Energy Transformation Taskforce

Revising Frequency Operating Standards in the SWIS

Information Paper

November 2019

An appropriate citation for this paper is: Revising Frequency Operating Standards in the SWIS

Energy Transformation Taskforce

David Malcolm Justice Centre
28 Barrack Street
Perth WA 6000
Locked Bag 11 Cloisters Square WA 6850

Main Switchboard: 08 6551 4600

www.energy.wa.gov.au

Contents

Abbreviations

The following table provides a list of abbreviations and acronyms used throughout this document. Defined terms are identified in this document by capitals.

Term	Definition
Taskforce	The delivery of the Strategy is being overseen by the Energy Transformation Taskforce
ESS	Essential System Services (previously known as Ancillary Services)
ETIU	Energy Transformation Implementation Unit
SCED	Security-Constrained Economic Dispatch
SWIS	South West Interconnected System
AEMO	Australian Energy Market Operator
WEM	Wholesale Electricity Market
DER	Distributed Energy Resources
PSOWG	Power System Operation Working Group
NEM	National Electricity Market

1. Introduction

1.1 About the Energy Transformation Strategy

On 6 March 2019, the Hon Bill Johnston MLA, Minister for Energy announced the McGowan Government's Energy Transformation Strategy. This is the Western Australian Government's strategy to respond to the energy transformation underway and to plan for the future of our power system.

The delivery of the Strategy is being overseen by the Energy Transformation Taskforce (Taskforce), which was established on 20 May 2019. The Taskforce is supported by the Energy Transformation Implementation Unit (ETIU), a dedicated unit within Energy Policy WA.

The Energy Transformation Strategy is being delivered under three work streams. The revision of frequency operating standards is part of the Delivering the Future Power System work stream, as shown in Figure 1, below. Elements of the work fit within both the Power System Security and Reliability project and the Future Market Design and Operation project, the latter of which is implementing Security-Constrained Economic Dispatch (SCED) in the Wholesale Electricity Market (WEM).

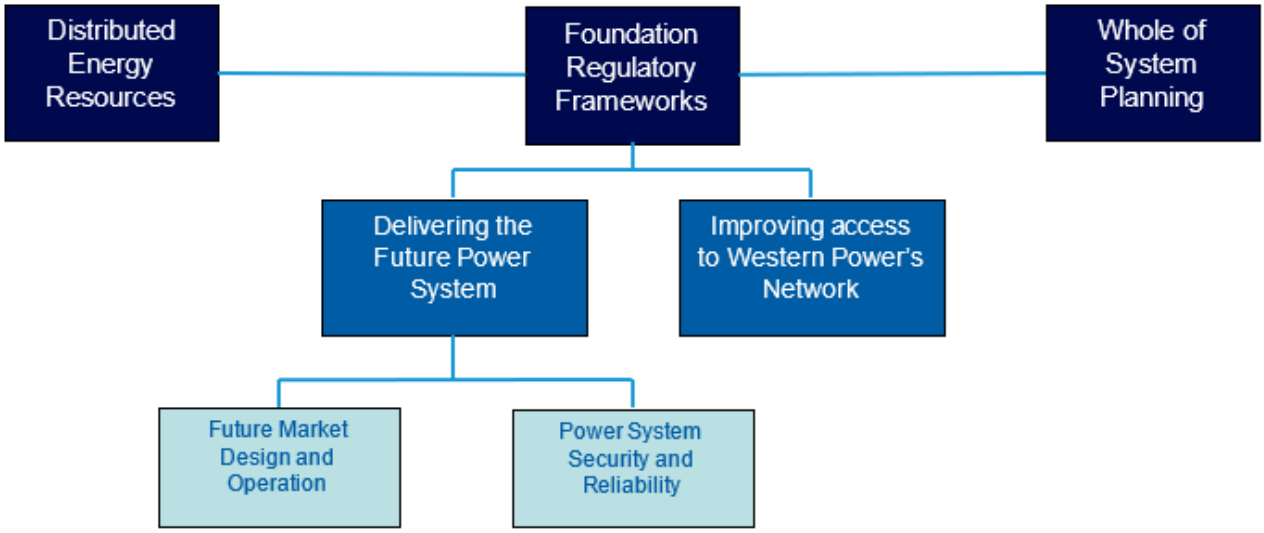

Figure 1: The revision of frequency operating standards sits under the Delivering the Future Power System work stream.

1.2 About frequency operating standards

Frequency operating standards specify the electrical frequencies at which the power system should be operated. They include terms, operational processes, and settings. Settings can be values or ranges, expressed in a variety of forms (e.g. minutes, hertz), which apply under different system and network conditions.

Frequency operating standards in the South West Interconnected System (SWIS) are currently outlined in section 2.2 of Western Power's Technical Rules. The Technical Rules were established in July 2007, at a time when Western Power was responsible for both System Management and Network Operation functions. In July 2016, system management functions were transferred to the Australian Energy Market Operator (AEMO) and it was intended that updated frequency operating standards would be transferred to a more appropriate instrument through further proposed reforms that did not eventuate.

While frequency operating standards reside in Western Power's Technical Rules, the management of them under different operating states is set out under the WEM Rules. This separation across two instruments with different change management processes has led to some inconsistency between the specification of the standards in Western Power's Technical Rules and their interpretation and use in the WEM Rules and associated procedures.

The modifications to the frequency operating standards outlined in this paper will be implemented through changes to the WEM Rules, and associated changes in the Technical Rules to reflect the transfer. The transfer of frequency operating standards to the WEM Rules was part of a suite of changes to the power system security and reliability framework determined by the Taskforce in July 2019. Further information about the transfer of frequency operating standards is outlined the information paper *Power System Security and Reliability Regulatory Framework.*

1.3 A case for change

This paper outlines modifications to the frequency operating standards to support the secure and reliable operation of the SWIS into the future. This work is being undertaken in the context of significant changes to the design of the WEM being progressed through the *Future Market Design and Operation* project (see Figure 1). This project necessitates a review of the frequency operating standards to ensure they are consistent with the adoption of a SCED regime for the WEM, a key feature of which is the co-optimised dispatch of energy and Essential System Services (ESS).

In August 2019, the Taskforce endorsed the *Essential System Services Framework Review*, which assessed recent reviews into power systems in Australia and internationally, recommending a suitable technical framework for ESS for the WEM to support the new SCED market design.

Problems with the existing frequency operating standards identified through this review were:

- references in the standards to key concepts that are not defined (e.g. an 'island', some operating bands);
- ambiguous response, stabilisation and recovery timeframes;
- the absence of clear definitions regarding situations where the frequency operating standards do not apply (such as for microgrids); and
- the non-alignment of the location of the frequency operating standards in the Technical Rules with the primary roles and responsibilities associated with the standard (which are split between the System Operator and Network Operator), posing challenges to the development of appropriate compliance and governance arrangements (see section 1.2 below).

The Taskforce determined that the frequency operating standards will be defined to avoid ambiguity so it can direct the required outcomes in the ESS framework. Defining the frequency operating standards is a fundamental input in determining the type and quantity of ESS required, and therefore the cost of providing these services, which is ultimately borne by end users such as households and businesses.

The review of frequency operating standards and their transfer to the WEM Rules is therefore required to be complete by mid-2020 to ensure the effective operation of the SCED market model which is scheduled to commence from 1 October 2022.

The increasing prevalence of distributed energy resources (DER), and potential for microgrids and stand-alone power systems to be deployed throughout the SWIS, as well as changes in institutional arrangements (i.e. the movement of System Management functions from Western Power to AEMO) are additional drivers for amendments to the frequency operating standards outlined in this paper.

1.4 Consultation

The changes outlined in this paper have been developed in close consultation with AEMO, Western Power, and industry stakeholders. The Power System Operation Working Group (PSOWG) of the Market Advisory Committee was consulted on the changes proposed in this paper through meetings held between September and November 2018.[1]

Following the release of this paper, amendments to the WEM Rules will be drafted and released for public comment early in 2020.

[1] The PSOWG was a working group convened under the Market Advisory Committee (MAC). On 29 July 2019 the MAC disbanded the PSOWG, with the working group's functions being subsumed by the Transformation Design and Operation Working Group (TDOWG), established under the auspices of the Taskforce. For more information on the TDOWG, please visit the Taskforce's consultation website. Papers produced under the PSOWG are available at www.erawa.com.au/rule-change-panel-psowg.

2. Changes to Frequency Operating Standards

The review of frequency operating standards was undertaken with the view that the revised standards should:

- be consistent with the adoption of a SCED market model and a revised ESS framework;
- adopt a simplified approach to terminology and wording, where possible;
- maintain consistency with current frequency settings, adapted to fit within the structure of the revised standards;
- be clear in how they must apply to the power system and any islanded systems in the SWIS;
- ensure definitions are technology-neutral, to the extent possible; and
- support a robust and effective governance framework.

This section outlines amendments to frequency operating standards, separated into sub-sections based on common themes. In reviewing the standards, comparisons to the National Electricity Market (NEM), and the UK, New Zealand and Ireland Grid Codes were made, along with consideration of the differences between the SWIS and these other jurisdictions. In many cases this resulted in a decision to use consistent terms with the NEM, but with the continuation of existing settings, which in many cases are better-suited to the needs of the SWIS.

The amendments presented in this section were discussed with industry stakeholders at two workshops, where general support for proposals was received. In some cases, matters that were presented for discussion at these workshops have not been further outlined in this information paper as the stakeholder-endorsed position was to maintain the existing standard.

2.1 Containment, recovery, and stabilisation

The frequency operating standards include bands for frequency and time settings in relation to containment, stabilisation, and recovery of the system frequency. These bands are used to specify different stages of system recovery from a deviation in system frequency. AEMO uses these parameters when determining ESS requirements. The narrower the band is, or the quicker the system frequency must return to a particular band, the greater the typical requirement for the ESS in that timeframe.

The NEM frequency operating standards includes frequency and time settings for containment, stabilisation and recovery of system frequency as explicit terms. While concepts of containment, recovery and stabilisation apply in the current SWIS frequency operating standards, they are not explicitly worded or defined. Defining these concepts will provide consistency of terminology, simplify the current frequency operating standards and allow them to be used in determining required ESS quantities.

In defining these concepts, there is no intention to change frequency settings. The current settings will be adapted only to the extent necessary to enable their mapping across to the defined frequency-related terms.

2.1.1 Taskforce Design Decision – Containment, recovery and stabilisation

The Taskforce has adopted the following design decisions:

- The NEM concepts of *containment*, *stabilisation*, and *recovery* will be defined for the WEM.
- The current frequency operating standard settings will be adapted only to the extent necessary to enable their mapping across the frequency-related terms.

2.2 Operating frequency bands and limits

The following are defined terms to be included in the WEM rules for use in the frequency operating standards. They provide the allowable frequency ranges for various events and will be used in setting ESS quantities:

- *Normal operating frequency band*: represents the normal frequency operating range.
  - This is currently equivalent to 50 Hertz (Hz) +/- 0.2Hz in the SWIS.
- *Normal operating frequency excursion band*: except as a result of either a credible or non-credible contingency event, this is a very small 'deadband'[2] that allows for infrequent/momentary excursions outside of the normal frequency operating band.
  - There is currently no equivalent in the SWIS.
- *Credible contingency event frequency band:* represents the allowable frequency operating range for credible contingencies events i.e. generation fault, load trip or network fault.
  - This is currently equivalent to the 'single contingency event' settings of 48.75Hz to 51Hz in the SWIS.
- *Extreme frequency excursion limit:* represents the allowable frequency operating range for more extreme non-credible contingency events.
  - This is currently equivalent to 'multiple contingency event' settings of 47Hz to 52Hz[3] in the SWIS.

The terms endorsed by the Taskforce to be adopted relate to existing settings in the SWIS, with the exception of the *normal operating frequency excursion band*, for which there is currently no equivalent. This term provides an absolute target or reporting level for normal operations when the system is not operating within the *normal operating frequency band*, which is 99% of the time. This allows for the specification of performance targets around the remaining 1%.

Creating new SWIS definitions for n*ormal operating frequency band, normal operating frequency excursion band,* and *extreme frequency excursion limit* will enable these to be referred to in other security related rules and procedures. The term *credible contingency event frequency band* and some other frequency bands embedded within the frequency operating standard definitions will be discussed in later sections.

Despite the above, it is generally good practice to operate as close as possible to 50Hz under normal operating circumstances to ensure that the levels of ESS are sufficient (and to not continuously over-speed or under-speed mechanical equipment). Therefore, it is proposed to have a general

[2] A 'deadband' is an allowable frequency deviation range where no action or response is required on the part of the Market Operator or network-connected facilities to return the electrical frequency of the power system back to the normal operating frequency band.

[3] This is essentially the same as multiple credible contingency limits in the current Technical Rules frequency operating standards.

condition that, other than under controlled circumstances (such as in the case of testing), AEMO operate the power system as close as possible to 50Hz.

2.2.1 Taskforce Design Decision – Operating frequency bands and limits

The Taskforce has adopted the following design decisions:

- New SWIS definitions for the terms outlined in Section 2.2 will be defined, such that these can be referred to in other security-related rules and procedures.
- Settings from the current frequency operating standards will be adopted for the new definitions, with the exception that there will be initial values for the new *normal operating frequency excursion band* which shall be 49.7 Hz to 50.3 Hz, similar to that adopted in the NEM.
- Include a general provision to operate at or close to 50Hz, other than under controlled circumstances.

2.3 Accumulated time error

An 'accumulated time error' is the difference between the current time and the time measured by integrating the instantaneous operating frequency of the power system. It is a measure of how often and how long the power system is operated away from 50Hz.

In the SWIS the accumulated time error must be less than 10 seconds for 99% of the time.

While the current setting is considered appropriate,[4] a rolling 30-day period will provide clarity on the measurement criterion.

2.3.1 Taskforce Design Decision – Accumulated time error

The Taskforce has adopted the following design decision:

- The current setting for accumulated time error will be retained but will be refined to specify a rolling 30-day period.

2.4 Credible contingency event frequency band

In the SWIS, the concept of 'credible contingency event' is currently used as part of the criteria to inform transmission and distribution system performance and planning requirements. In the NEM, arrangements for system security and reliability leverage the concept to operate the power system securely and reliably and establish what operating state the power system is in (as well as addressing network reliability as part of network planning and operation).

The current Technical Rules uses 'contingency event' as a way of specifying reasonable events the frequency operating standards should cover under normal operation, and to define the extreme boundaries of operation when non-credible (or multiple credible) contingency events occur. The NEM

[4] In the NEM, work is currently under way to determine whether an accumulated time error measure should be retained as part of the frequency operating standards; www.aemc.gov.au/sites/default/files/2018-12/Fact%20Sheet%20-%20Accumulated%20time%20error_0.pdf. As there is minimal impact in retaining this for the SWIS, this can be subsequently reviewed for the WEM frequency operating standards, based on learnings from the NEM if required in future.

frequency operating standard separates out different types of events (i.e. generation, network and load) to allow for different allowable frequency bands (however in some cases the actual allowable frequency bands are the same).

During consultation, stakeholders identified no particular reason to specify different frequency bands for the SWIS to cover for different types of events.[5] As such, the Taskforce endorses the adoption of the concept of a single 'credible contingency event frequency band' for the SWIS, covering all events – be it a 'generator event', 'load event' or 'network event' – that AEMO considers could credibly occur and which could result in a frequency disturbance. This definition is also broad enough to accommodate new technologies that can act as both a generator and a load.

In the SWIS, the *credible contingency event frequency band* is proposed to match the current single contingency frequency operating standard setting in the Technical Rules, being 48.75 Hz to 51 Hz.

2.4.1 Taskforce Design Decisions – Credible contingency event frequency band

The Taskforce has adopted the following design decision:

- The definition of 'credible contingency event frequency band' will be adopted based on the current SWIS single contingency event settings of 48.75 Hz to 51 Hz.

2.5 Performance parameters

In both the NEM and the SWIS, performance parameters are defined for the various frequency bands. They define (as necessary) things such as the number of allowable excursions outside of a band, timeframes for remaining within a band, and the type of events to be included/excluded. The current frequency operating standards in the Technical Rules contain some performance parameters; however, there is ambiguity in the way that the parameters are written.

To enable measurement of the system's performance against these performance parameters, it is important to have a common, consistent understanding of when events commence and complete. Attachment 1 outlines the proposed performance parameters for the SWIS, largely taken from the current frequency operating standards in the Technical Rules and clarified where currently ambiguously defined (or absent).

One of the key elements currently missing from the Technical Rules frequency operating standards are definitions to assist in measuring the timeframes of these events. The Taskforce has therefore endorsed the definition of the following concepts for the purposes of the frequency operating standards:

- A *contingency event*, including a *credible contingency event*, *separation event* or *multiple contingency event,* commences at the time AEMO records the system frequency in its 'SCADA' system[6] going outside of the applicable *normal operating frequency excursion band* and is completed at the time at which the frequency has *recovered*.

[5] Note that industry has been consulted on a revised definition of *credible contingency event* which will cover various types of continencies, including generator events, load events and network events – this will be covered in a future SWIS Operating States paper.

[6] SCADA is a commonly-used acronym for Supervisory Control and Data Acquisition, a system of software and hardware used to measure and control the behaviour of equipment, in this case market facilities and network elements.

- *Stabilise* means when the system frequency has remained above or below the required level for at least 20 seconds[7].
- *Recover* means the time at which the system frequency returns to the required range, provided it does not go outside that range at any time over the following 1 minute.

2.5.1 Taskforce Design Decisions – Performance parameters

The Taskforce has adopted the following design decisions:

- Adopt performance requirement definitions for each of the frequency bands, as per Attachment 1.
- The current SWIS settings are adopted for each of the bands, with the exception of new values for the currently non-existent normal operating frequency excursion band (see section 2.2).

2.6 Islands

There is currently only a single setting for an island within the frequency operating standards of the Technical Rules. The term is not defined; however, there is a note under the standards which states:

> *"An island is formed when the interconnection between parts of the interconnected transmission system is broken, for example if the interconnection between the Goldfields region and the remainder of the power system is broken"*[8].

This note may have been appropriate at the time the Technical Rules were established, when an island was usually the result of a contingency event. However, the circumstances in which parts of the SWIS may become islanded are changing with advancements in technology such as microgrids and embedded storage. The range of parties who can control an islanded system is also changing, and may include System Management, the Network Operator, or a private network owner under a variety of scenarios.

A revised definition of an 'island' is required to clarify the circumstances in which revised settings will apply. However, there are also several locations within the SWIS that have historical arrangements in place whereby they can operate autonomously as their own islands under certain network conditions. Examples of this are the TransAlta network in the Goldfields and large refinery operations in the South West and around Kwinana. In these cases, AEMO has no direct control of frequency in the island, and ongoing supply may be based on contractual arrangements (i.e. where other market customers are involved).

Therefore, the definition of 'island' for the purposes of the frequency operating standards needs to be limited to ensure that these circumstances are not inadvertently captured when they are not intended to be. There are two primary categories of island that the standards need to limit: those that are operated privately, and those that are operated by Western Power as a regulated part of the SWIS. These are typically connected to the SWIS under normal conditions (and therefore subject to the normal frequency operating standards) but may operate independently when islanded. Two new definitions are proposed to capture these[9]:

[7] The term stabilise is used in reference to performance requirements within frequency bands. The definition provides additional clarity on how to determine if the performance requirement has been met.

[8] See table 2.1, section 2.2.1 of Western Power's Technical Rules.

[9] These are based on discussions with Western Power, seeking to align terminology used elsewhere.

1. *embedded system* means a *network* connected at a connection point on the *SWIS* which is owned, controlled or operated by a person who is not a *Network Operator* or AEMO.[10]
2. *disconnected microgrid* means 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*.

The Taskforce has therefore endorsed the definition of an 'island':

> *Island* means a part of the *SWIS*, excluding *embedded systems* and *disconnected microgrids*, that includes *generation systems* (or other energy sources), *networks* and *loads*, for which all of its alternating current network connections with other parts of the *SWIS* have been disconnected, provided that the part:
>
> - is smaller than the rest of the *SWIS* that it has disconnected from, i.e. does not include more *generation systems* (or other energy sources) and *loads* (determined by on-line quantities before disconnection); and
> - contains *generation systems* (or other energy sources) capable of being dispatched by AEMO to supply the demand within the part of the *SWIS* that has been disconnected, in accordance with the applicable *power system security* and *power system reliability* standards.

In terms of performance standards for an island, the proposed standards are also shown in Attachment 1. These are slightly more relaxed than for the integrated system and are based on reasonable endeavours. This reflects the relative difficulty of operating these smaller, often more turbulent parts of the system, and that these are typically only operated manually under unusual outage conditions, for short periods of time.[11]

The current standard also does not define a 'separation event', which describes the types of events that can result in the formation of an island. Similarly, there is no concept of an 'island separation frequency band' which describes the frequency that the system must remain operating within following a separation event (on both sides of the island).

The NEM only describes a 'separation event' resulting from credible contingency events in relation to a transmission element. Therefore, in defining a separation event in the SWIS, a bespoke definition has been developed in order to account for the appropriate range of situations in which an island may form. The definition adopted by the Taskforce is:

> *Separation event* means either planned or unplanned switching that results in the formation of an *island*.

The frequency settings to apply both within the island and the rest of the SWIS *following a separation event* will be the same as the frequency band for other credible contingency events at 48.75 Hz to 51 Hz (Attachment 1). There is merit in maintaining a separate definition to allow for different settings for an island if this is considered appropriate at some future time. There are also separate performance requirements for a *separation event* (see Attachment 1) requiring a definition for an *island separation frequency band* to apply in both the integrated system and the island immediately following the *separation event*.

[10] Being a transmission network and/or a distribution network that may also contain generating systems or energy storage.

[11] Increasing the performance standard requirements for islands can lead to the need to invest in more high-cost solutions for what is typically a low-occurrence, short-lived event.

Finally, it is important that the WEM frequency operating standards recognise that at times it is reasonable for an island to temporarily be de-energised when formed. This allows for a post-contingent response (where generation is capable of starting without support from the main grid) and prevents inefficient pre-contingent dispatch of high cost generation to cover for a small number of *credible contingency events*. Once re-energised, the *island* performance standards would subsequently apply.

2.6.1 Taskforce Design Decisions - Islands

The Taskforce has adopted the following design decisions:

- *Embedded systems* and *disconnected microgrids* will be excluded from the SWIS frequency operating standards.
- A new definition of an *island*, *separation event* and *island separation frequency band* will be adopted, as outlined in section 2.6 and shown in Attachment 1.
- For islands, performance settings will be amended as follows:
  - The performance standards within an *island* are based on reasonable endeavours.
  - The *island separation frequency band* for a *separation event* is to be 48.75 Hz – 51 Hz, which is the same as the *credible contingency event frequency band* for a *credible contingency event*.
  - No accumulated time error will be applied within an island.
  - The recovery timeframe for a *credible contingency event*, *separation event*, *multiple contingency event* and *separation event* (within the island), to enable a return to the normal frequency operating range will be 'as soon as practicable'.
  - An island is permitted to be temporarily de-energised with frequency subsequently restored to the applicable requirements as soon as practicable.

2.7 Related Further Work

2.7.1 RoCoF limits

The Taskforce paper *Frequency Control Technical Arrangements* identified the need for a Rate of Change of Frequency (RoCoF) Control Service. This is a fast-response service to restrict the rate of change of frequency (to avoid or delay reaching the frequency nadir[12]) in the first few hundred milliseconds (ms) after a contingency. There is currently no equivalent fast-response service in the WEM.

To this end, the Taskforce paper *Essential System Services Framework Review* recommended the addition of 'RoCoF safe limits' to the SWIS frequency operating standards to ensure that the change in system frequency over short periods of time (following contingency events) does not exceed the point at which equipment begins to disconnect from the power system or exhibit other abnormal or damaging behaviour.

The level of RoCoF required is not the same for all facilities, so the safe limits will necessarily reflect the technical requirements of the least capable facilities in the power system and of the connections to the power system. Further work is in progress under the Delivering the Future Power System workstream of the Energy Transformation Strategy to determine the settings required for RoCoF,

[12] Frequency nadir is the lowest point of system frequency beyond which load shedding is triggered. For the SWIS, this is 48.75 Hz.

which will be progressed through TDOWG in early-2020 for industry consultation. The drafting of the SWIS frequency operating standards will allow for these safe limits.

2.7.2 Periodic Review

Industry stakeholders have expressed support for a periodic review of frequency operating standards to ensure that they continue to be fit for purpose and balance the needs for secure power system operation with efficiency and effectiveness.

Further consideration will be given to the potential for a periodic review, including the responsible party for conducting the review, as well as the scope, process and frequency. This work will be undertaken in consultation with industry through TDOWG in early-2020.

3. Next steps and timing

Detailed drafting of WEM Rule changes required to implement the amendments to the frequency operating standards will be undertaken over the coming months, to enable public comment on the proposed amendments in early-2020. The changes will be scheduled to become effective upon the commencement of other new market arrangements (particularly ESS) on 1 October 2022.

The amendment of Western Power's Technical Rules in relation to frequency operating standards will be led by Western Power and will likely follow the changes outlined in this paper.

Those wishing to engage the policy team throughout the development of draft changes to the WEM Rules are encouraged to contact the ETIU on (08) 6551 2397 or at energytransformation@treasury.wa.gov.au.

Attachment 1 – SWIS and island settings

Performance parameters							
	SWIS (interconnected system)				Island		
Frequency band	**Condition**	**Containment**	**Stabilisation**	**Recovery**	**Containment**	**Stabilisation**	**Recovery**
	Accumulated Time Error	<10 seconds for 99% of the time over any 30-day period	N/A	N/A	N/A	N/A	N/A
Normal operating frequency band	**Without credible contingency event**	49.8 to 50.2 Hz (99% of the time over any 30-day period)	N/A	N/A	49.5 Hz to 50.5 Hz (reasonable endeavours)	N/A	N/A
Normal operating frequency excursion band	**Operation not within normal operating frequency band**	49.7 Hz to 50.3 Hz	49.8 to 50.2 Hz within 5 min	N/A	N/A	N/A	N/A
Credible contingency event frequency band	**With credible contingency event**	48.75 Hz to 51 Hz	Below 50.5 Hz within 2 min	49.8 Hz to 50.2 Hz within 15 min	48.75 Hz to 51 Hz (reasonable endeavours)	N/A	49.5 Hz to 50.5 Hz as soon as practicable
Island separation band [same as credible contingency event frequency band]	**Separation event**	48.75 Hz to 51 Hz	Below 50.5 Hz within 2 min	49.8 Hz to 50.2 Hz within 15 min	48.75 Hz to 51 Hz (reasonable endeavours)	N/A	49.5 Hz to 50.5 Hz as soon as practicable
Extreme frequency band	**Multiple contingency event**	47 Hz to 52 Hz (reasonable endeavours)	Above 47.5 Hz within 10 seconds Below 51.5 Hz within 1 min Below 51Hz within 2 min 48.0 Hz to 50.5 Hz within 5 min (reasonable endeavours)	49.8 to 50.2 Hz within 15 min (reasonable endeavours)	47 Hz to 52 Hz (reasonable endeavours)	N/A	49.5 Hz to 50.5 Hz as soon as practicable