WHOLESALE ELECTRICITY MARKET PROCEDURE

DEVELOPMENT OF LIMIT ADVICE

Version 1.0
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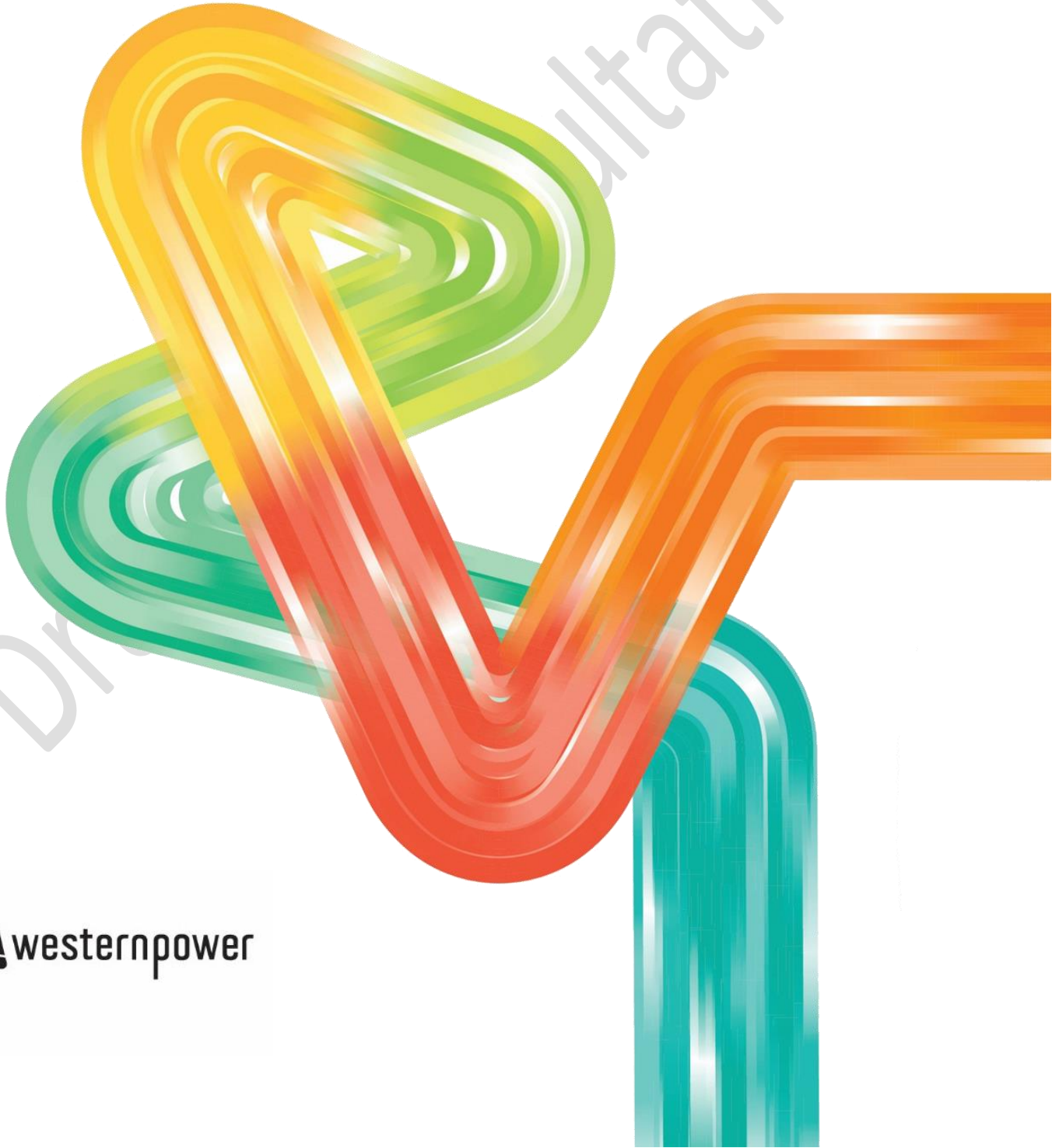

westernpower

ELECTRICITY INDUSTRY ACT 2004

ELECTRICITY INDUSTRY

(WHOLESALE ELECTRICITY MARKET)

REGULATIONS 2004

WHOLESALE ELECTRICITY MARKET RULES COMMENCEMENT:

This WEM Procedure took effect from 8:00 AM (WST) on [insert date TBC].

Version Release History

Version	Effective Date	Summary of Changes
1.0	dd/mm/yyyy	Initial WEM Procedure: Development of Limit Advice Note: This version does not include RCM requirements.

Document control

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Change history

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Contents

1. Overview

1.1 Relationship with the Wholesale Electricity Market Rules

1.1.1 This Wholesale Electricity Market (WEM) Procedure: Development of Limit Advice (Procedure) is made in accordance with clauses 1.33.1(b) and 2.27A.11(a) of the WEM Rules.

1.1.2 The purpose of this Procedure **[clauses 2.27A.11 and 2.27A.9]** is to document the processes to be followed by Western Power and the matters it must consider in developing and updating the Limit Advice, including the approach taken by Western Power in applying:

(a) a Limit Margin;

(b) the Wholesale Market Objectives; and

(c) good electricity industry practice.

1.1.3 This Procedure applies to Western Power in its capacity as the Network Operator in the SWIS.

1.1.4 This Procedure does not apply to other Network Operators, or Western Power in capacities other than as the Network Operator in the SWIS.

1.1.5 In this Procedure, where obligations are conferred on a Rule Participant, that Rule Participant must comply with the relevant obligations in accordance with **[clauses 2.9.7A, 2.9.7B, 2.9.7C, 2.9.7D and 2.9.8]** of the WEM Rules, as applicable.

1.1.6 References to particular WEM Rules within this Procedure in bold and square brackets **[clause XX]** are included for convenience only and are not part of this Procedure.

1.1.7 References to particular Technical Rules within this Procedure in bold and braces **{rule XX}** are included for convenience only and are not part of this Procedure.

1.2 Definitions and interpretation

1.2.1 The following principles of interpretation apply to this Procedure, unless otherwise expressly indicated:

(a) terms that are capitalised, but not defined, have the meaning given in the WEM Rules;

(b) to the extent that this Procedure is inconsistent with the WEM Rules, the WEM Rules prevail to the extent of the inconsistency;

(c) a reference to the WEM Rules or WEM Procedures, includes any associated forms required or contemplated by those WEM Rules or WEM Procedures; and

(d) words expressed in the singular include the plural and vice versa.

1.2.2 In addition, the words, phrases and abbreviations in Table 1.1 have the meanings set out opposite them when used in this Procedure.

Table 1.1: Defined terms

Term	Definition
Cutset	A group of Network Elements connecting two or more areas of the Network, and having voltage and rotor angle stability dependence on the power transfer between that group of Network Elements and either: • another group of Network Elements; or • the rest of the Network. Cutset boundaries are defined to allow the transfer capability of the SWIS to be simplified for the purpose of developing network limits and limit equations.
Marginal Transfer Limit	The value defining the maximum power transfer capability across a particular Network element or group of Network elements after which the power system will be operating outside of its technical limits.
Network Element	A single identifiable major component of the Network, involving an individual circuit or phase of that circuit, or a major item of Network equipment, necessary for the functioning of a particular circuit or connection point.
Network Operating Case	A scenario reflecting various operational aspects of the Network, used for the purposes of simulating, modelling and assessing Network outcomes.
Network Reinforcement Scheme (also referred to as special protection schemes)	An automatic protection system designed to detect abnormal or predetermined system conditions, and take corrective actions other than and/or in addition to the isolation of faulted components to maintain system reliability, including for example generator runback schemes and inter-tripping schemes.
Non-Thermal Limit Equation	A mathematical equation defining the maximum power transfer capability between Cutsets to prevent network voltage or power system stability problems during network normal or following network contingencies.
Thermal Network Limit	The value defining the maximum power transfer capability across a particular transmission Network Element due to temperature or related effects.

1.3 Related documents

1.3.1 The following WEM Procedures and documents are associated with this Procedure and are available on AEMO's website:

(a) WEM Procedure: Limit Advice Requirements;

(b) WEM Procedure: Constraint Formulation;

(c) WEM Procedure: Congestion Information Resource;

(d) WEM Procedure: IMS Interface;

(e) WEM Procedure: Network Modelling Data; and

(f) WEM Procedure: Power System Security.

1.3.2 The Technical Rules also provide background information to this Procedure and are available on the Economic Regulation Authority's (ERA) website.

2. Overview of Limit Advice

2.1.1 In accordance with clause 2.27A.1 of the WEM Rules, Western Power must provide Limit Advice in respect to its Network to AEMO, including **[clause 2.27A.2]**:

(a) Limit Equations in respect of Network Limits, excluding Limit Equations for Essential System Services or, if, in respect of a particular Network element, a mathematical expression is not appropriate, the Network Limit for that particular Network Element;

(b) Limit Advice Inputs; and

(c) supporting information and data specified in the WEM Procedure: Limit Advice Requirements.

2.1.2 To meet these requirements, Western Power must develop two forms of Limit Advice in relation to its Network:

(a) Thermal Network Limits (see section 3 of this Procedure); and

(b) Non-Thermal Limit Equations (see section 4 of this Procedure).

2.1.3 Western Power must use its reasonable endeavours to ensure that all Limit Advice is complete, current and accurate at the time it is provided to AEMO **[clause 2.27A.6]** for use in the security constrained economic dispatch engine and publication.

2.1.4 Where Western Power becomes aware that Limit Advice is incomplete, not current, or inaccurate it must advise AEMO promptly, update the Limit Advice, and provide that updated advice to AEMO in the time and manner required (see section 5 of this Procedure) **[clause 2.27A.6]**.

2.1.5 Where:

(a) under clause 2.27A.4 or 2.27B.5 of the WEM Rules, AEMO; or

(b) under clause 2.27C.7(a) of the WEM Rules, the ERA,

requests additional information related to the Limit Advice, Western Power must make reasonable endeavours to provide that information in the requested form and in the requested timeframe (see section 6 of this Procedure).

3. Developing Thermal Network Limits

3.1 Overview

3.1.1 Western Power must develop Thermal Network Limits for each Network Element to define the maximum capacity for electrical throughput related to the capability. This is based on the limitations of various Network equipment and protection settings.

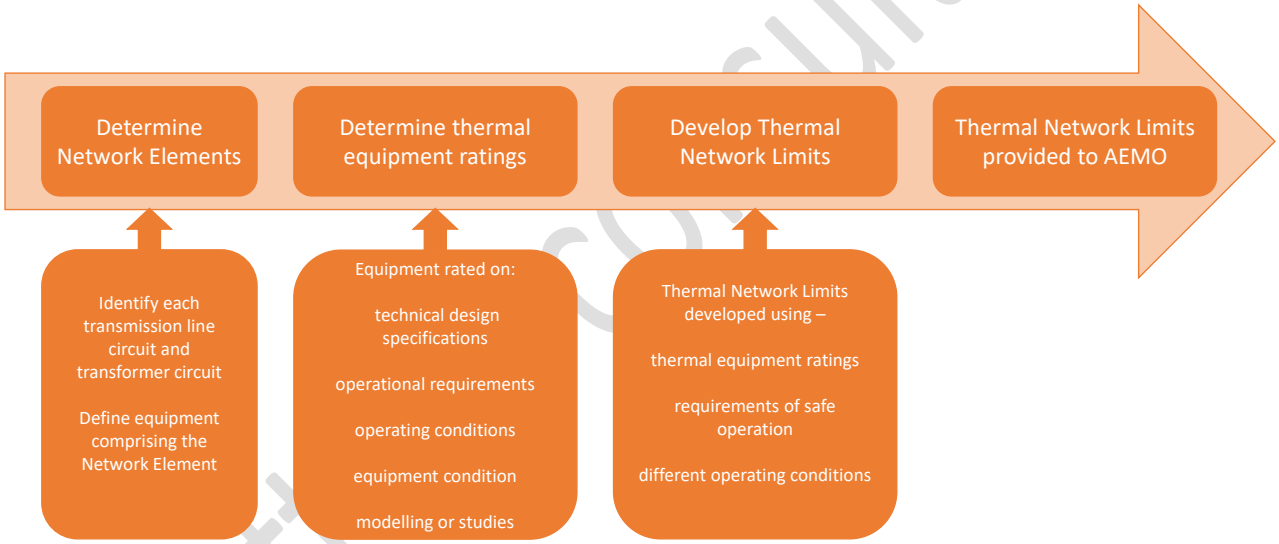
3.1.2 To develop Thermal Network Limits for each Network Element, Western Power must:

(a) define appropriate groups of Network equipment as Network Elements (see section 3.2 of this Procedure);

(b) determine thermal equipment ratings for each piece of Network equipment in a Network Element (see section 3.3 of this Procedure); and

(c) set the Thermal Network Limit for each Network Element (see section 3.4 of this Procedure).

Figure 3.1: Thermal Network Limit development process



3.2 Defining Network Elements

3.2.1 Western Power must group the various pieces of equipment comprising the transmission system, including any part of the distribution system that Western Power considers is used for the transmission of electricity, as part of the secure operation of the transmission system or the SWIS ("Network Elements").

3.2.2 Western Power must define the relevant Network equipment comprising each transmission line circuit and transformer circuit as an individual Network Elements.

3.2.3 Western Power must:

(a) create a new Network Element, where a new line or transformer circuit is added to the Network; and

(b) update the definition of the Network Element, where any Network equipment comprising that Network Element is removed or replaced for any reason.

3.3 Determining thermal equipment ratings

3.3.1 Western Power must determine thermal equipment ratings for each piece of Network equipment comprising a Network Element.

3.3.2 Western Power must determine the thermal equipment rating for each piece of Network equipment comprising a Network Element considering the following:

(a) the technical design specifications of the Network equipment using applicable Australian and International standards (including for example those developed by the International Electrotechnical Commission), relevant guidelines (including for example those developed by Energy Networks Australia) and good industry practice;

(b) operational requirements for the Network equipment such as criticality, availability requirements, load flows and protection settings;

(c) operating conditions, that may include coincident ambient conditions (summer and winter) and geographic location;

(d) equipment condition, where appropriate and available; and

(e) the outcomes of any modelling or studies performed by Western Power.

3.4 Developing Thermal Network Limits

3.4.1 When determining the Thermal Network Limit for each line circuit, Western Power must consider the:

(a) individual thermal equipment ratings for each item comprising the Network Element;

(b) current transformer metering limit of accuracy;

(c) relay thermal rating;

(d) minimum line protection; and

(e) protection operating limits.

3.4.2 When determining the Thermal Network Limit for each transformer circuit, Western Power must consider the:

(a) cooling mode;

(b) load profile;

(c) ambient temperature;

(d) transformer long time emergency rating;

(e) ratings and limits of each of the internal and external components; and

(f) protection operating limits.

3.4.3 Western Power must:

(a) determine the Thermal Network Limit for each line and transformer circuit as the lowest limiting factor; or

(b) document any alternative method for determining the Thermal Network Limit, with reasons.

4. Developing Non-Thermal Limit Equations

4.1 Overview

4.1.1 Western Power must create Non-Thermal Limit Equations for each Cutset, to define, where required, the maximum capacity for electrical throughput between the Cutset and the rest of the Network related to the impact on power system security and stability. This includes, but is not limited to:

(a) the operating standards in the WEM Rules **[Chapter 3]**; and

(b) voltage and stability standards in the Technical Rules **{rules 2.2.2, 2.2.7, 2.2.8, 2.2.9, 2.2.10 and 2.2.11}**.

4.1.2 To develop Non-Thermal Limit Equations, Western Power must:

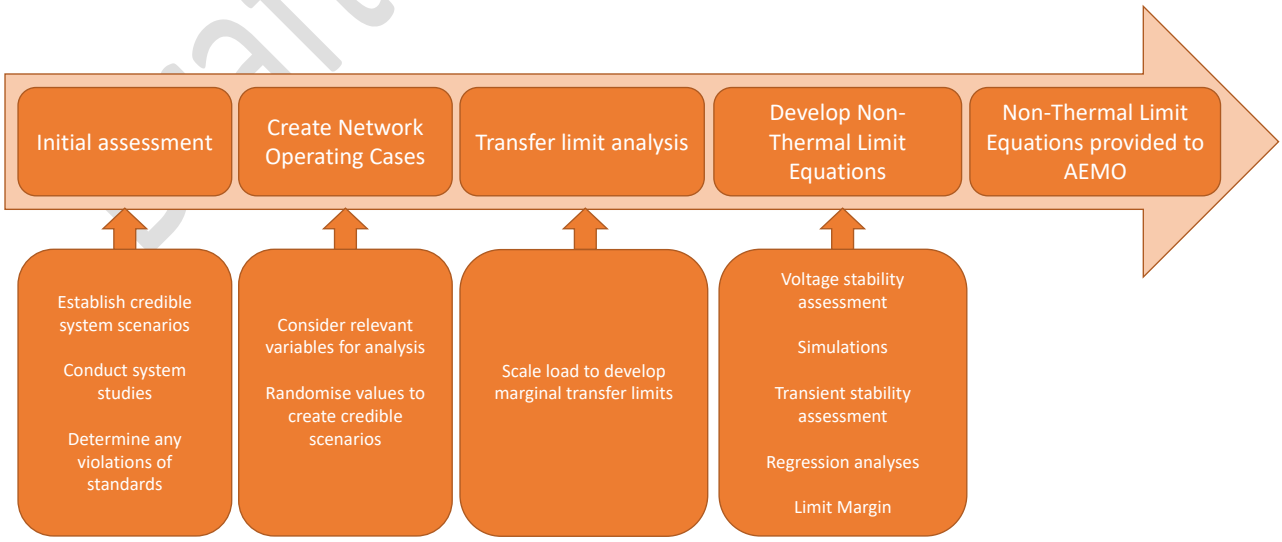
(a) conduct an initial assessment to determine whether there are any violations of the standards (see section 4.2 of this Procedure);

(b) create Network Operating Cases under which to assess the limits (see section 4.3 of this Procedure);

(c) conduct transfer limit analysis to determine the power transfer limit for voltage and transient stability (see section 4.4 of this Procedure); and

(d) develop marginal transfer limits (see sections 4.5 and 4.6 of this Procedure) and apply a Limit Margin (see section 4.7 of this Procedure).

Figure 4.1: Non-Thermal Limit Equation development process



4.2 Initial assessment

4.2.1 Western Power must set up a number of credible system scenarios under system normal and system abnormal conditions, to provide the maximum export from and import to each applicable Cutset. This may include consideration of:

(a) operational conditions such as equipment availability, generation, demand and protection settings;

(b) seasonal operational conditions, including coincident ambient conditions, based on geographic location;

(c) the outcomes of any modelling or studies performed by Western Power;

(d) relevant engineering standards, including to adjust for seasonality; and

(e) applicable Australian and International standards, guidelines and good industry practice.

4.2.2 Western Power must undertake system studies for credible system scenarios developed in step 4.2 to determine whether any of the standards in step 4.1 are violated.

4.2.3 Where Western Power assesses:

(a) there is no violation of the standards in step 4.1, no further action is taken; and

(b) one or more violations of the standards in step 4.1, Western Power uses the process in sections 4.3 to 4.7 of this Procedure for developing all Non-Thermal Limit Equations for the Network.

4.3 Network Operating Case creation

4.3.1 Western Power must develop a number of Network Operating Cases for each Cutset reflecting credible system conditions.

4.3.2 In developing the Network Operating Cases in step 4.3.1, Western Power must consider, as a minimum, the following variables:

(a) generation scheduling, including where relevant new committed Facilities;

(b) generation loading levels;

(c) reactive device availability or status;

(d) load power factor;

(e) bus voltages;

(f) network configuration including prior Network Outages where applicable; and

(g) any applicable Network support arrangements.

4.3.3 Western Power must randomise values for each of these variables to create a series of Network Operating Cases.

4.4 Transfer limit analysis

4.4.1 Western Power must undertake transfer limit analysis to determine the power transfer limit for voltage stability and transient stability for each of the violations identified in step 4.2.3. This is done by progressively scaling load in each Cutset until it results in a marginally stable power system outcome for the relevant limit ("Marginal Transfer Limit").

4.5 Voltage stability Network Limit formulation

4.5.1 Western Power must undertake a voltage stability assessment for each of the violations identified in step 4.2.3 to determine the maximum power transfer limits through each Cutset that will result in a marginally secured condition and meet the voltage and reactive power margin requirements specified by the Technical Rules, including but not limited to:

(a) Steady state voltage requirements - Following a contingency event, the minimum steady state voltage on the Network must be 90% of nominal voltage and the maximum steady state voltage must be 110% of nominal voltage. The step changes in steady state voltage levels resulting from a switching operation must not exceed +6% and -10%. **{rule 2.2.2(b)}**

(b) Reactive power margin requirements - Western Power determines a power transfer limit across relevant Cutsets so that sufficient reactive power margins are achieved at all locations across the Network. This assessment is performed using a standard load flow approach. The 95% of this power transfer limit (corresponding to zero reactive margin) is used for regression in determining the limit equation. **{rules 2.3.8(b) and 2.2.11}**

4.5.2 Wester Power must then perform regression analysis on the marginal transfer limits determined in step 4.4.1 to determine a contribution factor, or coefficient, for each of the variables identified as relevant in the particular limit, which collectively form the Non-Thermal Limit Equation.

4.6 Transient stability Network Limit formulation

4.6.1 Western Power must undertake a transient stability assessment for each of the violations identified in step 4.2.3 to determine the maximum power transfer limits through each Cutset so that will result in a marginally secured condition and:

(a) no loss of synchronism between one or more generators, or groups of generators, following a credible contingency **{rules 2.2.7}**; and

(b) no undervoltage recovery or temporary overvoltage on the Network, or rotor angle instability, following a credible contingency **{rules 2.2.8, 2.2.9 and 2.2.10}**.

4.6.2 Western Power uses a time domain dynamic simulation, to assess transient stability. This assessment includes, where applicable, consideration of:

(a) rotor angle transient instability, including where:

i. the max relative rotor angle between any two machines in different areas moves to exceed 180 degrees following a contingency event; or

ii. halving time greater than 5 seconds, based on comparison of initial and subsequent maxima and minima, following a contingency event;

(b) a post-contingent voltage at every network location recover to 0.9 pu within 10 seconds after fault is cleared in dynamic simulation to minimise the risk of potential cascading failure in the power system as a result of one or more generators tripping on under voltage protection following a contingency event;

(c) the actual reactive capability of generating units;

(d) the impact of generator governors; and

(e) the use of dynamic load models.

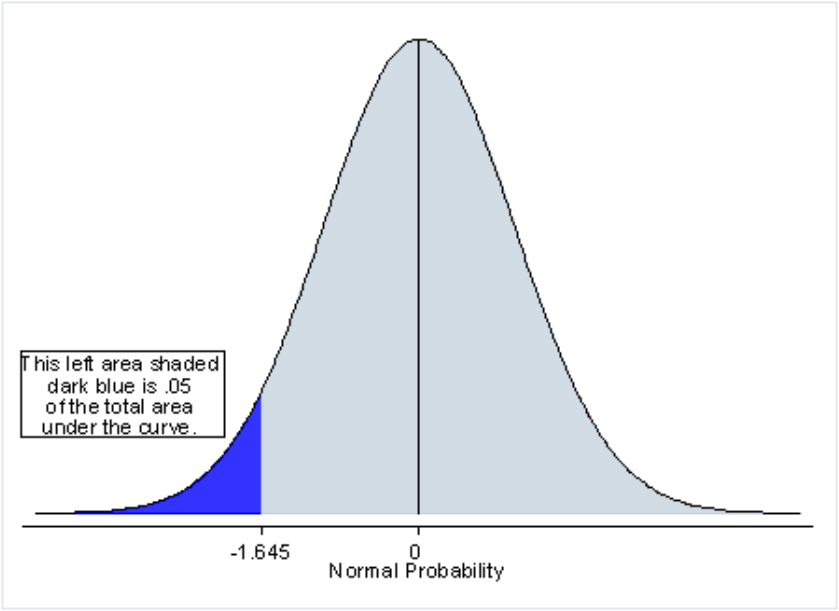
4.6.3 Western Power then must perform regression analysis on the marginal transfer limits determined in step 4.4.1 to determine a contribution factor, or coefficient, for each of the variables identified as relevant in the particular limit, which form the Non-Thermal Limit Equation.

4.7 Application of Limit Margins

4.7.1 Western Power must apply a Limit Margin to all Non-Thermal Limit Equations produced in steps 4.5.2 and 4.6.3.

4.7.2 Western Power determines the Limit Margin by using a 95 per cent confidence level of a normal distribution and the corresponding z value of 1.645 (shown in Figure 4.2). This method reflects standard industry practice in Australia.

Figure 4.2: Confidence level used by Western Power to determine Limit Margins



4.7.3 Western Power determines the Limit Margin for each Non-Thermal Limit Equations as follows:

Limit Margin= 1.645 x the Standard Error of the Non-Thermal Limit Equations

5. Provision of Limit Advice

5.1.1 Western Power must provide the Limit Advice relating to Thermal Network Limits to AEMO with detail and information including, but not limited to:

(a) Thermal Network Limits for the Network; and

(b) any other information required under the WEM Procedure: Limit Advice Requirements.

5.1.2 Western Power must provide the Limit Advice relating to Non-Thermal Limit Equations to AEMO in a report. This report must include:

(a) Non-Thermal Limit Equations;

(b) the Limit Margin forming part of the Non-Thermal Limit Equations; and

(c) any other information required under the WEM Procedure: Limit Advice Requirements.

5.1.3 Western Power must provide the Limit Advice produced in step 5.1.1 or 5.1.2 to AEMO in the time and manner required, as appropriate, under the:

(a) WEM Procedure: Limit Advice Requirements;

(b) WEM Procedure: Network Modelling Data; and

(c) WEM Procedure: IMS Interface.

6. Maintaining and updating Limit Advice

6.1.1 Western Power must review the relevant Thermal Network Limits and Non-Thermal Limit Equations when requested by AEMO, or as soon as practicable where it identifies significant changes that may affect Limit Advice.

6.1.2 Western Power must review and update Thermal Network Limits where Western Power identifies any new or changed information that may affect Limit Advice, including but not limited to variation in operating, maintenance or equipment conditions.

6.1.3 Western Power must review and update Non-Thermal Limit Equations where it identifies significant changes that may affect Limit Advice, including but not limited to:

(a) system configuration including connection of new generators or loads;

(b) generator models and parameters;

(c) new or amended Network Reinforcement Schemes (also referred to as special protection schemes);

(d) Network configuration;

(e) long-term load forecasts; and

(f) performance of generators or loads resulting for example from a disturbance event, or notified by a Rule Participant.

6.1.4 Where Western Power's review under step 6.1.2 or 6.1.3 identifies any Limit Advice is incomplete, not current, or inaccurate, it must advise AEMO promptly, update the Limit Advice in accordance with section 3 or 4 of this Procedure as relevant, and provide that updated advice to AEMO in the time and manner required **[clause 2.27A.6]**, as appropriate, under the:

(a) WEM Procedure: Limit Advice Requirements;

(b) WEM Procedure: Network Modelling Data; and

(c) WEM Procedure: IMS Interface.

7. Supporting information and data

7.1.1 Where information additional information related to Limit Advice is requested:

(a) under clause 2.27A.4 or 2.27B.5 of the WEM Rules, by AEMO for it to perform its functions in formulating, developing, maintaining and updating Constraint Equations and Constraints Library; or

(b) under clause 2.27C.7(a) of the WEM Rules, by the ERA where it considers that information is relevant to its Limit Advice review,

Western Power must make reasonable endeavours to provide that information in the requested form and in the requested timeframe (see section 5 of this Procedure).

7.1.2 All information provided by Western Power in response to a request by AEMO under step 7.1.1(a) of this Procedure is considered as Limit Advice **[clause 2.27A.5]**.