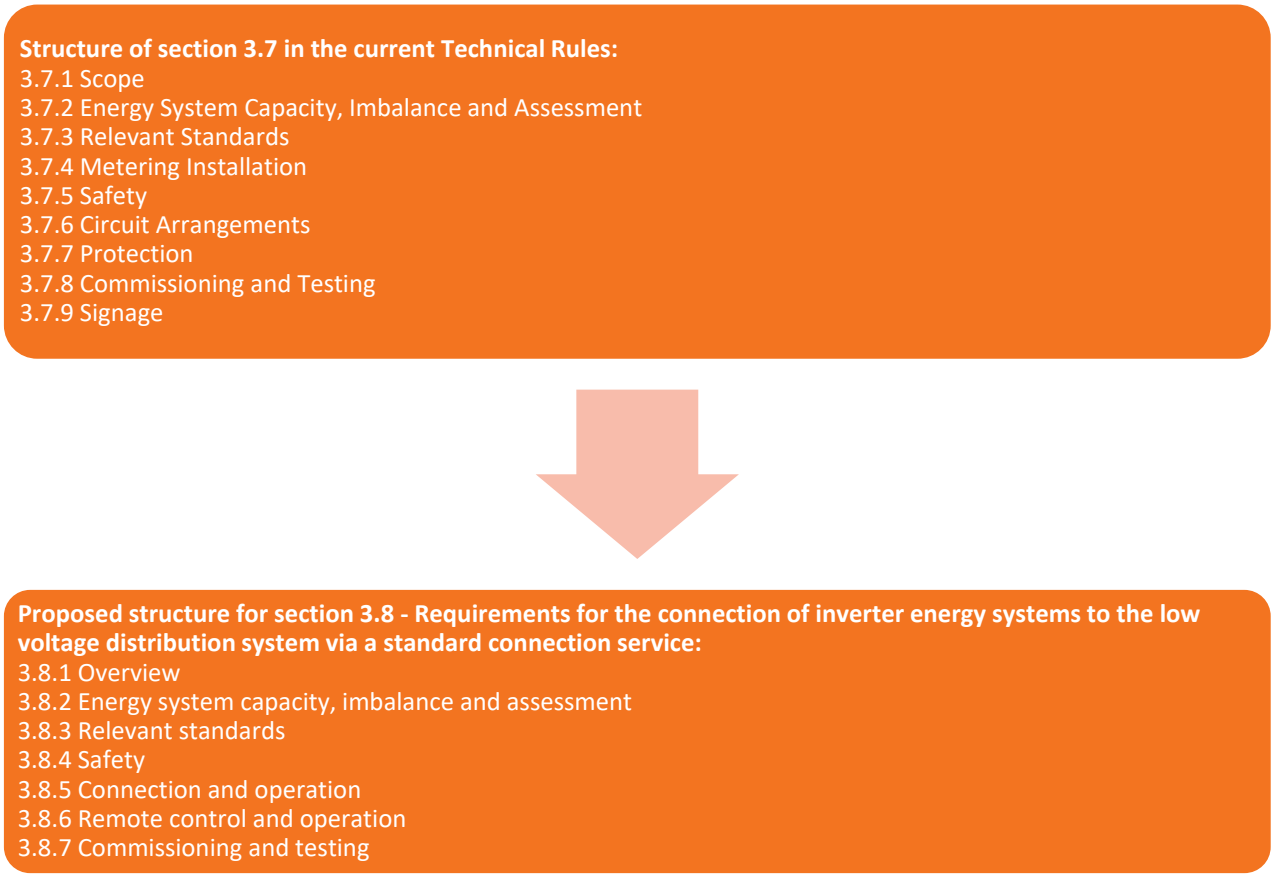
b) In addition to option a) remove information that is best specified via a connection standard maintained by the Network Service Provider.

c) In addition to option b) implement revisions to clauses that recognise the capability that is provided by inverters that comply with AS/NZS 4777.2.

Option c) is preferred as this approach addresses all the identified concerns.

The recommended option is implemented by translating the requirements expressed in section 3.7 of the current Technical Rules into a new set of requirements in section 3.8 of the proposed Technical Rules. Figure 6-2 compares the structure of the existing section 3.7 and the new section 3.8.

Figure 6-2: Overview of inverter energy system requirements specified in section 3.8



The key changes made between the clauses in the existing section 3.7 and the new section 3.8 include:

- Information that is better expressed in the relevant connection standard have been removed from the Technical Rules. This has resulted in the removal of:
  - Metering requirements that currently appear as clause 3.7.4 in the current Technical Rules,
  - Requirements for labelling of switches currently specified in clause 3.7.5.1, and
  - Requirements specified in section 3.7.6 of the current Technical Rules with only main switch requirements retained in the new section 3.8.
- The requirement for inverters to comply with AS/NZS 4777.2 has been added to clause 3.8.1(d) and the requirements in section 3.8.3 specifying relevant standards clarified.
- As discussed in section 6.8.1 of this report, protections requirements have been moved to section 3.5 and consolidated with other User protection requirements.
- Adding a requirement that the Network Service Provider's approval be sought before changing parameters on an installed inverter energy system and including a requirement for the User to audit settings if requested to do so by the Network Service Provider.
- Adding specific requirements to provide for export limit control, generation limit control and including provisions that require the User to provide remote control of the inverter energy system if requested to do so by the Network Service Provider. These additional requirements are all achievable by inverters that comply with AS/NZS 4777.2.

Western Power considers that the recommended option delivers benefits to Users seeking to connect inverter energy systems via a standard connection service because:

- The clarified technical requirements align with contemporary practice.
- The technical requirements implement appropriate refinements allow Users to leverage the capability available in inverters that are compliant with AS/NZS 4777.2 to reduce connection costs.

6.7 Loads

Section 3.4 of the Technical Rules specify the technical requirements than must be met by facilities that consume electrical power (i.e., loads). Western Power did not identify a need to restructure this section of the Technical Rules and proposed the following key revisions:

- Changes that support the consolidation of all User protection requirements in section 3.5 of the proposed Technical Rules.
- Insert clarifications that where a User's facility includes both load and generation, the User should ensure that load shedding facilities provided by the User only disconnect loads and not generation at the site.

The rational for each of the key revisions are presented in the subsequent sections.

6.7.1 Protection requirements

As noted in section 6.8.1 of this report, Western Power recommends consolidating the User protection requirements in section 3.5 of the Technical Rules to address issues identified with the existing fragmented definition of User protection requirements. To support this change, a change to clause 3.4.1 is proposed to include a new clause identifying the sub-clauses within the revised section 3.5 that are applicable to consumers (3.4.1 (c) of the proposed Technical Rules).

6.7.2 Load shedding facilities

The Technical Rules currently contain provisions requiring consumers to provide their loads to be shed to help prevent frequency collapse following non-credible contingency events.

Current issue

It is increasingly common for User facilities to contain a mix of loads and generation. It is important that in response to underfrequency events loads are tripped and not generation. However, there is no provision in the Technical Rules that specifies this requirement.

Solution options & preferred solution

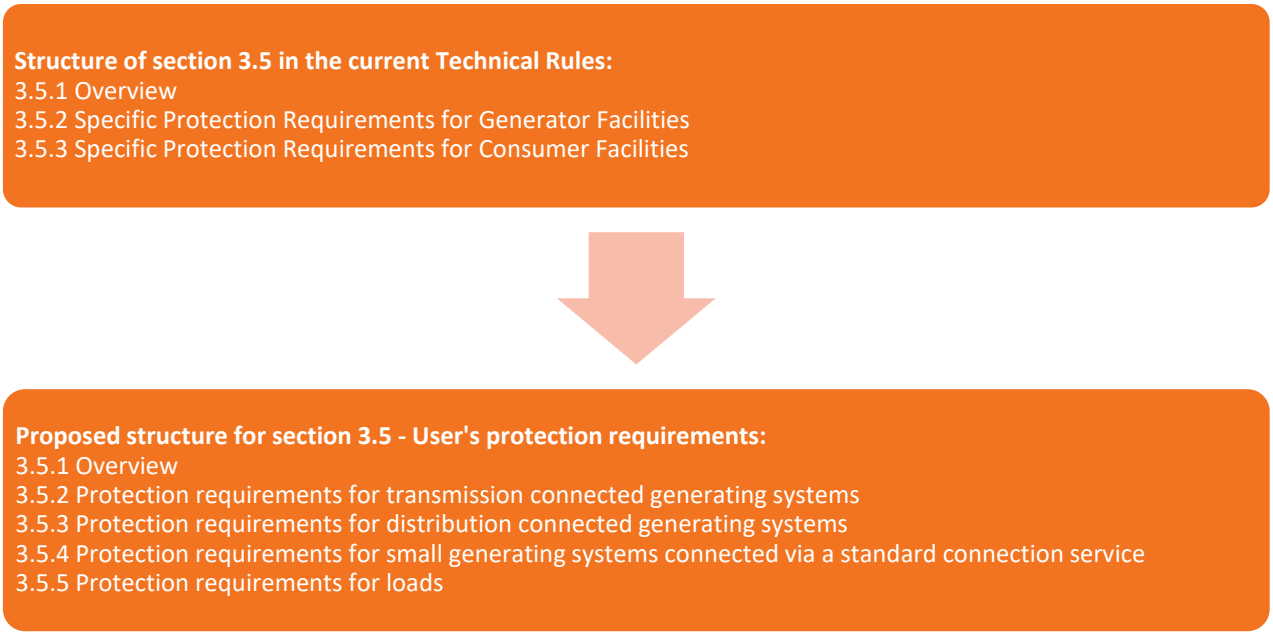
Western power proposes adding a new clause (3.4.9.1(b) of the proposed Technical Rules) to clarify that under frequency load shedding facilities provided by a consumer should trip load and not generation within the User's facility.

6.8 User protection

This section presents the review of the User Protection requirements within the Western Power Technical Rules. The principal focus area is section 3.5, which covers obligations on Users related to protection. However, work on section 3.5 of Technical Rules was considered in conjunction with section 2.9, which covers Transmission and Distribution System Protection (refer to Chapter 5 of this report).

The structure of section 3.5 of the Technical Rules is illustrated in Figure 6-3, which compares the structure in the current Technical Rules and the revised structure proposed by Western Power.

Figure 6-3: Overview of User Protection Requirements



The key revisions proposed for the User protection requirements include:

- Restructuring the User protection requirements to consolidate all requirements into relevant clauses within section 3.5, which efficiently identify applicable protection requirements for different types of facilities.
- Recognising the need to cooperate on protection system design and implementation.
- Clarifying the need to seek Network Service Provider approval for changes to User protection systems,
- Clarifying the scope of protection requirements specified for large generating systems,
- Clarifying acceptable anti-islanding protection arrangements for transmission connected large generating systems,
- Aligning protection and disturbance ride-through requirements,
- Relaxing location of protection function for small generating systems connected to the low voltage distribution system,
- Allowing distribution connected generators to utilise back-up protection provided by protection functions implemented in AS NZ 4777 compliant inverter,
- Allowing distribution connected generators connected via AS NZ 4777 compliant inverters to utilise earth-fault protections integrated withing an anti-islanding scheme
- Clarifying anti-islanding protection requirements for distribution connected generating systems.
- Clarify protection requirements for consumer facilities.

The rational for each of the key revisions are presented in the subsequent sections, a key focus of the revisions to the protection requirements has been to improve clarity for Users and to incorporate appropriate relaxation and qualifications into the requirements to help Users reduce costs while not compromising power system security.

6.8.1 Revised Structure

Current Issue

The existing organisation of chapter 3 of the Technical Rules has protection obligations appearing in section 3.5 and additional protections requirements distributed across other subsections of chapter 3. This approach makes it difficult for a User to identify the protection requirements that apply to their facility. Continuing this approach with the introduction of new sub-sections into chapter 3 to clarify requirements for all types of generating systems also creates the risk of inadvertent inconsistency between protection requirements for generators connecting to the same network voltage level.

Solution options & preferred solution

Western Power considered the following solutions to address this issue:

a) Revise chapter 3 with all User protection requirements consolidated in section 3.5

b) In addition to a) include clauses in the overview section of each subsection of chapter 3 providing technical requirements for different types of User facilities, that identify the relevant clauses in section 3.5 that apply to the type of User facility

c) In addition to b) adopt a structure within clause 3.5 that avoids unnecessary repetition of protection requirements for User facilities connected to the same network voltage level.

d) No change continue with protection requirements distributed across chapter 3.5

Option c) is preferred as it provides for more efficient specification of protection requirements, assists Users to identify the requirements applicable to their facilities and reduces the risk of inadvertently specifying inconsistent protection requirements for Users connected as the same voltage level.

The key revisions to the proposed Technical Rules made to implement the recommended option are:

- Adopt the high level structure shown in Figure 6-3 for section 3.5
- Add appropriate clauses to the overview sections of sections 3.3, 3.4, 3.6, 3.7 and 3.8 specifying which clauses in section 3.5 apply
- Add clauses in each of sections 3.5.2, 2.5.3, 3.5.4 and 3.5.5 that restate which classes of facilities must adhere to the protection requirements specified in each section.
- remove clause 3.6.10. 3.6.11 and 3.6.12 in revisions 3 of the Technical Rules, replacing that clause by equivalent provisions in clause 3.5.3 of the revised Technical Rules.
- remove protection requirements in clause 3.7.7 in revisions 3 of the Technical Rules, replacing that clause by equivalent provisions in clause 3.5.4 of the revised Technical Rules.

6.8.2 Approval for changes to User protection systems

Current issue

Sub-clause 3.5.1(h) states that a “consumer” must not adjust its protection settings without the Network Service Provider’s approval. However, the rest of clause 3.5.1 refers to “user”. The terms “Consumer” and “User” are defined as per Table 6-1 (below) in the Technical Rules. The requirements in clause 3.5.1(h) should apply to all Users not just consumers.

Table 6-1 Relevant consumer and user definitions in the Technical Rules

Term	Current definition
Consumer	A *User* who consumes electricity supplied through a *connection point*.
User	Has the meaning given in clause 1.3(b)(3) [of these Technical Rules]. 1.3(b)(3) of the Technical Rules is replicated below: *Users* of the *transmission or distribution system* who, for the purposes of these *Rules* include: (A) every person who seeks access to *spare capacity* or *new capacity* on the *transmission or distribution system* or makes an *access application* under the *Access Code* in order to establish a *connection point* or modify an existing *connection*; (B) every person to whom access to *transmission* and *distribution* capacity is made available (including every person with whom the *Network Service Provider* has entered into an *access contract* or *connection agreement*).

Additionally, while the existing clause may prohibit a user from adjusting their protection settings without approval of the Network Service Provider, it does not explicitly prohibit other potential modifications without notifying the Network Service Provider, such as modification of a protection scheme or replacement equipment. Unapproved changes to protection systems should be avoided to ensure appropriate coordination of any changes to User protection systems within Network Service Provider protection systems.

Solution options

Western Power considered the following options to address the above issues:

a) Amend clause 3.5.1(h) to address the terminology issue outlined i.e. correct the use of the term 'consumer', and augment the wording of the clause to include provisions requiring approval for all modifications of protection schemes or equipment.

Leave the clause unchanged.

Western Power recommends changes consistent with option a). The current terminology issue should be addressed. Further, updating clause 3.5.1 of the Technical Rules to include provision for seeking the Network Service Provider's approval before a user modifies any protection systems or equipment, in addition to the modification of protection settings, is considered appropriate given the need to coordinate protection scheme functionality between the User and the Network Service Provider.

6.8.3 Cooperative design of protection systems

Clause 3.5.1(d) of the Technical Rules requires a User and the Network Service Provider to cooperate on specified aspects of the design and implementation of protection systems. With the aspects requiring coordination listed in the clause.

Current Issue

Protection systems are often implemented to enable a User connection to proceed while avoiding or deferring the need for network augmentations. Clause 3.5.1(d) currently does not explicitly require coordination of the functionality of protection systems including generator runback schemes and other special protection schemes, which may lead to confusion over the need to coordinate their design.

Solution options & preferred solution

Western Power considered the following solutions to address this issue:

a) Revise clause 3.5.1(d) to include a specific provision requiring the coordination of the functionality of protection systems required as a condition of the User's connection to the transmission or distribution system

b) No change to the existing wording

Option a) is preferred as it provides greater clarity for Users regarding the need to coordinate the functionality of all protection systems which included and special protection system.

6.8.4 Clarify scope of protection requirements for large generating systems

Current issue

Clause 3.5.2(b) in the current Technical Rules states that the protection systems for a generating unit must be designed to protect the generating unit. This wording indicates that the large generating system protection requirement may exceed the scope specified in clause 3.5.1(a) which states that the requirements in clause 3.5 are limited to the User's protection system requirements that are necessary to maintain power system security and not protection systems installed to cover risks to the User's equipment.

The inconsistency between the two clauses should be addressed to avoid potential confusion.

Solution options

Western Power considered the following options to address the above issue:

a) Amend sub-clause 3.5.2(b) to remove the statement which could be interpreted as extending the scope to all protection systems necessary to protect the generating system.

Leave clause unchanged.

Western Power recommends changes to the Technical Rules consistent with option a). This will prevent any confusion regarding the scope of protection requirements specified in the Technical Rules.

6.8.5 Acceptable anti-islanding for transmission connected generating systems

Anti-islanding protection is also referred to a loss of mains or loss of supply protection. It is designed to ensure that a generating system is prevented from supplying an isolated portion of the power system when it is not appropriate to do so.

Current Issue

Clause 3.5.2(d)(2) in the current Technical Rules details that a generator's generating unit must be disconnected from the transmission and distribution system if there is a loss of supply to the User's installation. The current wording does not specify the type of loss of mains protection scheme to be used (i.e. Rate of Change of Frequency, vector shift, etc), hence the requirement is open to interpretation. There are differing technical characteristics associated with each type of loss of mains or anti-islanding scheme. The existing wording leave open to interpretation which schemes are acceptable and for the avoidance of doubt it would be better to state what scheme type(s) is preferred by Western Power to remove the ambiguity.

Western Power notes that clause 3.6.10.3 in the current Technical Rules details acceptable methods of loss of mains detection that apply at distribution voltages. A cross reference to these methods is recommended for clarity.

Western Power notes that clause A12.13.3.3 of the WEM Rules specifies requirements for transmission connected generating systems that participate in the WEM to install appropriate anti-islanding systems. The WEM Rules require the details regarding the performance of the anti-islanding systems to be documents in accordance with guidelines produced by the Network Operator. The anti-islanding requirements in the Technical Rules should be consistent with the requirements in the WEM Rules.

Solution Options

Western Power considered the following options to address the above issues:

a) Provide additional details in clause 3.5.2 specifying acceptable anti-islanding schemes

b) Revise clause 3.5.2 to include:

   i) a requirement for an appropriate anti-islanding scheme which is consistent with guidelines produced by the Network Service Provider, and

   ii) a requirement for the Network Service Provider to develop the anti-islanding guideline for large generating systems connected to the transmission system

c) Leave the clause unchanged.

Western Power recommends amendments to the Technical Rules consistent with option b). This is the preferred solution as it maintains consistency with the requirements defined in the WEM Rules and delivers the required additional clarity regarding the appropriate anti-islanding requirements.

6.8.6 Aligning protection and disturbance ride-through requirements

Clause 3.3.7.7, 3.3.7.8 and 3.3.7.9 in the revised Technical Rules introduce various generator performance standards that require large generating systems to ride-through disturbances. It is important that protection systems on large generating systems do not have settings which will prevent the generating system from meeting the disturbance ride through requirements.

Current Issue

The existing protection provisions in the Technical Rules for large generating systems, do not include clauses which specify that generating system protection systems and settings should be set to enable the disturbance ride through requirements to be achieved. The absence of a clause specifying this requirement risks misalignment between the disturbance ride through requirements and the User protection requirements.

Clause A12.13.3.4 in the WEM Rules specifies that transmission connected generating systems participating in the WEM must include protection schemes:

- necessary to disconnect the generating system during abnormal conditions in the power system that would threaten the stability of the generating system, or risk damage to the generating system, and
- that enable the disturbance ride through generator performance standards to be achieved.

The existing generating system protection requirements in the Technical Rules are therefore not aligned with those in the WEM Rules.

Solution Options

Western Power considered the following options to address the above issues:

a) Provide an additional clause in section 3.5.2 reflecting the drafting in WEM Rules clause A12.13.3.4. This aligns the protection requirements in the Technical Rules for transmission connected generating systems with those in the WEM Rules for transmission connected generating systems participating in the WEM.

b) In addition to a) include a similar clause in section 3.5.3.2 to ensure a similar requirement is specified for large generating systems connected to the high voltage distribution network

c) Leave the clauses unchanged.

Western Power recommends amendments to the Technical Rules consistent with option b). This is the preferred solution as it maintains consistency with the requirements defined in the WEM Rules and delivers consistency between the generating system protection requirements and the disturbance ride-through requirements in the generator performance standards.

6.8.7 Relaxing location of protection function for small generating systems connected to the distribution system

Clause 3.6.10.1(a) in the current Technical Rules requires that protection functions for generating systems connected to the distribution system respond to quantities measured at the connection point.

Current Issue

This requirement can result in additional expense for generating systems that connect to the low voltage distribution network that do not have monitoring equipment available at the connection point. This particular requirement has been the subject of over 60 exemption requests and Western Power has allowed the use of quantities measured at other locations provided that doing so would not reduce the ability to maintain power system security.

Solution Options

To reduce the need for future exemptions and reduce the cost faced by Users connecting small inverter connected generating systems to the low voltage distribution system, Western Power recommends revising the corresponding clause in section 3.5.3 of the proposed Technical Rules.

In the proposed Technical Rules, clause 3.5.3.2(b) states:

> *For a generating system with an aggregate rated capacity less than or equal to 1 MVA and comprised of inverter connected generating units, the Network Service Provide may accept protection functions that respond to quantities measured at other locations within the Users facility provided these protection arrangements:*
>
> *(1) are consistent with any guidelines developed by the Network Service Provider, and*
>
> *(2) do not reduce the ability to maintain power system security.*

The proposed change allows relaxation of the measurement location for the quantities used in the generating system protection functions to be varied where this does not impact power system security.

6.8.8 Back-up protection provided by inverter protection functions

Clause 3.6.10.1(d) in the current Technical Rules requires that protection systems for generating systems connected to the distribution system provide sufficient back-up protection to cover for the failure of any one protection device.

Current Issue

This requirement has been the sources of a significant number of exemption request from Users seeking to connect generating systems via inverters compliant with the latest Australian Standard. Users have sought, and in many cases, been granted exemptions (> 550 exemptions granted). The exemptions recognise that the protection functions provided by inverters complying with AS/NZS 4777.2 are suitable options for the back-up protection.

Solution Options

To reduce the need for future exemptions and reduce the cost faced by Users connecting small inverter connected generating systems to the low voltage distribution system, Western Power recommends revising the corresponding clause in section 3.5.3 of the proposed Technical Rules.

In the proposed Technical Rules, clause 3.5.3.2(f) states:

> *All dedicated protection apparatus must comply with the IEC 60255 series of standards. Integrated control and protection apparatus may be used provided that it can be demonstrated that the protection functions are functionally independent of the control functions, i.e. failure or mal-operation of the control features will not impair operation of the protection system.*

And a note appearing after clause 3.5.3.2(e) states:

> **Note:**
> This may be achieved by providing back-up *protection schemes* (including *protection* functions implemented in AS/NZS 4777.2 compliant inverters) or designing the *protection system* to be fail-safe, e.g., to trip on failure.

The propose change allows back-up protection to utilise the protection functions provided by the AS/NZS 4777.2 compliant inverters.

6.8.9 Combined earth fault and anti-islanding protection

Clause 3.6.10.1(g) in the current Technical Rules requires that:

- protection systems for generating systems connected to the distribution system provide earth fault protection for earth faults on the distribution systems, and
- generating systems connected to the high voltage distribution systems have a sensitive earth fault protection scheme.

Current Issue

The clause 3.6.10(g) requirements have been the source of a significant number of exemption requests from Users seeking to connect generating systems via inverters compliant with the latest Australian Standard. Users have sought, and in many cases been granted, exemptions (> 600 exemptions granted) recognising that for these generating systems the earth fault protection can be integrated with an anti-islanding scheme.

Sensitive earth fault requirements are relevant to loads.[47] However, in the current Technical Rules these requirements have been included in section 3.6, which is applicable to generators only.

[47] Sensitive earth fault is a form of earth fault protection that is set to be highly sensitive to detect fallen overhead conductors that may not produce a lot of fault current.

Solution Options

To reduce the need for future exemptions and reduce the cost faced by Users connecting small inverter connected generating systems to the low voltage distribution system, Western Power recommends revising the corresponding clause in section 3.5.3 of the proposed Technical Rules.

In the proposed Technical Rules clause 3.5.3.2(h) and the note following it state:

> *All power stations must provide earth fault protection for earth faults on the distribution system.*

Note:
The earth fault *protection scheme* may be earth fault or neutral *voltage* displacement (depending on the earthing system arrangement). For *generating systems* with an aggregate rated capacity of less than or equal to 1 MVA and *connected* via *inverters*, the earth fault *protection* may be integrated within an anti-islanding scheme.

The sensitive earth fault requirements are now appropriately located under the load section within section 3.5 of the proposed Technical Rules.

6.8.10 Anti-islanding protection requirements for distribution connected generating systems

Clause 3.6.10.3 in the current Technical Rules specifies the anti-islanding protection requirements for distribution connected generating systems. The clause requires two different functional types of anti-islanding protection be provided. In addition, generating systems with a rated capacity above 1 MVA are required to have each functional type of anti-islanding protection incorporated in a physically separate protection relay.

Current Issue

As currently drafted, clause 3.6.10.3 of the Technical Rules does not acknowledge the potential to utilise the anti-islanding protection incorporated in inverters to reduce the cost of meeting anti-islanding requirements. Inverters compliant with the AS/NZS 4777.2 incorporate anti-islanding protection functions that can be utilised in many situations to help reduce the cost of provided anti-islanding protection while maintaining a sufficiently reliable protection scheme to mitigate any system security or safety risk.

Solution Options

To reduce the cost to Users of providing anti-islanding protection while providing sufficiently reliable anti-islanding protection to maintain power system security and safety, Western Power has proposed revisions to the anti-islanding requirements for distribution connected generating systems.

The revised requirements are implemented in clauses 3.5.3.4(b) through (e) of the proposed Technical Rules. The revised requirements allow the following potential relaxation of the anti-islanding requirements:

- For generating systems with an aggregate capacity of ≤1 MVA that are connected to the low voltage distribution network via inverters that comply with AS/NZ 4777.2, the Network Service Provider may accept the anti-island protection incorporated within the inverters as sufficient.
- For generating systems with an aggregate capacity of ≤1 MVA that are connected to the high voltage distribution network via inverters that comply with AS/NZ 4777.2, the Network Service Provider may accept the anti-island protection incorporated within the inverters providing one of the anti-islanding protection functions provided the other function is provided by an IEC 60255 compliant external generator protection relay.

6.8.11 Protection requirements for loads

Current Issue

Clause 3.5.3 in the current Technical Rules uses the term “total fault clearance time” rather than “maximum total fault clearance time” as per other clauses (3.5.2(b) and 2.9.4). This should be amended for consistency.

Clause 3.5.3 does not include any requirement for loads connected to the high voltage distribution system to provide a sensitive earth fault protection scheme. Western Power may require this protection for high voltage connections to ensure appropriate detection and clearing of high impedance faults within the facility. This requirement has been located in section 3.6 of the current Technical Rules, which deals only with generation (while the requirement is relevant to loads).

Solution Options

Western Power recommends making the following changes to the consumer protection requirements specified in clause 3.5.5 in the proposed Technical Rules to address the above issues:

a) Amend sub-clause 3.5.5(a) replacing the phase total fault clearance time with maximum total fault clearance time accordingly.

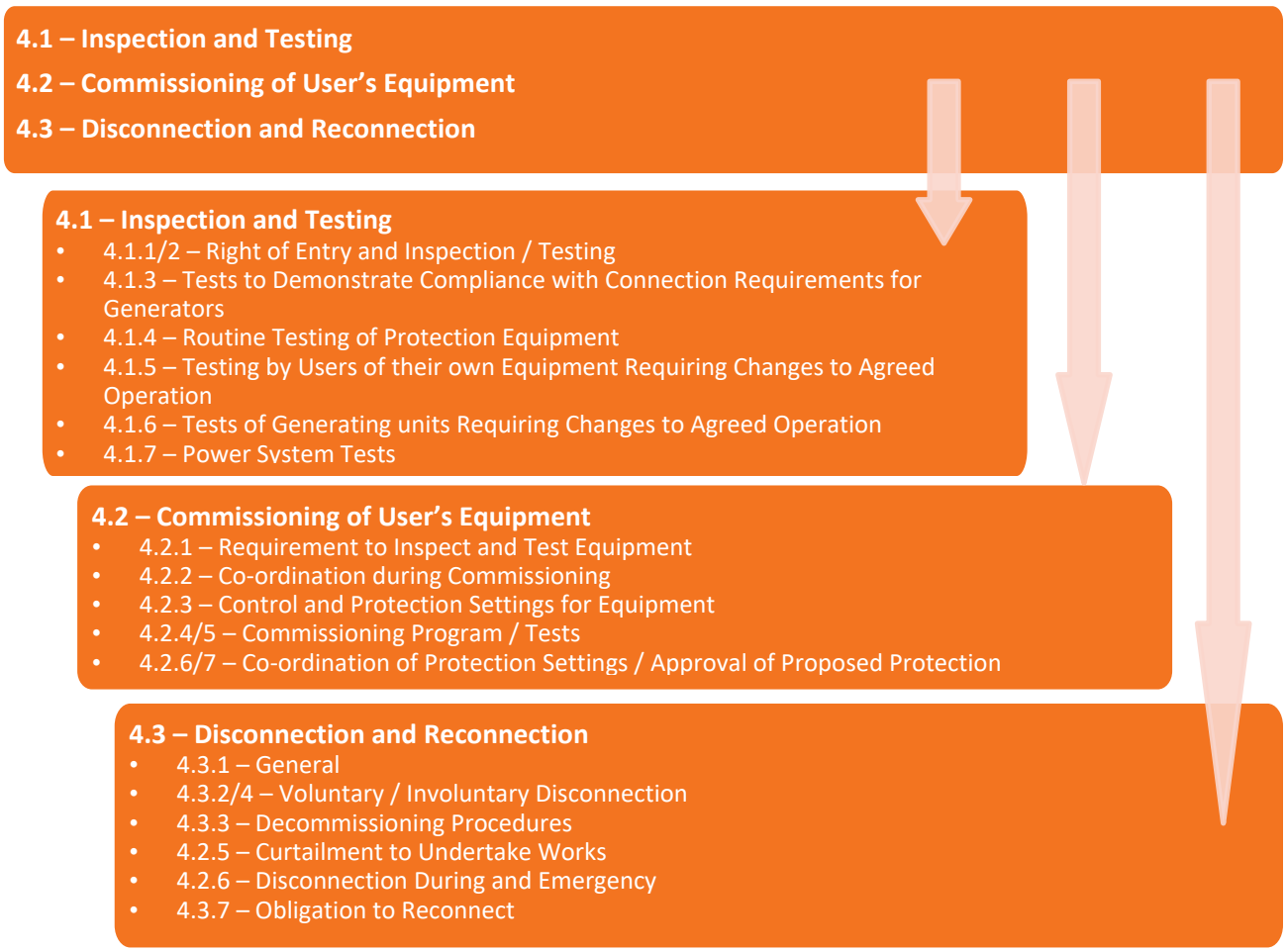
b) Add a new clause 3.5.5(c) specifying the requirement for sensitive earth fault protection for facilities connected to the high voltage distribution system.

Implementing these changes will clarify the protection requirements for consumer facilities in the Technical Rules.

7. Inspection, testing, commissioning and decommissioning

The inspection, commissioning and testing requirements that apply to Users connecting to Western Power's networks are outlined in chapter 4 of the Technical Rules.

The structure of this chapter of the Technical Rules is illustrated in the following diagram.



The limitations, issues and proposed solutions to address issues that have been identified through the Technical Rules review process are discussed in the sub-sections that follow.

7.1 Right of Entry and Inspection

Clause 4.1.1 of the Technical Rules outlines why Users, System Management or Network Service Providers can undertake inspections of equipment connected to the network. The current drafting allows the Network Service Provider, System Management and any User (or their representative) whose equipment is connected to the transmission system with appropriate notice to enter and inspect any of the Network Service Provider's or any other User's facility.

The Network Service Provider and System Management (now AEMO) require this privilege to inspect facilities to:

- ensure the facility owner is complying with its obligations, the Technical Rules, and any relevant connection agreement,
- investigate any operating incidents,

- investigate any potential threat by that facility to power system security, and
- conduct training associated with that facility.

7.1.1 Current issue

Clause 4.1.1(a) of the Technical Rules states that Users have the same rights as the Network Service Provider and System Management to inspect facilities owned by other Users and the Network Service Provider. While it is reasonable for the Network Service Provider and System Management (now AEMO) to possess this right, the rationale for allowing other Users to possess the right to enter and inspect other User's or the Network Service Provider's facilities is not clear.

As the clause is currently drafted, there is potential for misuse of the right of entry and inspection powers where Users are concerned, and there is no provision to refuse these rights.

Clauses 4.1.1(d), (e), (f) and (h) seek to limit the rights of the inspector by:

- requiring adequate notice be given to facility owner being inspected,
- limiting the regularity of the inspections to once every six months except in cases of non-conformance and by the Network Service Provider and System Management where investigation of operating instances under clause 5.7.3 of the Technical Rules is concerned,
- limiting the actions that can be taken during the inspection, and
- limiting the duration of the inspection to one day unless otherwise approved by the owner of the facility being inspected.

However, these clauses only mitigate and do not eliminate the risks associated with giving all Users the right to enter and inspect other's facilities.

7.1.2 Solution options & preferred solution

Western Power considered the following options that would address this issue:

a) Revising clause 4.1.1 of the Technical Rules to limit the right to inspect to the Network Service Provider. This involves redrafting the clause to remove explicit mention of User's and System Management's right to enter and inspect. While Western Power considers AEMO, in its role as System Management, should have the right of entry and inspection as currently drafted, AEMO's rights are detailed in the WEM Rules. The provisions under this option would be updated to require the Network Service Provider to share any collected information with AEMO, as appropriate.

b) Revising clause 4.1.1 of the Technical Rules to limit the right to inspect to Network Service Provider and AEMO. This involves redrafting the clause to remove explicit mention of the User's right to enter and inspect.

c) No change.

Option b) is preferred as it clarifies the scope of the right to the required parties (the Network Service Provider and its representatives). It also reflects AEMO's rights under the WEM Rules but is clearer than option a), whereby AEMO is omitted from the clauses. This option appropriately allows the Network Service Provider to perform inspections as required to perform its role under the Technical Rules, maintains AEMO's rights under the WEM Rules, and removes the potential for Users to use the right to enter and inspect inappropriately.

7.2 Testing by qualified persons

Testing by competent personnel is critical to the safe execution of tests that deliver reliable test results. It is important that the Technical Rules, when referring to tests, require that they be conducted by appropriately qualified persons.

As appropriate, some clauses in the Technical Rules specify that a suitability qualified person must undertake tests and sign off on activities such as the commissioning of generators. Qualified persons are referred to in the Technical Rules as chartered professional engineers with National Engineering Register (NER) standing qualified in a relevant discipline or personnel experience in the area required. For example, clause 4.2.5(g) of the Technical Rules states:

> *"All commissioning tests under this clause 4.2.5 must be carried out under the supervision of personnel experienced in the commissioning of power system primary equipment and secondary equipment".*

7.2.1 Current issue

Western Power has identified a series of clauses where the use of an appropriately qualified person is insufficiently specified. Unqualified testing personnel can lead to inaccurate testing results or unsafe testing procedures; hence it is important to ensure personnel with appropriate qualifications and experience perform testing.

Clauses where the use of a suitability qualified professional is required are summarised in Table 7-1.

Table 7-1: Clause to be updated to ensure a suitability qualified person undertakes activities, tests, and sign-offs

Clause	Description of drafting and issue
Cause 4.1.2	Clause 4.1.2 of the Technical Rules details the right of Users or the Network Service Provider to require equipment owners of suspected non-compliant equipment to conduct testing to demonstrate compliance. Clause 4.1.2(e) of the Technical Rules states that the testing requested under clause 4.1.2 "may be conducted only by persons with the relevant skills and experience." This sub-clause is vague in its qualification requirements of the tester. While this may be necessary due to the range and level of difficulty of testing that can be conducted under this clause, clause 4.1.2 of the Technical Rules will benefit from more specific and explicit qualification requirements.
Clause 4.1.3	Clause 4.1.3 of the Technical Rules details the need for Generators to demonstrate their equipment's compliance with the connection requirements. Clause 4.1.3(a)(3) of the Technical Rules states that these compliance tests are to take place only after a suitably qualified chartered engineer has tested and certified the installed equipment. While clause 4.1.3(a)(3) of the Technical Rules requires the initial compliance testing be performed only after the generator has been tested and certified by an appropriately qualified engineer, there is no requirement for a qualified person to undertake the compliance tests. Clause 4.1.3 of the Technical Rules would benefit from an additional sub clause requiring that the tests to demonstrate connection requirement compliance are supervised or undertaken by a chartered engineer experienced in the operation of the specific equipment.

Clause	Description of drafting and issue
Clause 4.1.5	Clause 4.1.5 of the Technical Rules details the responsibilities of a User to perform a test on their equipment that requires the facility to be operated in a manner that is different to that described in their connection agreement. Operating equipment in a manner that differs from that contemplated in the connection agreement creates a significant risk to Power System Security as the connection agreement enforces a user to operate in a manner to maximise power system security. Currently, there is no sub-clause that requires that these tests are overseen by an appropriately qualified person. As these tests are undertaken with significant inherent risk to the Power System it is prudent to require that an additional sub-clause is added requiring that these tests are undertaken by a chartered engineer with experience in the relevant field.

7.2.2 Solution options & preferred solution

Western Power considered the following options that would address this issue:

a) Adopt similar requirements as those that appear in clause 4.2.5(g) of the Technical Rules in relevant clauses identified as having an issue (refer to Table 7-1) to guide the qualifications of those who should undertake tests to determine compliance.

b) No change.

Western Power proposes drafting consistent with option a). Changes consistent with option a) will ensure the appropriately qualified person undertakes critical activities and tests. The revisions will help maintain system security by requiring that appropriately experienced personnel oversee commissioning and compliance tests. Accordingly, the proposed revisions to the Technical Rules include amendment of clause 4.1.2(e), addition of a new clauses 4.1.3(a)(5) and 4.1.5(i).

In addition to the proposed solution, Western Power considered options for the clauses listed above to adopt a narrowed specification of the experience required in each case. However, increased specificity is not recommended as adopting narrowed definitions can be counterproductive by inadvertently excluding some personnel who have appropriate experience and thereby placing unnecessary restrictions on Users.

7.3 Notification of power system tests

Power system tests are required to confirm that the transmission, distribution or power systems are performing to requirements.

Clause 4.1.7 of the Technical Rules sets out the criteria for tests required by the User, the Network Service Provider or System Management, including the notice periods given by the Network Service Provider before tests can be conducted. Power system tests are performed in accordance with this clause to verify the power transfer capability of the transmission or distribution system and to investigate power system performance. The tests are critical to the ongoing reliability of the distribution and transmission systems as they allow Users and the Network Service Provider to verify the capability of the power system by calibrating the measured and simulated performance.

7.3.1 Current issue

Clause 4.1.7(d) of the Technical Rules requires the Network Service Provider to provide Users who could reasonably be expected to be affected by a proposed test with at least 15 business days' notice of a proposed power system test. It has been identified that 15 business days' notice is too short for potentially impacted Users to enter a state of readiness or adequately identify the risk imposed on the operation of their facilities. If the Network Service Provider opts to provide the minimum notice period, Users may be ill-

prepared for the power system test and the risk of operational incidents with consequential risks to power system security increases.

A related issue is the lack of required consultation between the Network Service Provider and potentially impacted Users. For example, clause 4.1.7(c) requires the Network Service Provider to conduct tests requested by System Management or a User unless it considers that the grounds for testing are unreasonable. Throughout 4.1.7, the requirement (or right) for the Network Service Provider to conduct power system tests to conduct test regardless of input from affected Users creates potential risks. Where appropriate input from Users is not sought or considered, this may result in Users not fully understanding the implications or effect the proposed test, resulting in Users being ill-prepared for the required changes in operation during the test.

In other jurisdictions, the notice period that applies for similar tests is longer. For example, the Great Britain Distribution Code (DOC 12.4.1.1) requires a distribution network operator or a User to give six months of notice of a proposed system test when that test may have an effect on the others' systems.[48] The proposal to undertake such a test must be given in writing, and there is a process for recipients of the information to notify the test proposer if the information provided in the proposal notice is insufficient.

7.3.2 Solution options & preferred solution

Western Power considered the following options that would address this issue:

a) Add a new subclause in clause 4.1.7 of the Technical Rules specifying that if the Network Service Provider is satisfied that a system test is necessary, it must develop a proposed test procedure. The test procedure will describe how the tests will be undertaken and identify any potential impacts on Users during the tests. The test procedure will be finalised through consultation with affected Network Users. The Network Service Provider will be required to publish the draft test plan at least two months before the start of any test.

b) No change.

Option a) is preferred as the development of a test procedure and appropriate engagement with affected Users will help ensure:

- involved parties have a shared understanding of the process,
- that the User or Users understand the implications to their operations during the tests, and
- sufficient time is provided to allow affected Users to effectively identify and action any changes needed to manage their operations during a proposed power system test.

Provisions in the WEM Rules currently specify conditions under which a User should submit a commissioning test plan for approval by AEMO[49]. Further guidance is provided in the Commissioning Tests Power System Operating Procedure[50] that specifies the level of detail required in those plans, including notice periods. In some instances, system tests may need to be coordinated with the commissioning of User facilities. In those instances it is expected that the system test procedure would be appropriated aligned with the commissioning test plan developed in accordance with the WEM Rules.

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48 The Distribution Code of Licensed Distribution Network Operators of Great Britain, Issue 34, 7 September 2018, DOC12.4.1. Available at: http://www.dcode.org.uk/assets/uploads/D_Code_v34_clean_-_Published_070918.pdf

49 Refer to section 3.21A of the WEM Rules.

50 AEMO, WEM Rules – Power System Operation Procedure: Commissioning Tests, 1 June 2019. Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/wa_wem_consultation_documents/2018/aepc_2018_06/final/psop--commissioning-tests-clean.pdf?la=en&hash=2CD741BEBA49A57B197A979C704E78C8

Failing to change the Technical Rules risks confusion around the process for system tests and providing inadequate notice to Users potentially disrupts their activities. Therefore, maintaining the existing drafting is not recommended.

7.4 Aligning GPS compliance with the WEM Rules

Proposed changes to clause 3.3 of the Technical Rules (outlined in section 6 of this report) introduce similar generator performance standards (**GPS**) arrangements to those in the WEM Rules for large generators (>5 MVA), both transmission and distribution connected. These larger generators play a critical role in power system security.

Revisions to the WEM Rules introduce a range of new obligations, processes and roles with respect to testing and ongoing monitoring of GPS compliance for transmission connected market generators.[51] Those provisions, in many instances, differ from the existing provisions in Chapter 4 of the Technical Rules. The provisions in Chapter 4 of the Technical Rules will apply to similar-sized generators that do not participate in the WEM and may be connected to the transmission or distribution networks.

7.4.1 Current issue

While complete alignment is not possible between the Technical Rules and the WEM Rules[52], there are advantages in aligning the compliance arrangements for large generators across the two instruments.

These large generators can have a significant effect on the operation of the power system so they should be treated the same regardless of the regulatory instrument that applies to their facilities. Further, misalignment between the WEM Rules and Technical Rules where larger generators are concerned creates complexity in registration and potential confusion for operators and facility owners.

A gap in the alignment of the compliance regimes would also be inconsistent with changes in Chapter 3 of the Technical Rules that recommend the adoption of GPS and a negotiation process similar to that which applies in the WEM Rules to larger generators covered by the Technical Rules.

7.4.2 Solution options & preferred solution

Western Power considered the following options:

a) Revise relevant provisions in Chapter 4 of the Technical Rules covering compliance monitoring and reporting, testing and commissioning of large generating systems to align reasonably closely with the WEM Rules. The Network Service Provider will be assigned roles allocated to AEMO in the WEM Rules regarding approval of compliance plans and receipt of non-compliance notifications, etc. The Technical Rules will leverage the procedures in the WEM Rules wherever possible (e.g., compliance plan template).

b) Adopt similar revisions to option a) for all generating system regardless of size.

c) No change.

Option a) is recommended as it makes the Technical Rules a more valuable instrument providing additional clarity for connecting parties, including regarding whether the WEM Rules of Technical Rules compliance regime applies to large generators. It also maintains a broadly consistent approach between the WEM Rules and the Technical Rules for larger generators that assist in delivering system security.

[51] Market generators in both the proposed Technical Rule changes and in the WEM Rules are those that are registered as a Market Generator in accordance with the WEM Rules.

[52] The Technical Rules cannot place obligations on AEMO as the System Operator, for example.

Large generators captured by the processes in Chapter 4 of the Technical Rules have a similar potential to create adverse system security impacts if they fail to perform in accordance with their technical requirements as market generators who fail to meet the GPS requirements defined through the WEM Rules process. It is therefore appropriate that similar compliance obligations exist for both classes of generation.

Option b) is not recommended as they would leave large generators who negotiate their GPS via the updated Technical Rules with a reduced requirement to undertake ongoing compliance assessment. This is likely to provide inferior system security outcomes compared to option a).

The proposed revisions to the Technical Rules implement option (a) by including:

- Amendment to clause 4.1.3 clarifying when the compliance process in the WEM applies and when that in the Technical Rules applies
- Addition of clause 4.1.3(a)(3) requiring compliance testing following a relevant generator modification
- Revision of clauses 4.1.3(b) and (c).

As discussed further in section 7.7, option b) was not preferred as it would create an undue compliance burden for Users with small generating systems.

7.5 Option to renegotiate GPS where non-compliance is detected

GPS are required to ensure power system security. It is critical for a generator to comply with the agreed GPS because if a sufficient number of generators become non-compliant, the security of the power system can become threatened. An insecure power system is susceptible to faults resulting in poor reliability and potentially major loss of supply events.

7.5.1 Current issue

Chapter 4 of the Technical Rules is drafted as a once-through process, meaning that there is currently no avenue for a generator to revisit or re-negotiate their GPS obligations in response to non-compliance detected via tests conducted under chapter 4.

Proceeding with relevant modifications to generating equipment can alter the ability of generators to comply with their GPS. It is therefore appropriate that relevant generator modification trigger an appropriate review of the ability to meet GPS. This review should allow the generator and the Network Service Provider to renegotiate the GPS so that the Network Service Provider can ensure power system security while allowing the generator to adjust settings and equipment to optimise their operations.

7.5.2 Solution options & preferred solution

Western Power considered the following options to address the above issue:

a) For large generators, extend clauses covering the review of test results to allow for the potential to renegotiate GPS for larger generators. Where a renegotiation is required, the clauses in Chapter 4 should reference the relevant process in Chapter 3 of the Technical Rules.

b) Preclude renegotiation triggered by non-compliance, but allow renegotiation triggered by proceeding with a relevant modification to the generating system. This is best achieved by a modification to clauses in Chapter 3 of the Technical Rules to align with similar drafting in clause 3A of the WEM Rules. Clauses in Chapter 4 should provide for renegotiation between the interim and final approvals to operate (outlined in section 7.10 of this report) if required following tests conducted under an interim approval to operate.

c) No change.

Western Power has identified option b) as the preferred option. Amendments to allow renegotiation of GPS to reflect modifications provides appropriate flexibility for both Users and the NPS to adapt and proactively manage settings over time. However, allowing generators to renegotiate GPS following a non-compliance, as envisioned in option a), weakens the obligation on these Users to ensure their ongoing compliance.

A proactive approach to renegotiation of GPS settings ahead of planned changes (and excluding non-compliance) will ensure the Network Service Provider and AEMO can continue to rely on records of the technical requirements when managing the power system.

7.6 Rectification of non-compliance

Users can become non-compliant with their agreed GPS and specified technical requirements due to operational changes or the replacement of equipment. Non-compliant Users may threaten power system security, for example, by lowering the power system's fault ride-through capability. Hence, it is necessary for the Network Service Provider to possess some mechanism to enforce compliance by Users with the agreed standards and technical requirements or, if necessary, take appropriate action to ensure power system security is maintained.

Clauses 4.1.2(j) and 4.1.3 of the Technical Rules detail procedures for rectifying non-compliance issues with User equipment detected in testing. While the clauses place responsibility on the User to rectify non-compliance, they do not outline sanctions the Network Service Provider may apply as an enforcement mechanism, nor do they require ongoing operation monitoring to confirm equipment compliance has been achieved following any remediation activities. In the absence of other provisions, the only remedy available to the Network Service Provider is disconnection.

7.6.1 Current issue

The current drafting of clauses 4.1.2 and 4.1.3 of the Technical Rules do not provide for appropriate escalation measures prior to disconnection of a User if remediation to address non-compliances are not undertaken in a timely and effective manner.

The lack of intermediate remediation measures does not align with requirements in Great Britain or under the WEM Rules. In Great Britain, continued failure by a user to rectify a non-compliance situation (e.g., operating outside technical parameters) results in the user being disconnected either as a breach of their Connection Agreement or a breach of the Distribution Code (DC DCode DOC5.4.9). However, the Great Britain Distribution Code also contains a section (DOC5.6.6 Dispute Resolution) detailing the process to be followed by a generator following failure to meet technical parameters identified from a test. This includes a proposed rectification plan and expected compliance date. Chapter 3A of the WEM Rules specifies arrangements for developing rectification plans and implementing rectification activities when required, including the requirement to notify the ERA and Network Operator of any non-compliance.

In addition to the issues above, Western Power also considers clauses 4.1.2(j) and 4.1.3 of the Technical Rules do not provide enough detail around the process of reattainment of compliance.

7.6.2 Solution options & preferred solution

Western Power has identified the following options to address the above issues:

a) Extend clause 4.1.3 of the Technical Rules to adopt a process similar to that in the WEM Rules if testing reveals a non-compliance.

b) In addition to option a) include clauses that describe the actions that the Network Service Provider may take in response to failed attempts to rectify any non-compliance. These additional clauses will allow actions ranging from issuing a warning letter to disconnection of non-compliant equipment. An additional clause will also provide for the development of a plan of action with clear dates associated with actions.

c) No change.

Western Power considers option b) to be the preferred solution, as it provides a more complete solution. Proposed changes will ensure that non-compliances are consistently treated regardless of how they are detected. Updated clauses provide:

- better guidance regarding what is expected from Users to rectify any non-compliance.
- better definition of the rectification process than current arrangements, which should improve consistency of treatment of non-compliance and improve system security.
- the Network Service Provider (and AEMO) additional enforcement mechanisms allowing appropriate actions to be taken to ensure a secure power system.

7.7 Compliance provisions for small generators

For smaller generators (≤ 5 MVA), obligations that ensure compliance with technical requirements are needed that do not impose a cost on these smaller connections that is disproportionate to the risk posed by an individual non-compliance.

7.7.1 Current issue

The current framework in chapter 4 of the Technical Rules generally provides for compliance assessment performed during initial commissioning with provisions allowing the Network Service Provider to request additional testing when considered necessary.

Given the requirements for inspection, testing and commissioning that apply to large generators are being updated to align with WEM Rules changes (refer to section 7.4 of this report), Western Power has considered whether the existing Chapter 4 requirements should be retained or updated for small generating systems.

7.7.2 Solution options & preferred solution

Western Power considered the following options to address the above issue:

a) Maintain the existing approach in Chapter 4 of the Technical Rules for all Users, other than those controlling large generating systems, that does not require ongoing monitoring and testing to confirm compliance with technical requirements (differentiated from protection requirements covered in Attachment 12). The User is required to confirm compliance during initial commissioning

b) Extend the regime developed for larger generators to small generators and loads that require Users to undertake testing and monitoring to provide an ongoing demonstration of compliance with their technical regimes, executing test plans agreed with the Network Service Provider, reporting any non-compliance to the Network Service Provider and agreeing with the Network Service Provider rectification actions.

Option a) is the preferred option as it provides the right balance between compliance costs and system security for these smaller generators, and it allows for testing following specified trigger events.

Option b) is not necessary as the existing provisions provide adequate opportunities for the Network Service Provider to require testing to investigate suspected non-compliance.

7.8 Obligation for Users to update computer models and associated parameters

Computer models are used in software simulation packages (such as Power Factory) to model the power system. The Network Service Provider and AEMO rely on tests performed by Users to verify and update their computer models with respect to connected assets so that the models accurately reflect actual performance. The need to revise computer models may also be identified through power system test completed in accordance with clause 4.1.7 of the Technical Rules.

As the Network Service Provider and AEMO rely on power system simulations that use models supplied by Users to make decisions about the operation and planning of the power system, it is critical for those models to reflect, as closely as reasonably possible, the actual performance of the assets. If modelling information originally provided during the connection process proves to be inconsistent with actual measured performance, it is critical that the modelling deficiencies are corrected. Failure to do so could lead to incorrect assumptions in the way the Network Service Provider and AEMO operate the power system.

7.8.1 Current issue

Obligations in the Technical Rules require Users to provide information to the Network Service Provider and AEMO at the commissioning stage[53]. However, the obligations for Users to provide updated computer model information where subsequent testing has revealed an inconsistency between theoretical and actual performance is not clear.

While model validation is noted as a purpose for tests undertaken under clauses 4.1.3, 4.1.6 and 4.1.7 of the Technical Rules, Western Power has identified issues in the drafting of the following clauses in Chapter 4 of the Technical Rules related to Users providing updated computer models and associated parameters:

- Clause 4.1.3 (a)(1) Test to demonstrate compliance with connection requirements for generators
- Clause 4.1.6 Testing of generating units requiring changes to agreed operation
- Clause 4.1.7 (j) Power system tests

7.8.2 Solution options & preferred solution

Western Power considered the following options to address the issue outlined above:

a) Update the Technical Rules to require Users to update models and associated information to the Network Service Provider beyond initial commissioning requirements, consistent with the changes to the WEM Rules. This requires changes to clauses in Chapter 4 of the Technical Rules to require Users to provide sufficient data and information following testing for the Network Service Provider and AEMO to update their computer models to reflect the results of the tests.

b) No change.

Western Power proposes adopting option a). Adopting this option will ensure obligations on Users to provide modelling information to the Network Service Provider and AEMO is clearly set out. This ensures

[53] For example, clause 4.1.3(a) of the Technical Rules requires Generators to provide evidence, including in the form of modelling information and data sufficient to produce accurate computer models to the Network Service Provider and System Management to commencing commercial operations, as part of its connection requirements.

that tests the Network Service Provider or AEMO rely on to verify the performance of the connected assets provide enough data and information to update the Network Service Provider's and AEMO's computer model to reflect the results of the tests.

Adoption of the changed drafting also aligns with:

- changes to the WEM Rules, as reflected in clause 3A.2.2, which requires that transmission connected generating systems participating in the WEM provide as generating system model that complies with the modelling procedure developed by the Network Operators in accordance with clause 3A.4.2 of the WEM Rules.
- revisions proposed for Chapter 3 of the Technical Rules that reinforce that the User is responsible for ensuring the computer model provided reasonably reflect the plant performance as specified in the model guidelines produced by the Network Service Provider.

The changes to Chapter 4 and the revised obligations in Chapter 3 will, in practice, act as a general requirement for Users to ensure their computer models and associated parameters are accurate with the operation of their generator units.

7.9 Right to request information

The Network Service Provider requires adequate knowledge of the equipment within a Users' facility to understand potential implication for the operation of the power system. The Technical Rules currently provide a right to inspect facilities as a means for confirming details of connected equipment.

In many cases the need for an inspection could be avoided by the User providing information on the connected equipment.

Accurate information regarding a User's facility that is made available on request is necessary for the Network Service Provider to assess the ongoing impact of the User's facility on the performance and security of the transmission and distribution system.

There are three clauses in Chapter 3 of revision 3 of the Technical Rules that cover the provision of information from Users, in this case, Generators and Consumers, to the Network Service Provider:

- Clause 3.3.2 of the Technical Rules requires the Generator to provide all data reasonably required by the Network Service Provider to assess the impact of connection of a generator to the transmission or distribution system.
- Clause 3.4.5 of the Technical Rules requires a Consumer (that is, a user operating a load facility) before connection to the transmission or distribution system to potentially provide the information detailed in Clause 3.4.5(b) (1) to (13) of the Technical Rules. This information is used by the Network Service Provider to design and install the connection assets and determine the impact of connecting the load to the transmission and distribution system.
- Clause 3.6.3 of the Technical Rules requires a small Generator (or small power station) to provide information as detailed in clauses 3.6.3(b) and (c) on the design, construction, operation and configuration of that Generator. This information is needed for the Network Service Provider to determine if the connection of that Generator will have a negative effect on the distribution system.

These requirements have been retained in the proposed revisions to chapter 3 of the Technical Rules. They form part of the User's condition of connection. Hence, the provisions of information that are required by Clauses 3.3.2, 3.4.5 and 3.6.3 of the Technical Rules will be difficult to apply to existing Generators and Loads (who have already gone through the connection process).

7.9.1 Current issue

Currently, within the Technical Rules, there is no specific clause that allows the Network Service Provider to request information from Users.

Operational settings can change over time, and equipment is replaced from time to time. The inability of the Network Service Provider to request up-to-date information may result in the Network Service Provider's register of information on the facilities connected to the distribution and transmission systems to drift from actual specifications. Failure to address this information gap can lead to system security issues if the Network Service Provider and AEMO are unaware of the performance of User equipment (even where the levels are within compliant requirements).

7.9.2 Solution options & preferred solution

Western Power considered the following options to address the above issue:

a) Redraft clause 4.1 of the Technical Rules to include a new clause that establishes the right for the Network Service Provider to request information from Users, which allows the Network Service Provider the ability to gather information from Users (both existing and new) and share this information with AEMO where appropriate.;

b) No change – rely on the existing provisions in chapter 3, even for existing generators.

Option a) is the preferred solution as it addresses a gap in the existing Technical Rules that fails to provide an explicit right to for the Network Service Provider to request information. This right will be important to allow the Network Service Provider to confirm the technical capability of legacy User facilities. Additionally, an information provision will be a more efficient way of obtaining information as opposed to the inspection processes currently allowed by clause 4.1.1 of the Technical Rules.

The changes proposed in Chapter 3 of the Technical Rules (outlined in section 6 of this report) mean it is neater to provide for the requirements in Chapter 4 in a single location. As such, option b) is also not desirable in the context of other changes.

7.10 Interim and final approval processes

Recent revisions to the WEM Rules implemented an enhanced process for generators participating in the WEM to gain approval to operate. The process provides a staged approval framework consisting of an interim approval to operate to allow testing, with that approval replaced by an approval to operate on successful completion of tests to demonstrate compliance with technical requirements. This process supports the maintenance of power system security by clarifying the process for large generating systems to demonstrate that they are meeting expected performance requirements.

7.10.1 Current issue

Chapter 4 of the Technical Rules does not provide for staged interim and final approvals to operate for large generators. This means that the commissioning process defined in the Technical Rules is not aligned with that defined in the WEM Rules for transmission connected generating systems that participate in the WEM. Specifically, the Technical Rules do not allow for a User to be granted an interim approval to operate to allow demonstration of performance. There is also not clearly defined process for allowing operation once a User has demonstrated that their facility meets the relevant technical requirements.

Adopting a similar interim and final approval processes to that applying under Chapter 3A of the WEM Rules, would help align the processes in the Technical Rules and the WEM Rules providing improved clarity for Users.

7.10.2 Solution options & preferred solution

Western Power has identified the following options to address the above issues:

a) Amend clause 4.2.2 of the Technical Rules to add clauses implementing interim approval to operate and final approval to operate arrangements similar to those in the WEM Rules.

b) No change.

Western Power prefers option a) as it allows the User temporary permission to operate so that tests can be undertaken to prove compliance with technical performance with the final approval to operate issued once compliance has been validated. This provides a pragmatic framework allowing the temporary operation of User facilities necessary to demonstrate compliance.

The requirement for final approval to operate following an interim approval stage should provide a more robust process helping to prevent Users from operating facilities if they had not demonstrated compliance within the timeframes agreed when the interim approval was granted. The option for an interim approval should enhance the ability to meet system security and provide improved clarity for Users regarding the process and approvals associated with commissioning.

Option a) also aligns with the approach adopted in the WEM Rules.

8. Transmission and distribution system operation and coordination

Chapter 5 of the Technical Rules defines requirements for the operation and co-ordination of the Network Service Provider's and Users' facilities. The requirements in chapter 5 are intended to complement rather than duplicate related provisions in the WEM Rules.

The structure of this chapter of the Technical Rules is illustrated in the following diagram.

The limitations, issues and proposed solution to address issues that have been identified through the Technical Rules review process are discussed in the sub-sections that follow.

8.1 Clarifying Network Operator roles and responsibilities

The existing structure of chapter 5 does not differentiate the specific roles and responsibilities for operating the transmission and distribution networks performed by Western Power. The current drafting assigns operational obligations to either Users, the Network Service Provider or System Management.

8.1.1 Current issue

As System Management is no longer part of Western Power it is appropriate to revise Chapter 5 of the Technical Rules to clarify the operational responsibilities that remain with Western Power. Providing improved clarity around operational responsibilities will also support ongoing reforms that are considering whether a Distribution System Operator role should be defined and what activities should be allocated to the Distribution System Operator.

8.1.2 Solution options & preferred solution

Western Power considered the following options to address this issue:

a) No change to existing structure with all operational roles performed by Western Power expressed as Network Service Provider obligations.

b) Clarify Western Power's operational roles and responsibilities by separately specifying Distribution Network Operator and Transmission Network Operator roles and restructuring Chapter 5 to group obligations

c) Clarify Western Power's operational roles and responsibilities by separately specifying Distribution Network Operator and Transmission Network Operator roles, while maintaining existing structure for Chapter 5

d) Clarify Western power's operational roles and responsibilities by defining Distribution Network Operator and Transmission Network Operator roles and further differentiating operational obligations applicable for market participating entities and those who do not participate in the WEM.

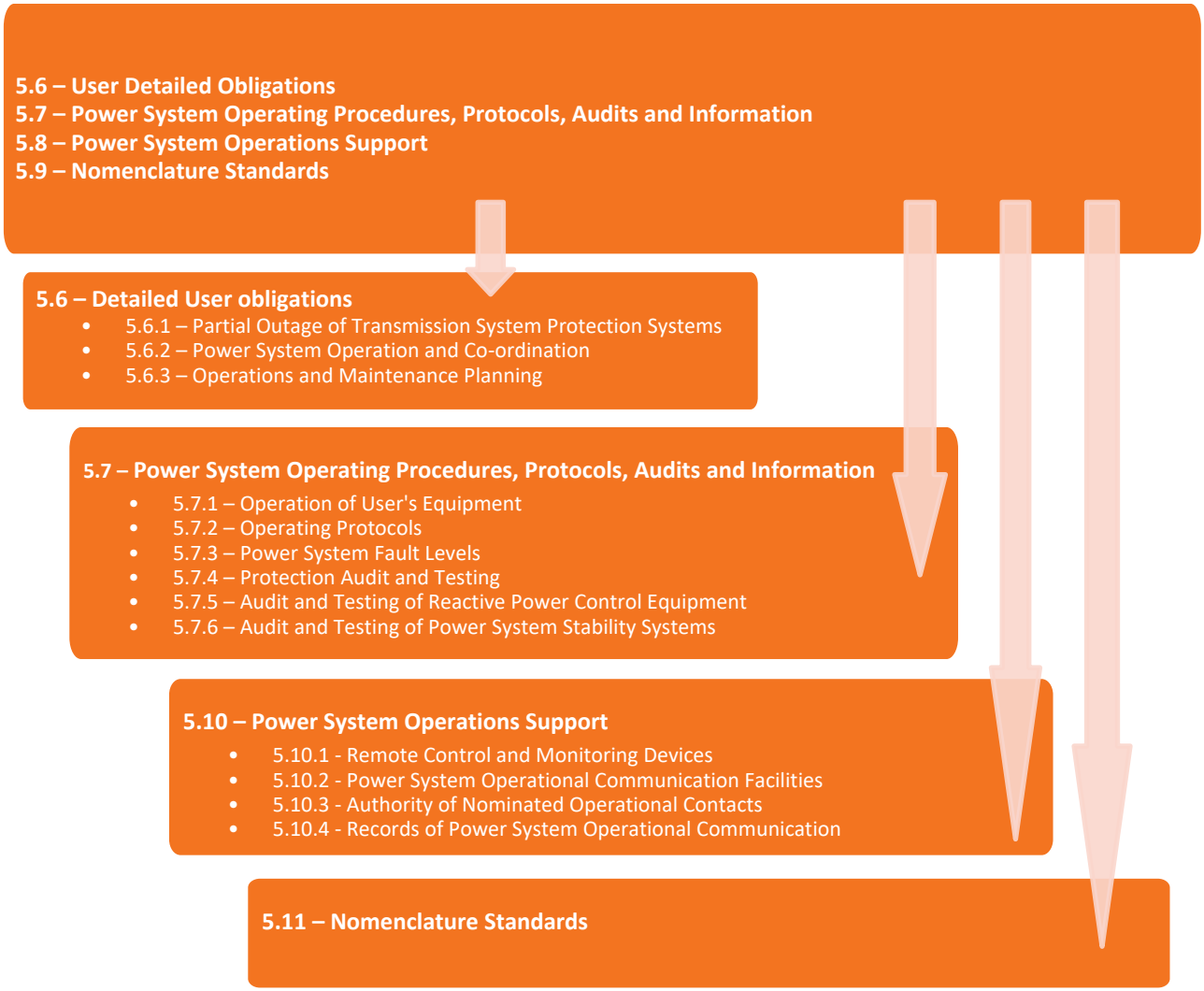
Western Power proposes changes consistent with option b). The proposed approach substantially restructures chapter 5. Compared to other options, the proposed changes provide much greater clarity regarding the operational roles and responsibilities allocated to Western Power as the operator of the transmission and distribution networks. The greater clarity will benefit stakeholder and assist with making any subsequent revisions necessary to accommodate distribution system operator functions.

The proposed changes result in the structure shown in Figure 8-1 and Figure 8-2. In addition to the structural changes the introduction provided in clause 5.3.1 was expanded to explain that in Chapter 5 of the Technical Rules the Network Service Providers operational obligations and responsibilities have been classified as Transmission Network Operator or Distribution Network Operator obligations and responsibilities.

In the remainder of this chapter unless otherwise stated any clause number in chapter 5 of the Technical Rules refers to the restructured clauses illustrated in Figure 8-1 and Figure 8-2.

Figure 8-1: Overview of revised structure for Chapter 5

Figure 8-2: Overview of revised structure for Chapter 5



8.2 Application

Clause 5.1 of the Technical Rules provides high-level guidance regarding the application of the specified operational requirements. The current drafting states:

> *This section 5 applies to the operation and coordination of the Network Service Provider's and Users' facilities to the extent not covered under the Market Rules. For Market Generators (as defined under the Market Rules, and generally being Generators the rated capacity of whose generating system equals or exceeds 10 MW) the rules that apply for power system operation and coordination are those found within the Market Rules.*

8.2.1 Current issue

The application guidance provided in clause 5.1 of the Technical Rules requires amendment to address the following issues:

- The clause currently recognises that generators participating in the WEM must comply with the relevant operational arrangements specified in the WEM Rules. This could result in confusion as the requirement to comply with the WEM Rules applies to all WEM participants, not just generators with a rated capacity equal to or exceeding 10 MW.

- The clause is currently silent on whether the Technical Rules specify the requirements for operational coordination between Western Power and AEMO. This omission has the potential to create confusion.

8.2.2 Solution options & preferred solution

Western Power considered the following options to address the above issues:

a) Delete references to the need for any WEM Participants to comply with the operational arrangements defined in the WEM Rules and rely on Users knowing those requirements are specified in the WEM Rules.

b) Refining clause 5.1 to note that all WEM participants must comply with the relevant operational requirements in the WEM Rules and to clarify the requirements for the operation and coordination between the Network Service Provider and AEMO are described in the WEM Rules and not included in chapter 5 of the Technical Rules.

Option b) is recommended as it provides guidance that will assist stakeholders in understanding the relationship between the operational requirements specified in the WEM Rules and the Technical Rules.

8.3 Alignment with revisions to network planning criteria and network service provider obligations

As discussed in sections 3 and 4 of this report, various revisions are proposed to the Network Service Provider obligations and the network planning criteria specified in chapter 2 of the Technical Rules. Those revisions necessitate an adjustment to related provisions in chapter 5 of the Technical Rules.

8.3.1 Current issue

To align with the revisions to the planning criteria, additional clauses were added to Chapter 5 of the Technical Rules to define operational criteria that Western Power seeks to meet when planning and operating the power system with the criteria:

- Recognising the need to operate the system consistent with the power system performance standard defined in Chapter 2 of the Technical Rules,
- Providing alignment with the planning criteria specified in chapter 2 of the Technical Rules, and
- Aligning with the power system security provision defined in the WEM Rules.

The revisions to Network Service Provider obligations in chapter 2 clarify obligations on the Network Service Provider to provide information to Users and network limit advice to AEMO. For consistency various clauses in Chapter 5 that addressed similar requirements were deleted where the requirements were adequately defined in Chapter 2 of the Technical Rules

8.3.2 Solution options & preferred solution

Revisions were made to the following clauses in chapter 5 of the Technical Rules to maintain alignment with the revisions introduced in Chapter 2 of the proposed Technical Rules:

- Clause 5.2.1(a)(3) was added to clarify that Chapter 5 specifies operational criteria with the criteria applicable to the transmission network specified in clause 5.4.1 of the proposed Technical Rules and that applies to the distribution network defined in clause 5.5.1 of the proposed Technical Rules. The operational criteria specified in sections 5.4.1 and 5.5.1 of the proposed Technical Rules have been defined to reflect the criteria assumed when planning the network as specified in the transmission and distribution planning criteria defined in section 2.5 and 2.6 of the proposed Technical Rules. The

proposed transmission planning criteria includes specific requirements regarding network loading, fault levels, voltage conditions and stability which must be achieved in planning timeframes. For consistency the operational criteria for the transmission system are specified in a similar manner in clause 5.4.1 of the proposed Technical Rules.

- Information provision requirements that appear as clause 5.3.2(a) and (b) in the current Technical Rules were deleted.
- Stability coordination requirements that appear as clause 5.6 in the current Technical Rules were deleted.
- Requirements specified in clause 5.4.1 in the current Technical Rules that require the Network Service Provider to assess and determine the limits of the operation of the transmission and distribution system were deleted as the limit determination obligations are now specified in clause 2.3.6 of the Technical Rules.
- As discussed in section 8.5, clause 5.4.5 of the proposed Technical Rules now includes guidance on the need to consider the ability to comply with the transmission planning criteria specified in chapter 2 of the Technical Rules when planning network outages.

8.4 Addressing technologies bias

It is important that the Technical Rules avoid drafting that is particularly biased towards particular technologies. Adopting this approach helps ensure that all options are considered allowing the most efficient investments to proceed.

8.4.1 Current issue

Clause 5.4.1(f) in the current Technical Rules lists technologies which may be utilised by reactive power facilities. The list does not include other technologies capable of providing reactive power, including inverter connected generating systems and electricity storage systems. The limited technology list may be construed as limiting the technology which can be deployed to provide reactive power facilities, which if adhered to could prevent the most efficient solution from being deployed.

8.4.2 Solution options & preferred solution

Western Power considered the following options to address this issue:

a) Extend the list of technologies listed in this clause to include inverter connected generating systems and electricity storage facilities,

b) Extend the list of technologies listed to include any technology capable of absorbing or injecting reactive power at the point of connection to the power system, or

c) Delete the clause and revise adjacent clauses to avoid the need to include a list of technologies.

Option c) is recommended as it removes an unnecessary provision and thereby avoids any restriction on technologies that may be deployed to provide reactive power.

This change has been implemented through the revisions to clauses 5.4.2 and 5.5.2 in the technical Rules. These clauses specify voltage control obligations that apply to the Transmission Network Operator and the Distribution Network Operator, respectively.

8.5 Clarifying arrangements for planning network outages

The appropriate coordination of planned outages of the elements of the transmission and distribution network and User facilities is an important aspect of operational coordination addressed by chapter 5 of the Technical Rules.

8.5.1 Current issue

Clause 5.8 in the current Technical Rules specifies obligations on Users regarding the notification and management of outages of their facilities. This clause is not intended to apply to Users who are registered as Market Participants (under the WEM Rules). For those Users, the outage planning requirements are specified in the WEM Rules and the relevant Market Procedure.

While this clause clarifies the obligations on Users, it offers no guidance regarding the process that Western Power should follow in assessing when to schedule a network outage. The lack of information regarding network outage scheduling may create confusion for stakeholders.

The Facility Outages Procedure published by AEMO in the requirement in the WEM Rules identifies network elements that fall within the oversight of the outage management process described in the WEM Rules.[54] For those network elements, the processes in the Facility Outages Procedure apply. However, it is unclear what processes apply for outages of other network elements.

With the revisions to the transmission planning criteria, it is beneficial for the maintenance and outage scheduling provisions in Chapter 5 of the Technical Rules to provide guidance on the need to consider the ability to comply with the transmission planning criteria when planning network outages.

8.5.2 Solution options & preferred solution

Western Power considered the following options to address this issue:

a) Introduce new a clause 5.4.5 that provides a detailed description of the processes the Transmission Network Operator will following in planning network outages.

b) Introduce a new clause 5.4.5 that specifies:

   i) An obligation for the Network Service Provider to develop an outage assessment guideline,

   ii) A requirement for the Transmission Network Operator to follow those guidelines when planning outages,

   iii) High-level principles that should be reflected in an outage assessment guideline including the need to consider the transmission planning criteria when assessing outages, and

   iv) As required by the WEM Rules, provide transmission equipment outage requests to AEMO.

c) No change - Retain the existing drafting.

Option b) is recommended as it provides improved transparency regarding the process used to plan transmission outages. Providing the specific details in the guideline simplifies the drafting of the Technical Rules and allows a more efficient process for amending the guidelines as necessary to refine the outage planning process while maintaining consistency with the principles defined in the Technical Rules.

[54] Facility Outages Procedure published by AEMO on 1 February 2020. Available at https://aemo.com.au/energy-systems/electricity/wholesale-electricity-market-wem/procedures-policies-and-guides/procedures

The proposed changes focus on improving clarity regarding the planning of transmission system outages as those outages have the potential to impact a much greater number of Users than distribution network outages.

8.6 Consistency with revised User requirements

As discussed in section 6 of this report, various revisions have been proposed to the User technical requirements specified in chapter 3 of the Technical Rules. Those revisions necessitate adjustments to related provisions in chapter 5 of the Technical Rules.

8.6.1 Current issue

A number of clauses in chapter 5 of the Technical Rules recognise that to provide a secure power system, Western Power should be able to require Users to operate their facilities in a manner that will deliver the technical performance specified in Chapter 3 of the Technical Rules.

Issue 1: Western Power identified potential ambiguity with the wording of those clauses, with the ambiguity relating to:

- the extent to which Western Power can request generators to alter their active control modes, setpoints and the dispatch of active and reactive power, and
- whether specific additional contractual arrangements are necessary to ensure Users comply with such requests made by Western Power.

Issue 2: The User technical requirements in Chapter 3 require specified Users to provide remote monitoring control and communication equipment. The standards that a User needs to adhere to when providing this equipment are not adequately defined in the current version of the Technical Rules, which creates confusion for Users. Specific examples of this issue include clause 3.3.4.1(b) and clause 5.10.1 in the current Technical Rules. These clauses state only remote monitoring equipment must conform to an acceptable standard as agreed by the Network Service Provider, but no details of the specific standard are provided. User facilities that participate in the WEM must also have appropriate remote monitoring, control and communications equipment to satisfy AEMO's requirements as specified in relevant WEM procedures (made under the WEM Rules).

The clauses giving rise to the above concerns required re-arrangement to accurately specify Transmission Network Operator and Distribution Network Operator roles and responsibilities.

8.6.2 Solution options & preferred solution

The solution options and preferred solutions to the two issues above were addressed separately.

Issue 1: Western Power considered the following options to address the issue concerning the ability to request Users to operate their facilities to deliver the Technical Requirements established through the processes defined in Chapter 3 of the Technical Rules:

a) Introduce revisions to appropriate clauses that:

   i) Clarify that the Transmission Network Operator or Distribution Network Operator is required to operate those parts of the transmission or distribution system that are not under the control of AEMO so as to ensure that the power system performance standards as specified in clause 2.2 or clause 6.2 are met, and

   ii) Recognise that to achieve the above may require a User to operate its equipment as necessary to maintain and restore secure and reliable operation of the power system.

b) No change - Retain the existing drafting.

Option a) is recommended as it provides clarity regarding when Western Power may request a User to operate its equipment to maintain and restore secure and reliable operation of the power system. This solution recognises the role of all Users in contributing to achievement of the performance standards.

For clarity, the clause is not intended to allow Western Power to request Users to operate their equipment outside of the technical limits provided for in the Technical Rules or otherwise agreed with Users. As such this proposed revision does not impose any additional obligation on Users beyond delivering the technical performance consistent with meeting the relevant User technical requirements. It also clarifies that Western Power can access additional capability through contractual arrangements with Users.

This change has been implemented through the revisions to clauses 5.3.1(a) and 5.3.2(a) of the proposed Technical Rules.

Issue 2: Western Power considered the following options to address the issue concerning the ambiguity in the appropriate standards for remote monitoring, control and communication equipment:

a) Revise the existing clause in chapter 5 addressing remote control and monitoring devices to clarify that:

   i) Those devices must be installed, operated and maintained by a User in accordance with the standards and protocols determined by the Network Service Provider or AEMO, and

   ii) The Network Service Provider must publish a 'Generating system control and monitoring guideline', describing the signals that a User may need to monitor and make available to the Network Service Provider or AEMO. In developing the guideline, the Network Service Provider must consider the procedure developed in accordance with clause 2.35.4 of the WEM Rules.

b) No change - Retain the existing provisions which allow communication standards to be negotiated on a case-case basis.

Option a) is recommended as it provides greater clarity for Users regarding the standards that their facilities need to meet. This should facilitate a more effective and efficient connection process.

This change has been implemented through the revision to clause 5.8.1 in the proposed Technical Rules.

8.7 Clarifying the role of User operating protocols

User operating protocols are developed to record and clarify non-standard or complex operational arrangements specific to a User's facility. Chapter 5 of the Technical Rules should provide sufficient guidance regarding the process for developing and maintaining those protocols.

8.7.1 Current issue

Some User facilities are connected via more complex and non-standard connection arrangements. These situations can give rise to specific matters that need to be considered when coordinating the operation of the User facilities and the transmission and distribution system. Information could include:

- Specific arrangements to coordinate outages of User facilities and the transmission system or the distribution system.
- Specific actions required to coordinate the operation of the User Facilities with the connected network.
- Specific technical information required to co-ordinate operations including details of protection, metering locations and arrangements at the connection point.

A common approach for capture this additional information employed by Network Service Providers operating in the NEM is to develop an operating protocol as an attachment to a connection agreement. The benefit of this approach is that all operating protocols that a Network Service Provider needs to refer to are developed in a consistent manner. The consistency simplifies the use of the documents operationally and reduces the risk of misinterpreting.

Western Power currently captures this information in a variety of ways, and there is no specific requirement in the Technical Rules addressing the requirement to produce and maintain an operating protocol. The lack of any specific requirement in the Technical Rules has contributed to inconsistent approaches being adopted, leading to inefficient outcomes and risking confusion regarding the operational coordination between the Western Power and Users.

8.7.2 Solution options & preferred solution

Western Power considered the following options to address the issue concerning the ambiguity in the appropriate standards for remote monitoring, control and communication equipment:

a) Revise chapters 3 and 5 of the Technical Rules to include:

   i) Requirements for Users, when required by the Network Service Provider, to negotiate a User Operating Protocol consistent with template maintained by the Network Service Provider,

   ii) A requirement for the Network Service Provider to maintain a template for User Operating Protocols,

   iii) A requirement for Users to operate their facilities in accordance with any relevant User Operating Protocol, and

   iv) A requirement for Users to maintain the User Operating Protocol to ensure it continues to accurately record relevant operating arrangements for their facility.

b) No change.

Option a) is recommended as it provides greater clarity for Users and Western Power regarding when an operating protocol is required and encourages a consistent approach to producing operating protocols.

This change has been implemented through:

- The revision of clause 5.7.1(b) to require Users to operate their facilities in accordance with the User Operating Protocol.
- The addition of clause 5.7.2, which:
  - places an obligation on the User to negotiate a User Operating Protocol if required to do so by the network Service Provider;
  - requires User Operating Protocols to be consistent with the template developed by the Network Service Provider, and
  - places an obligation on the User to maintain the User Operating Protocol.
- Revision of clause 3.1(b) of the Technical Rules to recognise that the User Operating Protocol should capture any additional restrictions or requirements beyond those specified in the other clauses in chapter 3 that apply to the User facility. Relevant links are provided for in clauses 5.5.3(e) and 5.5.4(c) of the proposed Technical Rules to ensure the Transmission Network Operator and the Distribution Network Operator consider these arrangements when taking approved outages.
- Revision of clause 5.3.3(h) to state that unless otherwise agreed with the Network Service Provider a User must operate their facilities in accordance with any relevant User Operating Protocol.

8.8 Clarifying system security obligations for the DNO and TNO

In parallel with the review of the Technical Rules, electricity market reform processes have identified the need to amend the WEM Rules to provide greater clarity around the framework for managing power system security. It is important that the operational requirements specified in chapter 5 of the Technical Rules are consistent with the power system security framework specified in the amended WEM rules.

8.8.1 Current issue

The current drafting in chapter 5 of the Technical Rules is not consistent with the allocation of power system security obligations and responsibility to AEMO and Western Power in the WEM Rules. Approved Tranche 2 and 3 amendments to the WEM Rules clarify that AEMO takes required actions to maintain power system security, including issuing directions to Western Power.[55]

The approved amendments to the WEM Rules clarify that AEMO has primary responsibility for deciding those actions that need to be taken to maintain power system security while Western Power operates the network and supports AEMO to maintain power system security. Western Power roles include:

- operating the network consistent with AEMO directions,
- developing secure transfer limits for the power system,
- monitoring the power system and advising AEMO of any power system security issues, and
- coordinating the operation of the transmission network with AEMO in accordance with the operating protocol established between AEMO and Western Power.

8.8.2 Solution options & preferred solution

The following changes to clauses in chapter 5 of the Technical Rules are proposed to align the power system security obligations in the Technical Rules with those specified in the approved amendment to the WEM Rules:

- Adding a new clause 5.3.1(b) to clarify that the operational activities performed by the Transmission Network Operator must be coordinated with AEMO following the processes defined in the WEM Rules and further informed by the relevant operating protocol established in accordance with clause 3.1A of the WEM Rules.
- Amending clause 5.4.2(a) to specify that the Transmission Network Operator must monitor rather than determine the adequacy of the capacity to produce or absorb reactive power.
- The obligation specified in clause 5.4.1(d) in the current Technical Rules that requires the Network Service Provider to design and construct the transmission and distribution system to control voltages requires revision. The requirement to design and construct should be replaced by a requirement to monitor voltages on the transmission system and implement operational arrangements to maintain voltages with the operational voltage envelope specified by AEMO and the voltage limits specified in clause 2.2. This revision is achieved by changing clause 5.4.2(b). The change avoids any conflict with the transmission planning criteria and maintains consistency with the system security arrangements in the amendments to the WEM Rules.

  A similar amendment is required to clause 5.5.2(b) of the Technical Rules, which specifies voltage management requirements assigned to the Distribution Network Operator.

[55] Refer to clause 3.4.5 in the approved tranche 2 and 3 amendments to the WEM Rules. Available at Wholesale Electricity Market Rules (www.wa.gov.au)

8.9 Clarifying acceptable timeframes for protection outages

Faults on the transmission network need to be cleared quickly and reliably to limit the potential for adverse impacts on power system security and the reliability of supply to customers. Given the importance of transmission system protection, the current Technical Rules (clause 2.9.2 and 2.9.3) specify requirements for the level of redundancy and availability that should be achieved by transmission system protection systems:

- Clause 2.9.2(a)(1) requires that elements of the transmission system be protected by main system protection comprising two fully independent protection schemes.
- Clause 2.9.3 specifies availability targets for transmission system protection and allows outages of up to 48 hours duration without removing the protected equipment from service. For longer duration outages, the clause specifies that protected equipment will be removed from service unless:
  - otherwise instructed by AEMO, or
  - a risk assessment demonstrates that it is appropriate to leave the equipment in service.

Chapter 5 of the Technical Rules also considers the availability of transmission system protection, specifying actions that should be taken to manage the impact of protection system outages.

8.9.1 Current issue

The existing transmission protection partial outage provisions expressed in clause 5.5.4 in current Technical Rules defines the obligations on the Network Service Provider to assess the risk associated with operating elements of the transmission system while there is an outage of one of the redundant protection schemes.

Clause 5.5.4 recognises that allowing the transmission equipment to remain energised while there is a protection outage may be prudent in many scenarios as it allows necessary maintenance to proceed without impacting the reliability of supply to customers or creating constraints on the dispatch of generation. The clause also recognises that while a transmission element is being operated with only one protection scheme available, there is a heightened risk that a fault may not be cleared, creating a potential system security issue.

The existing drafting provides discretion for the Network Service Provider to decide whether the proposed length of a protection system outage is short enough to warrant keeping the protected transmission elements energised. However, the clause does not provide sufficient guidance to ensure the discretion is exercised appropriately and consistently.

8.9.2 Solution options & preferred solution

Western Power considered the following options to address the issue:

a) Adding a new clause in chapter 5 that requires that the Transmission Network Operator consider the availability requirements specified in clause 2.9.3 when assessing the impact of transmission equipment protection outages.

b) Expanding the existing provisions in chapter 5 to specify acceptable durations for protection outages.

c) Expanding the existing provisions in chapter 5 to specify acceptable durations for protection outages and clarify that AEMO's involvement in assessing whether it is acceptable to leave protected equipment energised if that equipment falls within AEMO's area of oversight as defined in the AEMO-WP Operating Protocol (refer to clause 3.1A of the WEM Rules).

d) No change.

Option a) is recommended as it provides improved guidance regarding how the Transmission Network Operator should assess protection outages. Referencing the requirements in chapter 2 from the clause in chapter 5 ensures that there is appropriate recognition of the protection system design requirements when making operational decisions. The approach also avoids duplicating design requirements in chapter 5, which avoids the risk of inconsistencies emerging over time if modifications to the provisions in on chapter were not reflected in relevant clauses in the other chapter.

Option b) is not preferred as it leads to duplication of requirements with the potential for inconsistencies to arise over time. Option c) is also not preferred as it unnecessarily duplicates requirements expressed in the WEM Rules.

Option a) is implemented through the addition of clause 5.4.3(d) in the proposed Technical Rules.

8.10 Adequate consideration of all expected load conditions

The operational requirements specified in the Technical Rules should be specified in a manner that caters for all expected load conditions.

8.10.1 Current issue

Clause 5.4.1(b) in the current Technical Rules defines the obligations on the Network Service Provider to control voltage. This clause refers specifically to the need to assess the ability to "avoid voltage failure or collapse". While preventing voltage collapse is a legitimate concern when considering the adequacy of voltage control, a focus on voltage collapse tends to focus on consideration of peak demand conditions. The drafting may be interpreted as requiring less focus on other demand conditions.

The continued uptake of distributed energy resources such as rooftop PV systems is making control of voltage during light load periods challenging. It is, therefore, appropriate to consider revisions that avoid any undue focus on any one demand condition.

8.10.2 Solution options & preferred solution

Western Power considered the following options to address the issue:

a) Amend clause 5.4.2(b) to replace the words focussing on voltage collapse with a broader requirement to monitor voltages and implement operational arrangements to maintain voltage within the operational voltage envelope specified by AEMO and the voltages limits specified in the powers system performance standards (i.e., clause 2.2 of the Technical Rules)

b) No change.

Option a) is recommended as it avoids any interpretation that voltage issues need only be considered under peak demand conditions.

9. Disconnected microgrids and stand-alone power system performance

In recognition of the changes in power system technology and to deliver efficiencies, changes to the *Electricity Industry Act 2004* (the Act) allowing Western Power to use stand-alone power systems came into effect on 6 April 2020. The changes allowing Western Power use of these systems in the Great Southern, Goldfields, Wheatbelt, Mid-West and Geraldton. The Act defines stand-alone power systems as:

> *The wires, apparatus, equipment, plant or buildings (including generating works, a distribution system and any storage works):*
>
> *(a) which together are used, or to be used, for, or in connection with, or to control, the supply of electricity to a single customer or not more than a prescribed number of customers; and*
>
> *(b) which are not connected to another electricity network (other than that of the customer or customers).*

The intention is that stand-alone power systems are restricted to very small power system serving a single customer (e.g., a rural property) or a small group of customers.[56]

Disconnected microgrids are parts of the distribution system that become electrically disconnected from the power system and are able to run independently. They are operated by the Network Service Provider during the period they are disconnected. These are distinguishable from parts of the transmission system that become islanded but continue to be operated by AEMO. An example of a disconnected microgrid is the Kalbarri microgrid.

The term 'disconnected microgrid' has been defined by the Energy Transformation Taskforce as a part of the SWIS that is not an embedded system, that is designed to be separated from the SWIS at a particular connection point (or connection points) on a network, and that has separated from the SWIS and is being operated independently from the SWIS by a Network Operator.[57]

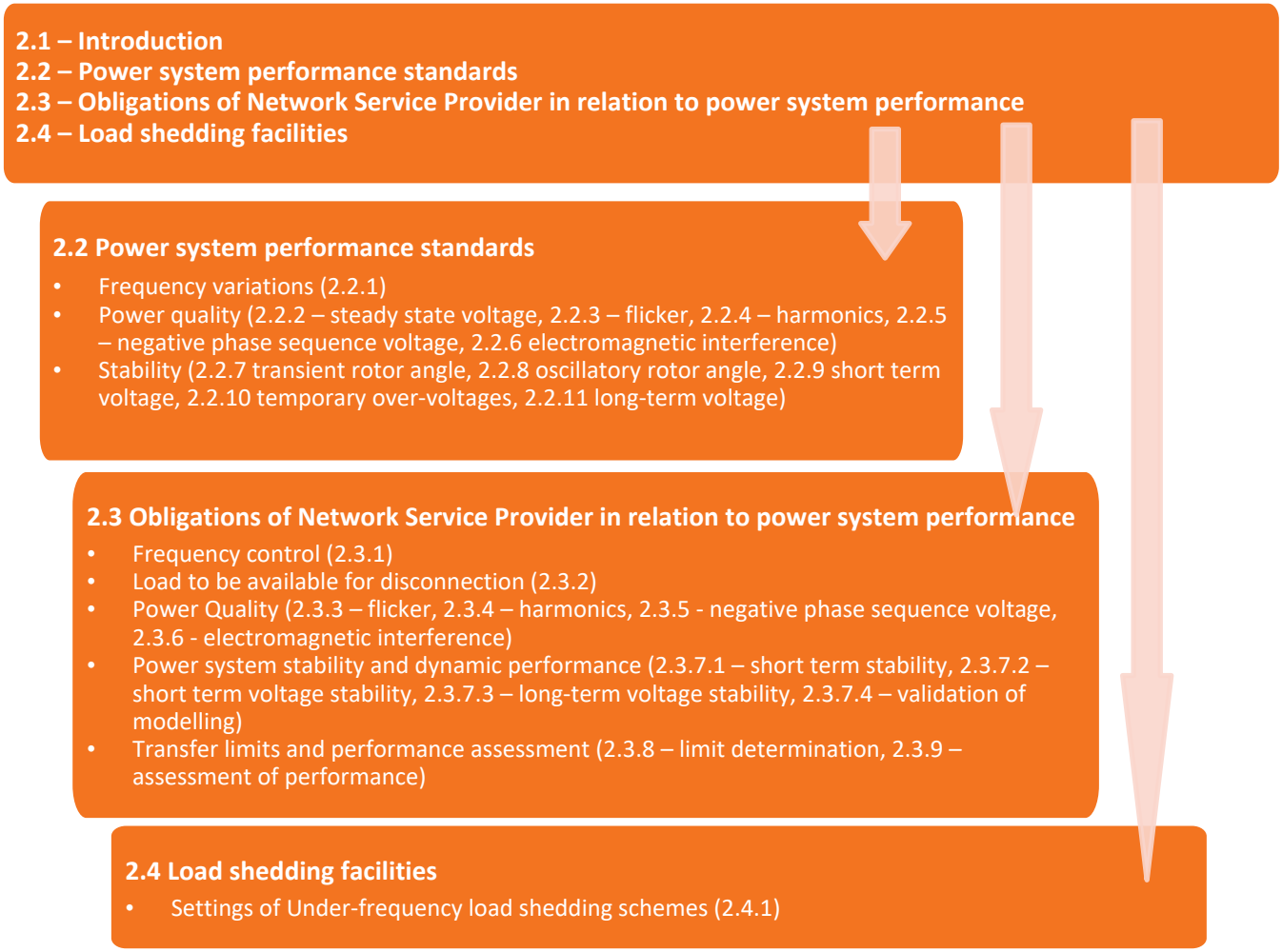
Disconnected microgrids can be managed under the existing regulatory arrangements, including the Technical Rules. However, the changes in the way the power system is being used, including in response to increased DER penetration, mean the likelihood and reliance on these systems is increasing. As such, Western Power considers explicitly covering disconnected microgrids in the Technical Rules would bring greater clarity to the management of these systems.

This chapter considers the coverage of disconnected microgrids and stand-alone power systems in the Technical Rules, specifically the system performance standards needed to ensure the safe and secure operation of these systems.

While Western Power proposes a new chapter of the Technical Rules to cover these systems, the existing chapter 2 structure was considered in the development of the chapter. The system performance standards covered in the current Technical Rules is illustrated in the following diagram.

[56] Western Australian Parliament, *Explanatory Memorandum for the Electricity Industry Amendment Bill 2019*, Legislative Council, 18 March 2020, p. 26. Available here.

[57] Energy Transformation Taskforce, *Revising Frequency Operating Standards in the SWIS*, November 2019, p. 8-9



The limitations, issues and proposed solution to address issues that have been identified through the Technical Rules review process are discussed in the sub-sections that follow.

9.1 Definitions for disconnected microgrids and stand-alone power systems

9.1.1 Current issue

The Technical Rules do not explicitly define disconnected microgrids and do not contemplate stand-alone power systems. Through the Technical Rules review process, Western Power considered the definitions that could be adopted for each of these systems.

9.1.2 Solution options

In making recommendations on the definitions that will be most usefully included in the Technical Rules, Western Power has considered:

- How definitions would work with existing definitions in the Technical Rules and associated legislative instruments.
- Useful delineations between systems that make sense on a technical basis (as opposed to those definitions that may be required for market purposes).

As part of the review process, Western Power also reviewed equivalent definitions used in other jurisdictions. However, the definitions used elsewhere were either not sufficiently advanced to be useful or risked becoming outdated rapidly because they named the systems.

The proposed definitions align with Western Australian policy guidance and existing regulatory instruments:

- The proposed definition for stand-alone power system is the same as the definition given in the Act.
- The proposed definition for disconnected microgrid builds on policy guidance provided by the Energy Transformation Task Force and builds on the definition used for stand-alone power systems in the Act.

Several queries were raised and clarified during the review process that are noted here for transparency:

- Under the Act changes, stand-alone power systems (and microgrids) are considered to be part of the covered network and therefore form part of the legal definition of the SWIS even if not electrically connected.
- Disconnected microgrids are, by definition, distribution voltage. When electrically connected to the SWIS, they therefore form part of the distribution system.

9.2 Frequency operating requirements

The frequency standards that disconnected microgrids and stand-alone power systems are technically capable of achieving differ depending on the technology used in each system. For example, disconnected microgrids with more synchronous generation connected will have more rotating inertia connected and allow for stricter frequency operating standards to be applied. However, the amount of rotating inertia connected to a system will change significantly under different operating conditions.

Operation outside of frequency standards can cause damage to user equipment connected to the power system, particularly motors and generators. Therefore, it is necessary to define minimum acceptable frequency operating requirements for microgrids and stand-alone power systems that are technically feasible to achieve (i.e., not cost-prohibitive) and that also adequately protect connected user equipment.

9.2.1 Current issue

The frequency operating requirements in the Technical Rules do not contemplate disconnected microgrids or stand-alone power systems. These systems inherently have lower rotating inertia[58] than larger power systems, so the adoption of less stringent requirements typically provide for more cost effective solutions without adversely effecting customer experience.

In selecting the preferred approach to specifying frequency requirements for disconnected microgrids and stand-alone power systems, Western Power considered approaches taken in other jurisdictions, as well as international practice regarding inverter standards and their response to frequency variations.

In Western Australia, Horizon Power has significant experience with the management of frequency in non-interconnected or isolated power systems and have recognised the need for relaxed frequency standards in those systems compared to the larger and more interconnected Pilbara Grid. The Table below contrasts the frequency standards in the Horizon Power Technical Rules (Table 9-1). Horizon Power is currently reviewing whether further relaxation of frequency standards is justified for microgrids and standalone power systems.

[58] Rotating inertia is the primary component governing rate of change of frequency under a contingency event.

Table 9-1: Horizon Power microgrid frequency operating standard

Power system	Condition	Frequency band normal operation	Frequency band following disturbance
Non-interconnected systems	Normal operation and following disturbance	49 to 51 HZ (less than 5 secs continuously outside this range permitted)	45 to 55 Hz (less than 5 secs continuously outside this range permitted)
Pilbara Grid	Normal operation	49.75 to 50.25 Hz	49 to 51 Hz (single contingency) 48 to 52 Hz (multiple contingency)

Source: Horizon Power, Technical Rules, 5 August 2020, Table 2.1 and Table 2.2, pp. 17-18.

AS/NZS 4777 defines stringent over- and under-frequency protection settings for inverters with specific settings specified for inverters operating in isolated or remote power systems (Australia C settings).[59] The standard requires inverters to:

- remain in operation for frequency between 45 Hz and 55 Hz (+/- 10 % of nominal frequency), and
- support control of frequency by increasing generation, if possible, as frequency moves below 49.5 Hz and reducing generation as frequency moves beyond 50.5 Hz.

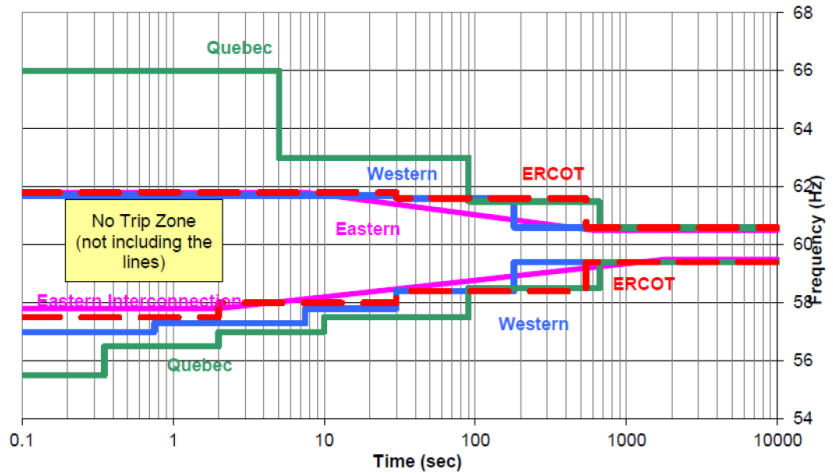
The standard specifies narrower settings for interconnected power systems such as the SWIS (Australia B settings). Those settings require that inverters ride through frequency in the range 47 Hz to 52 Hz with the response to correct frequency occurring once frequency falls below 49.85 Hz or rises above 50.15 Hz.

In North America, although nominal frequency is at 60 Hz rather than 50 Hz, some synchronous interconnected systems have more relaxed frequency requirements than others. Figure 6 shows the required inverter ride-through requirements for a number of North American power systems. The Quebec interconnection has a wider frequency ride through band, which reflects that this power system is dominated by hydro-electric generation, which tends to respond more slowly to control frequency and hence is only able to efficiently maintain frequency within a wider band (+10% to – 7.5%)[60]. The ERCOT system tends to have a greater proportion of thermal generation, which offers tighter frequency control. The eastern interconnection is a very large interconnected synchronous power system with high rotational inertia. In these systems, frequency is controlled more tightly and is reflected in the inverter ride through requirement being specified as a narrower frequency band (approximately +/- 3% of nominal frequency).

[59] AS/NZS 4777.1:2016 (Grid connection of energy systems via inverters - Installation requirements)

[60] CER – Provincial and Territorial Energy Profiles - Quebec (cer-rec.gc.ca)

Figure 6: Frequency ride through standards (Figure 4.3)



Source: North American Electric Reliability Corporation (NERC), *Inverter Based Resource Performance Guideline*, September 2018, Figure 4.3, p. 43.

9.2.2 Solution options & preferred solution

In developing a new minimum frequency operating standard for disconnected microgrids and stand-alone power systems, Western Power considered the following factors:

- The frequency range over which disconnected microgrids and stand-alone power systems could technically operate.
- Recognition of the inverter ride through settings that are likely to apply to inverters connected to disconnected microgrids will be much tighter than those for inverters connected to stand alone power system. This is because the inverters attached to disconnected microgrids need to be set to meet the requirements for operating while connected to the SWIS as this will be the predominant arrangement.
- The need for the frequency in disconnected microgrids to be controlled in a manner consistent with the settings of emergency frequency controls such as under-frequency load shedding. It may not be practical to alter under-frequency load shedding settings on formation of a disconnected microgrid and the setting will therefore generally remain unchanged from those that exist during normal operation when connected to the rest of the SWIS.
- The ranges within which customer equipment connected to these systems can operate.
- The time period over which ranges for normal operation should apply.
- The need to distinguish different ranges for normal and post-contingency event conditions, noting that this is linked to updated definition for contingency event.
- Existing practice including the limits that currently apply to the SWIS as outlined in the WEM FOS and in Horizon Power's systems (as outlined above).
- The requirement in section 25 of the *Electricity Act 1945* for the network operator to target +/-2.5% of their declared frequency (of 50 Hz), which provides for a range of 48.75 to 51.25 Hz

A wide-range of options were discussed in workshops that informed this submission and the proposed Technical Rules. Options considered various combinations the factors outlined in Table 9-2.

Table 9-2: Factors and option inputs considered for disconnected microgrid and stand-alone power system frequency requirements

Factor	Options
Normal operating frequency band	• 49 to 51 Hz (consistent with Horizon Power microgrids) • 49.5 to 50.5 Hz (consistent with islands in the SWIS) • 47 to 52 Hz (Australia B ride through frequency specified in AS/NZS 4777)
Permitted period outside of normal operating frequency band	• Must remain within the normal operating frequency band 99% of the time over any 30 day period (consistent with FOS specified in the WEM Rule) • Less than 5 secs continuously outside this range permitted (consistent with Horizon Power standard for non-interconnected grids)
Contingency	• No contingencies • Single contingency only • Multiple contingencies
Post continency frequency (where applicable)	• 45 to 55 Hz (consistent with Horizon Power standard for non-interconnected systems)

Normal operating frequency requirements

For the normal operating frequency, Western Power proposes the upper band for both disconnected microgrids and stand-alone power systems should be set at 52 Hz, the level at which AS/NZS 4777.2 allows inverters in Australia B regions to disconnect. Increasing the frequency above 50.25 and toward 52 Hz will curtail inverter connected generation and provides an effective means to control renewable generation in disconnected microgrids and stand-alone power systems. This provides a cost effective method for addressing excess generation within these smaller systems. Excess generation in these systems (often solar rooftop PV) may result in reverse power flows into the synchronous generation sources, which if not addressed risks tripping the entire system.

The lower band proposed for stand-alone power systems is 47 Hz, which provides for a wider frequency operating range providing greater technical flexibility, and with recognition of the range in which equipment operates. Equipment operating in the SWIS is already designed to anticipate frequency falling to 47 Hz and this means that adopting a 47 Hz limit for stand-alone system should not restrict the equipment that consumers can be supplied from in those systems.

For disconnected microgrids, a more limited range is proposed with the lower band being set to 49 Hz. A tighter range is proposed for these systems to recognise that components within the microgrid also need to operate when connected to the rest of the SWIS and may not be designed to cater to a wider range. A tighter range for disconnected microgrids also allows for more scope to manage contingencies within the disconnected microgrid (where applicable).

Some of the proposed ranges are beyond the ranges envisioned in the *Electricity Act 1945*. The technology employed in stand-alone power system and disconnected microgrids did not exist when the Act was drafted. Further, Western Power considers the 1945 Act was intended to apply to large power systems and therefore smaller islanded systems were unlikely to have been considered. As indicated in the notes proposed for the Technical Rules, the Network Service Provider must use its best endeavours to operate as close to nominal frequency as reasonably practicable.

Consistent with changes to the FOS being made for the WEM, Western Power also proposes that the FOS for disconnected microgrids applies for 99% of the time over any 30-day period.[61] This allows for various fault events and other system disturbances that occur on occasion that might otherwise require a wider frequency band. The use of an existing standard (over, for example, adopting Horizon Power's requirements), retains consistency across the Network Service Providers operating practices.

Contingencies and post-contingency requirements

Disconnected microgrids are expected to form and be supported primarily for parts of the distribution system that are connected to the remainder of the system via a single feeder.

A disconnected microgrid may or may not be designed to handle further contingencies. Where it is design to cater for certain contingencies (such as loss of single generator or battery), then the frequency operating band needs to be as wide as possible so allow continuous operation without over-investing. The proposed post contingency frequency operating requirements align with those used by Horizon Power for non-interconnected grids.

Stand-alone power systems are not expected to withstand a contingency event so no post contingency frequency operating standard is proposed for these systems. Withstanding most contingency events in a system as small as a stand-alone power system is uneconomical because the whole system may need to be duplicated.

9.3 Provision for emergency response generators

Emergency response generators are used by Western Power to support the network during planned and unplanned outages. When these generators are used, parts of the network can become disconnected or islanded in a manner which is electrically similar to a disconnected microgrid.

9.3.1 Current issue

It is onerous to require Western Power to maintain normal security of supply standards when emergency response generators are being used to support the network. There is an opportunity to clarify some of the technical requirements for these scenarios through the disconnected microgrid and stand-alone power system Technical Rules chapter.

9.3.2 Solution options & preferred solution

Western Power proposes to include frequency operating requirements for parts of the distribution system that are islanded and supported by emergency response generators. The proposed requirements are the same as those proposed for stand-alone power systems. The size of the system supported by emergency generators will vary. The wider frequency requirements allow for a broader set of possible solutions that maintain power to the customers without risking damage to equipment.

Similar to the provisions for disconnected microgrids and stand-alone power systems, it would be onerous to require portions of the network being supplied by an emergency response generator to survive multiple contingencies.

[61] ETIU, Revising Frequency Operating Standards in the SWIS, November 2019, Attachment 1.

9.4 Voltage requirements

Section 2.2.2 of the Technical Rules sets out the criteria relating to steady-state power frequency voltage. Clause 2.2.2(b) sets out the limits for voltage step changes resulting from switching operations and Table 2.2 in the Technical Rules that sets out the voltage step-change limits that apply for distribution and transmission systems.

9.4.1 Current issue

As the Technical Rules do not yet contemplate disconnected microgrids or stand-alone power systems, it is unclear if the existing distribution system voltage limits should apply to these systems.

Western Power considers it unlikely that the voltage step change limits currently set in the Technical Rules were intended to apply to disconnected microgrids or stand-alone power systems as these systems would not form part of the synchronised system. Further, the low system strength of disconnected microgrids and stand-alone power system makes it unlikely that these systems will be able to economically achieve the same criteria.

Voltage performance requirements for disconnected microgrids and stand-alone power system should be established in the Technical Rules to provide clarity for system operators and Users.

9.4.2 Solution options & preferred solution

In developing recommended changes, Western Power considered the fundamental characteristics of disconnected microgrids and stand-alone power system, to establish voltage standards that are reasonably achievable and provide adequate protection for consumers from excessive steady state voltages or voltage step-changes.

Western Power also considered the extent to which the voltage requirements for these systems should align with the proposed distribution voltage requirements (discussed in section 3.5 of this report).

Steady stage voltage limits

Western Power recommends adopting that same steady state voltage limits for a disconnected microgrid or stand-alone power system as proposed for the distribution system.

The revised distribution system steady state voltage limits are expressed with reference to the nominal voltage for those portions of the distribution system operating above 1 kV. The requirements for the low voltage distribution system reflect the limits established in AS 61000.3.100.

Adopting the same steady state standards for stand-alone power system and disconnected microgrids as the rest of the distribution system ensures consistent performance for Users (during steady state) regardless of whether they are supplied from the distribution system or not. Adopting these standards will not add appreciable cost to the stand-alone power system or the disconnected microgrid.

Voltage step change limits

More relaxed voltage step-change limits are recommended for disconnected microgrids and stand-alone power systems than those proposed for the distribution system. The smaller size of these systems affects the ability for these systems to respond to switching events and contingencies. It would not be economic to design these systems to maintain the same level of control over voltage step changes as can be achieved in larger power systems. The relaxed step change limits should not result in Users experiencing any adverse

effects as the voltages is still required to return to steady state limits following switching and overvoltage limits must not be exceeded.

Transient overvoltage limits

Western Power recommends adopting that same transient overvoltage limits for a disconnected microgrid or stand-alone power system as proposed for the distribution system. The over-voltage limit should remain unchanged to ensure no adverse impact to customer equipment. Allowing greater temporary over-voltages could risk damage to User equipment and is therefore not acceptable.

Similar to the steady state voltage limits, the updated distribution system requirements specify limits as percentage changes relative to nominal voltage. The proposed requirements continue to distinguish between locations with distribution voltages greater than 1 kV and those on the low voltage distribution system (1 kV and below). Drafting provides for a range of voltage levels that can be applied as required to the newly defined systems.

9.5 Power quality and stability

Power quality is a measure of how well the power system voltage waveforms conforms to established specifications. Users' equipment is designed to operate effectively and efficiently provided the quality of the power supply remains within specified limits. Failure to maintain power quality can result in User equipment not performing as designed, tripping or being damaged. The power system performance standards in the chapter 2 of the Technical Rules specify power quality criteria specifying harmonic voltage limits, negative phase sequence limits, flicker limits and limits for electromagnetic interference.

Power system stability refers to the ability for power system to return to a stable operating condition following a disturbance. Section 2.2 of the Technical Rules define requirements for transient stability, oscillatory stability and voltage stability. Failure to maintain power system stability can lead supply interruptions and in the worst case a complete system collapse or blackout.

9.5.1 Current issue

In the current Technical Rules, clauses 2.2.3 to 2.2.11 define the power quality and stability requirements for the SWIS. The size of disconnected microgrids and stand-alone power systems and the nature of generation and any storage technology employed to supply power in these systems alter the ability for the system to achieve a particular power quality and stability requirement.

As part of the review for the Technical Rules, Western Power considered whether the existing or proposed clauses could be applied to disconnected microgrids and stand-alone power system or if separate, equivalent clauses are required.

9.5.2 Solution options & preferred solution

The proposed power quality and stability requirements for disconnected microgrids and stand-alone power systems align with proposed Technical Rules for the distribution system as much as possible. Where more suitable requirements are required, these have been developed drawing on relevant Australian Standards.

Each requirement is discussed in turn.

Flicker and harmonics

The proposed flicker planning levels and harmonic voltage planning levels for disconnected microgrids and stand-alone power system are the same as those that apply for the same voltage level in the distribution system.

Parts of the distribution system that form a disconnected microgrid are planned to meet the flicker and harmonic distortion requirements that apply to that portion of the distribution system. This approach recognises that for most of the time the portions of the distribution network that make up the microgrid are connected to and operate as part of the distribution system. Hence it is appropriate that the flicker and harmonic distortion standards specified in section 2.2 of the Technical Rules apply when the microgrid is connected to the distribution system. To meet the flicker and harmonic distortion requirements the Network Service Provider with allocate limits to the Users supplied via the microgrid determined via the process specified in section 2.3 of the Technical Rules.

Specifying that the flicker and harmonic distortion requirements in section 2.2 of the technical Rules also apply to disconnected microgrids provides Users with a consistent set of requirements regardless of whether the microgrid is disconnected from the distribution network or not.

Further, customers supplied via disconnected microgrids and stand-alone power systems will expect to observe similar levels of flicker and harmonic distortion as they would if connected to the distribution network. Defining consistent flicker and harmonic distortion standards regardless of the supply system will align with this expectation.

One exception is required for stand-alone power systems, to cater for the situation where a consumer chooses to connect equipment that exceeds the allocated flicker and harmonic distortion limits. If this occurs, it is likely that the flicker and harmonic distortion standards specified in section 2.2 of the Technical Rules would not be achieved. Western Power does not believe that in this scenario it is appropriate to require the Network Service Provider to augment the stand-alone power system to address the power quality concern created by the connection of the consumers equipment. As such, an exclusion is proposed for these circumstances.

In practice, if customers raise issues with flicker or harmonic distortions at their properties where stand-alone power systems are installed, Western Power would be involved in the investigation to determine the cause and work with the customer to identify remedies.

Negative phase sequence voltage

The proposed negative phase sequence voltage limits for disconnected microgrids system are the same as those that apply for the same voltage level in the distribution system.

Similar to the rationale that applies to flicker and harmonics, disconnected microgrids are designed to be part of the distribution system and only intended to serve customers for a small proportion of the time. Specification of differing negative phase sequence limits is not appropriate.

In a stand-alone power system, any negative phase sequence voltage will be due to the consumer connecting unbalanced loads to a three phase system. Western power does not believe it is appropriate to require the Network Service Provider to augment the stand-alone power system to address negative phase sequence issues caused by the connection of customer equipment. In practice, there will be very few customers with three-phase connections where this could be an issue[62]. However, if customers with a three-phase connection raise issues with negative phase sequence at their properties where stand-alone

[62] The size of stand-alone power systems given the number of customers they are expected to support makes adoption of three-phase solutions highly unlikely. Negative phase sequence voltage issues are not applicable to single phase systems.

power systems are installed, Western Power would be involved in the investigation to determine the cause and work with the customer to identify remedies.

Electromagnetic interference

The proposed electromagnetic interference limits for disconnected microgrids and stand-alone power system are those limits set out in Tables 1 and 2 of AS/NZS 2344 (2016), which maintains consistency with the requirements that apply for distribution system. Adopting this approach places consistent requirements of equipment connected within a consumers premises regardless of whether the User is supplied by a stand-alone power system, disconnected microgrid or from the distribution system.

Oscillatory stability

The proposed oscillatory stability requirements for disconnected microgrid adopt the same principles as used for the distribution system, in that oscillations must be sufficiently damped regardless of origination. However, no definition for sufficiently damped is specified.

For disconnected microgrids, there is no definition for sufficiently damped as the requirements to maintain adequate damping will differ depending on the size of the system and the characteristics of the User facilities supplied from the system and is best determined by the Network Service Provider on a case by case basis.

There is no requirement for stand-alone power systems as these systems supply a single consumer and as such there is not opportunity for a poorly damped interaction between the facilities operated by different Users.

Voltage stability

The proposed voltage stability requirements for disconnected microgrids and stand-alone power system are the same as those that apply for the distribution (as applicable to the voltage level).

For both stand-alone power systems and disconnected microgrids the voltage stability requirement will be achieved by designing systems with sufficient reactive power capability to regulate voltage within acceptable limits for expected load and generation conditions.

9.6 Network service provider obligations

As set out in the sections above, Western Power proposes changes to define power system performance standards applicable to disconnected microgrids and stand-alone power systems. Associated network Service Provider obligations are required for these requirements to be given effect.

9.6.1 Current issue

Responsibilities for system performance requirements need to be clearly defined in the Technical Rules for disconnected microgrids and stand-alone power systems.

As part of the review process and in establishing proposed obligations, Western Power considered the scope of the Technical Rules to place obligations on the Network Service Provider and Users, as well as the most appropriate parties to assume responsibilities given the ownership of the systems.

The disconnected microgrids and stand-alone power systems to be covered by the Technical Rules will (or have been developed by Western Power) and form part of the covered network. Provisions are not intended to apply to any similar systems that are owned or operated by other parties.

9.6.2 Solution options & preferred solution

Consistent with the style of the Technical Rules, Western Power propose obligation on the Network Service Provider to ensure the power system performance standards established for disconnected microgrids and stand-alone power systems are met. Obligations are also proposed, where appropriate of the management and monitoring of the systems with respect to these requirements.

9.7 Protection requirements

Protection issues that arise in disconnected microgrids and stand-alone power systems due to the naturally low fault levels include:

- Loss of selectivity/grading.
- Failure to achieve fault clearance times.
- Loss of protection sensitivity.

The protection used in microgrid systems varies widely to cater for the unique load, generation and size of the system.

9.7.1 Current issue

The protection requirements specified in the Technical Rules may not suit the particular characteristics of disconnected microgrids and stand-alone power systems. Further, a review of protection used in microgrids across Australia and overseas does not suggest a standardised practice exists. The review suggest that it is normal to undertake a bespoke design of protection for each system.

The review of microgrid protection settings also revealed new ways of providing protection in these smaller systems are emerging as technology changes.

9.7.2 Solution options & preferred solution

Western Power proposes to use the Technical Rules to capture the high-level principles of protection for disconnected microgrids and stand-alone power systems. The proposed changes retain the need to provide for protection and allow for the maximum range of protection options to be used in these systems.

10. Attachments and other changes

Several changes are proposed that address issues spanning multiple sections or chapters of the Technical Rules. These changes are typically not material in nature and include updates to references, Glossary terms and explanations of structural changes.

Proposed changes to Attachments are also covered in this section.

10.1 Attachments

Attachments to the Technical Rules provide additional information and guidance. Changes proposed to the Attachments are summarised in Table 10-1. In most cases, changes are minor and proposed to address grammar, style and referencing matters. In some cases, changes to the titles of attachments are proposed for consistency and to reflect updated coverage.

Several changes are proposed to introduce new data requirements for generators. The additional data is required by the Network Service Provider to evaluate the effect of the generators on the power system. Changes are consistent with requirements under the NER (and the WEM Rules) and provide a more consistent coverage of generation technologies typically connected to the SWIS.

Three new attachments are proposed to support the revised transmission system planning criteria. The first two of these are required for interpretation of the new Technical Rules provisions. The final attachment provides several worked examples of how the new criteria should be applied. While not strictly required for the Technical Rules, there was broad agreement amongst organisations participating in the workshops that providing examples within Technical Rules would provide clarity.

Table 10-1: Summary of proposed amendments to attachments to the Technical Rules

Attachment	Proposed changes
Attachment 1: Glossary	• Updates to defined terms consistent with proposed changes outlined in this submission • Minor and consequential changes (as outlined in section 10.3)
Attachment 2: Interpretation	• No change
Attachment 3: Schedules of technical details in support of connection applications	• Minor and consequential changes
Attachment 4: Large generating unit design data	• Structural changes to reorder requirements • Minimum short circuit ratio requirements (consistent with chapter 2 and 3 changes) • Data on power quality characteristics for wind generators (consistent with chapter 3 changes) • Data for inverter connected generating systems – consistent with existing requirements in the Attachment that apply to small generators
Attachment 5: Submission requirements for electrical plant protection	• No change
Attachment 6: Large generating unit setting data	• Updated title

Attachment	Proposed changes
Attachment 7: Transmission system and equipment technical data of equipment at or near connection point	• Grammatical changes
Attachment 8: Transmission system equipment and apparatus setting data	• No change
Attachment 9: Load characteristics at connection point	• Minimum short circuit ratio requirements (consistent with chapter 2 and 3 changes)
Attachment 10: Distribution system connected generators up to 10 MW (except invertor-connected generators up to 30 KVA)	• Updated title • Allowance for the Network Service Provider to require data on power quality characteristics for inverter connected generators. • Clarity on reactive capacity curve requirements for inverter connected generators
Attachment 11: Test schedule for specific performance verification and model validation	• Minor changes • Adjustments to Figure A11.2 to fix where formatting errors had hidden parts of diagram
Attachment 12: Testing and commissioning of small power stations connected to the distribution system	• Minor changes
(new) Attachment 13: Guidance on economic justification	• Developed to support the proposed transmission system planning criteria
(new) Attachment 14: Background conditions for the transmission system planning criteria	• Developed to support the proposed transmission system planning criteria
(new) Attachment 15: Examples of demand groups	• Developed to support the proposed transmission system planning criteria

10.2 Typographic and editorial changes

In reviewing the Technical Rules, Western Power has identified and proposed several minor typographic editorial changes. Changes include:

- Spelling and grammatical corrections,
- Stylistic changes such as updates to formatting of diagrams, tables, headers, footers and the title page,
- Cross-referencing corrections, and
- Formatting changes to correctly identify terms where they are defined (and the definition is intended to be used).

These updates are not material, so they have not been separately identified in this submission. Minor corrections primarily improve the readability of the document.

10.3 Glossary updates

Terms in the Glossary of the Technical Rules have been updated to align with proposed changes outlined in the remainder of this document. When considering these updates, Western Power has considered the ideal outcome of aligning with the Act, the Access Code and the WEM Rules.

In addition to individual changes discussed elsewhere in this document, Western Power proposes changes to the Glossary to:

- Remove redundant terms that are no longer referenced in the document. Western Power notes some definitions have been retained despite these no longer being used as these are key terms used in various supporting documents and procedures.
- Demote generic terms where the use of a specific definition is not needed and could cause inaccuracies due to the high risk of stylistic errors (i.e., the term could accidentally be italicised). For example, the term 'equipment' is defined as 'a device used in generating, transmitting or utilising electrical energy or making available electric power.' The term is used when this meaning is intended but also many times when a more generalised use of the term is meant. The clause context is sufficient for readers to understand what definition of equipment is meant as such Western Power proposes no longer referring to this as a defined term.
- Update definitions to align with changes in definitions of associated terms.
- Reinsert definitions where definitions refer to other regulatory instruments and the definitions no longer appear in those instruments. For example, the term 'access contract' is given the same meaning as the Act, but this term is not used in the Act. The term is defined in the Access Code, so it is proposed that this definition apply.
- Moved definitions from clauses into the Glossary to allow for more consistent use of the moved definitions and facilitate referencing. For example, a definition for 'reasonably foreseeable load' is provided in clause 2.6(a) of the Technical Rules, and this has now been moved to the Glossary.
- Make minor amendments to improve the consistency of language and style.

These updates to the Glossary do not change the intended meaning of the terms and do not alter the requirements expressed in the Technical Rules, so they have not been separately identified in this proposal. The proposed Glossary changes primarily improve the readability of the document.

10.4 Update references to System Management

The Technical Rules were drafted when the System Management function was part of Western Power and covered by the Access Code. The role of System Management is now undertaken by AEMO, and it is no longer appropriate for the Technical Rules to refer to System Management or place obligations on AEMO in this capacity.

Western Power proposes changes to update or remove references to System Management. Changes fall into one of two categories:

1. Where the Technical Rules place a direct obligation on System Management, this has been updated to remove the requirement.

   AEMO's obligations are outlined in the Electricity Industry Act, the WEM Rules and other regulatory instruments. The Access Code (under the Electricity Industry Act) gives authorisation for the Technical Rules, and the Access Code does not provide for obligations on AEMO.

   In removing direct obligation on System Management from the Technical Rules, Western Power has considered whether the provision should be deleted entirely, replaced with a passive role for AEMO (for example, being notified of a change or afforded the opportunity to comment) or replaced with a role for the Network Services Provider and proposed updates accordingly.
2. Where the Technical Rules allow for a passive role for System Management, changes either:
   a. Remove the provision if the role is no longer needed

b. Update the provision to refer to AEMO if the role is still required

AEMO has an important role in managing power system security and reliability. It is appropriate for AEMO to continue to be notified and have the opportunity (but not obligation) to comment on matters that involve power system security and reliability.

Given the significant number of references to System Management in the current Technical Rules, proposed changes are not separately identified in this proposal. AEMO was involved in the workshops when the above principles for change were discussed and reviewed draft proposed changes before submission of this rule change request.

As discussed in section 2.2 of this report, revisions have been proposed to clause 1.3(b)(2) of the Technical Rules that identify that the role of AEMO is defined in the WEM Rules. The retention of the reference to AEMO in this clause does not place any obligations on AEMO. Rather, it clarifies for all users that AEMO has a role within the Technical Rules context.

10.5 References to operating states

The Technical Rules currently refers to a 'normal operating state' as defined in Table 10-2. The term is used both as a non-defined and defined term (i.e., italics is not always used). A reliable operating state is also used when referring to the operation of the power system but is not defined.

Table 10-2: Operating state definitions

Term	Definition
normal operating state	Characterises operation when all significant elements of a *transmission system* are in service and operation is within the secure *technical envelope*

10.5.1 Current issue

The WEM Rules uses defined operating states to describe states or modes of operation of the power system. At the time of this submission, Chapter 11 of the WEM Rules[63] defines operating states as follows:

- Normal Operating State: The state of the SWIS defined in clause 3.3.1 [of the WEM Rules].
- High Risk Operating State: High Risk Operating State: The state of the SWIS described in clause 3.4 [of the WEM Rules].
- Emergency Operating State: Emergency Operating State: The state of the SWIS defined in clause 3.5.1 [of the WEM Rules].

However, these terms have recently been reviewed and expected to be amended to separate the power system reliability standards in the SWIS. Amendments planned for the WEM Rules will remove the above definitions and adopt newly defined states: 'reliability operating state', 'satisfactory operating state; and 'secure operating state'.[64]

The use of the term normal operating state in the Technical Rules should be reviewed to ensure appropriate alignment with the updated state definitions that will be adopted in the WEM Rules. This will avoid confusion and ensure the power system is planned and managed by Western Power in a consistent manner with the WEM Rules.

[63] Wholesale Electricity Market Rules, 1 February 2021

[64] Tranche 2 Amending Rules, as published on 16 October 2020. [is the

10.5.2 Solution options & preferred solution

Western Power considered the following options to address the above issues:

a) Update the Technical Rules to refer to the operating states newly defined in the WEM Rules and include Glossary definitions that refer to the WEM Rule definitions.

b) Remove all references to operating states and use alternative terminology. For example, refer to 'normal operating conditions' as an undefined term instead of 'normal operating state' in clauses where a description of the system operating within normal limits is needed.

c) No change. Operating state definitions in the Technical Rules are independent of those proposed for the WEM Rules.

Western Power proposed changes consistent with option b). Significant consideration was given to adopting the WEM Rule definitions and modifying Technical Rules drafting – particularly for the transmission planning criteria in section 2.5 and for the transmission and distribution operating and coordination provisions in Chapter 5. The revised operating state definitions proposed for the WEM rules are not readily applied in the Technical Rules as the Technical Rules needs to address both planning and operational timeframes. The operating states defined in the WEM Rules are primarily used to define the framework and approach for managing power system security in operational timeframes. The review of the Technical Rules identified that roles and responsibilities could be adequately defined without reference to the operating states defined in the WEM Rules.

Option c) is not preferred because any misaligned use of terms referring to operating states in the Technical Rules and WEM Rules is potentially confusing.

10.6 Updated Australian Standards

The Technical Rules leverage international and Australian Standards when specifying technical requirements. Australian Standards are typically preferred in the first instance, and international standards are used where an equivalent Australian Standard does not exist or is not suitable. Referencing standards helps ensure alignment with practice in other jurisdictions and reduces the specifications needed in the Rules.

As part of the Technical Rules review, Western Power reviewed the standards referred to and considered if the current referencing was appropriate. In some instances, the standard was no longer appropriate, or the proposed drafting changes meant the standard reference was no longer needed. AS/NZS 60044 is no longer referred to in the Technical Rules.

In other cases, it was appropriate to retain the reference. However, the international and Australian Standards have been updated since the reference in the Technical Rules was introduced. As part of the Technical Rules review, Western Power reviewed each standard referred to and whether that standard had been updated. For each reference, Western Power considered whether references to standards should be:

- Maintained and continue to refer to the superseded standard.
- Updated to refer to the updated standard.
- Revised to omit the year of the standard, thereby providing for an automatic update mechanism when and if the standard is updated.

Western Power has proposed changes that seek to minimise costs to Users (e.g., retaining the existing standard or moving to the new standard where relevant clauses in the standard have changed), while

making updates that reflect technology changes and, if required, to facilitate meeting the power system requirements.

Table 10-3 summarises the standards referred to in the revised Technical Rules. It lists for each standard: the version referenced in the proposed Technical Rules, the year of the most recent version of the standards and whether the standard remains relevant in the context of the Technical Rules. Where the version referenced in the Technical Rules is not the most recent version this reflects an assessment by Western Power that some aspects of the historical standard need to be referred to in the Technical Rules.

In most cases, the Technical Rules do not refer to a version and where this is the case, Western Power considers it appropriate to maintain that convention. Where updated standards are available, Western Power has considered if the revised standard can be adopted and made changes to the relevant clauses consistent with the rationale provided above.

Table 10-3: Standards referred to the in Technical Rules

Standard	Version referenced in the proposed Technical Rules (prior to the update of the standard version)	Most recent version of the standard
AS 1359.101	None	1998
AS 3851 (1991) (Amendment 1-1992)	1991	1991
AS 60947.6.2	2004	2015
AS/NZS 2067	None	2016
AS/NZS 2344	2016	2016
AS/NZS 3000	None	2018
AS/NZS 4777	None	2020
AS/NZS 4777.2	None	2020
AS/NZS 5033	None	2014
AS/NZS 61000.3.100	2001	2011
AS/NZS 61000.3.6	2001	2012
AS/NZS 61000.3.7	2001	2012
AS/NZS 61000.4.7	1999	2012
IEC 60034-1	None	2017
IEC 60255	None	2009
IEC 61400-21	None	2019
IEC 61869	None	2007
IEEE 115-1983 - Test Procedures for Synchronous Machines	1983	2019

10.7 Structure of Technical Rules and retention of historical numbering

The Technical Rules review has resulted in Western Power proposing substantial changes to the drafting throughout the Technical Rules. Various sections in this submission discuss the specific structural changes proposed for the various chapters of the Technical Rules. In developing those changes, Western Power considered a number of alternatives and the impact of the proposed change. The aim being to validate that the added clarity delivered by the proposed change outweighed any additional effort required to adjust to the new structure and changes to historical clause references.

10.7.1 Structure changes

Structure changes are proposed to the Technical Rules for the following:

- Separation of the transmission and distribution system planning criteria. The adoption of a more flexible and full coverage transmission system planning criteria necessitated the separation of some clauses that were previously relevant to both transmission and distribution system planning. While several clauses are retained from the 2016 version of the Rules that pertain to both, the separation of the two planning criteria is clearer. Some clauses were recast to fit into the newly separated sections as a consequence of the new structure.
- More clearly differentiating performance standards for the transmission and distribution system voltages and preserving appropriate alignment with the WEM Rules as set out in section 3.1
- Grouping of the protection requirements for Users into a single section as discussed in section 6.8.1.
- Rearranging User requirements in chapter 3 to better clarify the requirements applicable to particular facilities as discussed in section 6.1.1 and through section 6 of this report.
- Restructure of Chapter 5 to reflect clarified TNO and DNO roles as outlined in section 8.1 of this report.
- Creation of a new Chapter 6 covering system performance for disconnected microgrids and stand-alone power systems. Stand-alone power systems are a new function and have not previously been covered by the Technical Rules, and, while disconnected microgrids are an existing function, these systems were not well catered for in the existing Rules and their technical requirements are more similar to stand-alone power systems than to the power system.

For each of the above structure changes, Western Power considered the merits of alternative drafting arrangements. On balance, Western Power considers the proposed structure changes promote clarity and are suitable for the adoption of future Technical Rule updates in response to foreseeable future policy and market governance changes (such as the creation of a Distribution System Operator role).

10.7.2 Retention of historic numbering

Western Power considered proposing changes to the Technical Rules that retain historical clause numbering. Such an approach would be consistent with the way the WEM Rules and the NER are updated, where the numbering for deleted clauses is retained, and new clauses are added either at the end of existing lists or with alphabetical suffixes if inserted mid-list.

Retention of historical clause references has some advantages:

- References to supporting documents such as procedures, processes and guidelines require less updating (to the extent that clauses have not been deleted).

- Where reference is made to a clause that has been replaced, there is no confusion as to whether the replacement text applies (because the newest version of the rules simply states 'deleted', and the reader is prompted to go to a historical version).

However, there are also disadvantages of such an approach:

- The document becomes lengthy and convoluted, making it difficult to understand what the requirements are.
- Updates may be more complex because drafting is piecemeal.

On balance, Western Power considered it appropriate to propose changes that offer a completely refreshed, clean version of the Technical Rules. The proposed changes are sufficiently substantive that procedures and processes with Western Power that refer to the Technical Rules clauses will need to be reviewed regardless of clause numbering.

Connection agreements for Users reference the version of the Technical Rules that applies to their facilities. Historic versions of the Technical Rules are maintained on the ERA website and may be readily referenced as needed to support the interpretation of connection agreements.

10.8 Coverage of new and emerging technologies

The Technical Rules do not necessarily contemplate or provide sufficient guidance for the adoption of new and emerging technologies, both with respect to how Western Power should treat them under the planning process and as part of potential solution options as alternatives to traditional network investment options. Further, the application of connection requirements for Users is potentially confusing where newer technology is concerned (for example, application of clauses to energy storage is not clear).

New and emerging technologies include forms of electricity and energy storage systems, alternative operational models such as microgrids and stand-alone power systems, as well as network technological developments related to traditional plant (for example, overhead lines, underground cables, substation switchgear).

In reviewing the Technical Rules, Western Power considered if direction was required within the Technical Rules to account for new and emerging technology solutions, including those that can connect directly to the SWIS or be used by Western Power as alternatives to traditional investment solutions. For example, should Technical Rules be amended to detail how apply specific technologies should be treated? Alternatively, should a more structured approach be adopted based on the underlying characteristics of equipment, for example, battery energy storage systems could be dealt with as both demand and generator?

Western Power considers the Technical Rules should be as technology-neutral as possible. This is achieved by focusing on the underlying technical requirements that support efficiently meeting power system performance requirements.

Clauses in the Technical Rules have been reviewed to align with this approach and avoid unnecessarily restricting or limiting the application of new technologies, solutions or concepts. This is achieved by minimising explicit naming or reference to individual technologies beyond what is necessary to describe characteristics, requirements or obligations. This is further discussed is section 6.1 of this report.

The following sections outline considerations given to particular concepts and technologies.

10.8.1 Virtual power plants or aggregated DER

Virtual power plants are typically cloud-based IT systems that aggregate the capacities of distributed energy resources (DER)[65]. In Western Australia, virtual power plants (also referred to as aggregated DER) are described in the DER Roadmap as "notional entities comprised of aggregated and controlled DER components that can provide generation and system support functions and participate in energy markets (like traditional generators)".[66]

The rise of virtual power plants in Western Australia is expected to change the incentives faced by DER and the financial flows between parties. However, the existence of virtual power plants does not alter the requirements that should be placed on the power system or, at this stage, the arrangements for User's connecting to power systems from a physical point of view.

Therefore, assuming that participation in the WEM by aggregators does not change the party responsible for compliance with the Technical Rules:

- Users responsible for facilities or equipment used in aggregation must meet the technical reequipments applicable to those facilities and equipment.

Aggregators may offer services to the Network Service Provider or the market. Western Power notes:

- If the aggregator is providing services to the Network Service Provider under a network support arrangement, then the Network Support Contract may be the appropriate vehicle to specify the relevant performance requirement such as the requirements over the controllability and observability of the service.
- If the aggregator is providing energy market services or ESS procured by AEMO then the aggregate would need to meet applicable performance requirements which may be specified in the WEM Rules or ESS contracts.

The role of aggregators may need to be revisited in the future. Particularly, if collectively, the participation by aggregators in the WEM begins to materially alter the way the power system is operated.

10.8.2 Electrical and energy storage

Electrical storage primarily relates to batteries and their ability to absorb excess energy (charge the battery) and release that energy (discharge the battery) when it is needed to add value by suppling demand and essential system services.

Changes to the *Electricity Industry Act 2004* allowing Western Power to use energy storage devices came into effect on 6 April 2020. While these changes allow Western Power to more freely deploy and utilise this technology, the Technical Rules did not require specific amendment to accommodate the use of Energy Storage to meeting the transmission and distribution planning criteria.

As discussed in section 6.1 of this report, revisions have been proposed to the User requirements to clarify those requirements that apply to electrical storage systems installed within User facilities.

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65 Distributed energy resources, or 'DER', are smaller–scale devices that can either use, generate, or store electricity and form a part of the local distribution system, which serves homes and businesses. DER can include renewable generation, energy storage, electric vehicles (EVs), and technology to manage load at the premises. These resources operate for the purpose of supplying all or a portion of the customer's electric load and may also be capable of supplying power into the system or alternatively providing a load management service for customers Source: Energy Policy WA, *Distributed Energy Resources Roadmap*, April 2020, p. 77. Available at: https://www.wa.gov.au/sites/default/files/2020-04/DER_Roadmap.pdf

66 Energy Policy WA, *Distributed Energy Resources Roadmap*, April 2020, p. 77. Available at: https://www.wa.gov.au/sites/default/files/2020-04/DER_Roadmap.pdf

10.8.3 Embedded networks

Embedded networks are private electricity networks that serve multiple premises and are located behind the same connect point to the distribution or transmission system.[67]

The Technical Rules are primarily concerned with the operation of the broader power system and the parts of the network that Western Power owns and operates. While the activities of customers and network elements behind a connection point will flow through to the wider electricity distribution and transmission systems, the focus of the Technical Rules is on the point of connection at that parent connection point. As such, Western Power is not proposing any new or different requirements for these systems in the current rule change request.

[67] Energy Policy WA, *Distributed Energy Resources Roadmap*, April 2020, p.77. Available at: https://www.wa.gov.au/sites/default/files/2020-04/DER_Roadmap.pdf


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