Economic Regulation Authority

Application to Revoke Technical Rules Exemption Granted to Western Power for Meadow Springs Substation

Technical Advice

MERZ Consulting

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Prepared By: Jaden Williamson
Approved By: Geoff Glazier

Merz Consulting
ABN 78 169 551 320

Level 2, 524 Hay Street
Perth WA 6000

Tel: +61 8 9460 3750

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Author(s):	Jaden Williamson and Geoff Glazier

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1. Scope

1.1 Background and scope

In December 2016, the ERA received an application from Mr Stephen Davidson to revoke Western Power's exemption from compliance with clause 2.5.4(b) (Normal Cyclic Rating (NCR) Criterion) of the Technical Rules' capacity requirements at the Meadow Springs zone substation.

Under section 12.45 of the Access Code, a person may apply to the ERA for an exemption granted in respect of a covered network under section 12.41 to be revoked and the ERA must consider the application and within a reasonable time advise the person of the ERA's determination in relation to the application.

The ERA's assessment of Mr Davidson's application was suspended for approximately 18 months because he applied to the Electricity Review Board for a review of the ERA's decision. Following completion of the Electricity Review Board process, the ERA recommenced its assessment of the application.[1]

The ERA prepared a short consultation paper which includes details of the application and the regulatory requirements. The public consultation closed on 15 March 2019. Submissions were received from Mr Davidson, Western Power and Geoff Brown & Associates (the technical consultant who advised the ERA on the original exemption).

Mr Davidson's application, the ERA's consultation paper and public submissions received can be found here:

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/meadow-springs-zone-substation-technical-rules-exemption-revocation-application

The ERA has requested that Merz Consulting (Merz) review Mr Davidson's application and the public submissions received (in particular Mr Davidson's most recent submission which claims there are errors and discrepancies in the information provided by Western Power) and provide advice to the ERA to assist it with its determination under sections 12.45 to 12.47 of the Access Code.

The primary focus will be to provide advice on whether the exemption should be revoked. This will include advising whether the calculation of the NCR capacity has been carried out correctly based on the current requirements of the Technical Rules and that the load forecasts are reasonable.

The secondary focus will be the specification of the NCR criterion and whether it is appropriate for ensuring efficient levels of investment.

All references to the Technical Rules are reference to the 1 December 2016 version of the rules unless otherwise stated. All data used in the following review is based on the latest information available at the time of the assessment.

[1] The Electricity Review Board dismissed the application on the basis that it did not fall within the scope of the Board's jurisdiction and because Mr Davidson was not a person aggrieved.

1.2 Limitation statement

The sole purpose of this report, and the associated services performed by Merz, is to provide the Economic Regulation Authority (ERA) with an overview of issues detailed in the scope above. That scope of services, as described in this report, was developed with the ERA.

In preparing this report, Merz has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the ERA and/or from other sources. Except as otherwise stated in the report, Merz has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, then it is possible that our observations and conclusions as expressed in this report may not reflect the most accurate outcomes.

Merz derived the data in this report from available information sourced from the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination and re-evaluation of the data, findings, observations and conclusions expressed in this report. Merz has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Merz for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of, the ERA, and is subject to, and issued in accordance with, the provisions of the agreement between Merz and the ERA. Merz accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

2. Requirements for Exemption

This section explores the requirements for the exemption by considering two key issues:

1) Does the NCR calculation for Meadow Springs Substation, consistent with the requirements of the Technical Rules, require action from Western Power?
2) What action is required of Western Power? Given the action required does the exemption for the Meadow Spring Substation remain a valid requirement.

2.1 Meadow Springs Substation Loads and NCR Capacity

2.1.1 NCR Criteria Capacity Calculation Definition

The NCR Criteria in the Technical Rules[2], clause 2.5.4.(b)(2) requires:

> *The maximum power transfer through a substation subject to the NCR risk criterion must be the lesser of:*
>
> *1) 75% of the total power transfer capacity of the substation, with all supply transformers in service; or*
> *2) the power transfer for which the maximum unmet demand for power transfer capacity following the loss of the largest supply transformer in the substation is equal to 90% of the power transfer capacity of the rapid response spare supply transformer.*

Within this definition power transfer is defined as:

> *"The instantaneous rate at which active energy is transferred between connection points."*

Within this definition connection point and active energy are defined terms being:

> *Connection Point: A point on the network where the Network Service Provider's primary equipment (excluding metering assets) is connected to primary equipment owned by a User.*
>
> *Active energy: A measure of electrical energy flow, being the time integral of the product of voltage and the in-phase component of current flow across a connection point, expressed in watt hours (Wh) and multiples thereof.*

The following components of these supporting definitions are troublesome in the application of the NCR planning criteria, in particular:

1) Active Energy measured in watt hours is not a measure of transfer capacity. *The instantaneous rate at which active energy is transferred* is fully reflected in the term *active power* within the Technical Rules (measured in Watts) but does not reflect the limiting factor of network element capacity which is typically measured by current (Amps) or Volt- Amps (VA).
2) The identification of the relevant connection points to apply to the application of the NCR criteria for a substation.

[2] The Technical Rules is a Western Power document, approved by the Authority which details how Western Power are to plan, design and operate their network. Obligations also exist within the Rules for connected Users.

These issues are discussed further in section 3 of this report. For the purposes of this section Merz has assumed the following:

1) Power transfer capacity will be defined and discussed in the terms of Active Power measured in Watts. To do this, a power factor determined with reference to the load power factor at peak load times has been used to translate capacities provided in aggregate power capacity (VA).
2) The connection points will be defined as follows:
   a) Supply connection points will be a generator (not specifically defined on the 132kV transmission system).
   b) Load connection points will be the aggregate of all of the distribution connection points downstream of the substation.

These definitions have been adopted as they are the closest connection points to the Meadow Springs Substation and reflect the role of the substation in transferring power, being to convert power on the 132kV network to power on the 22kV network.[3]

These definitions become material in the discussion of the inclusion of distribution transfer capacity in the power transfer capacity applied in the NCR criteria.

In the documentation provided, Western Power has used both apparent and active power. For this paper Merz has converted from apparent to real power on the basis of the conversion factor of the measured load being 0.99.

2.1.2 Distribution Transfer Capacity

Western Power has noted in its submissions that there exists operational flexibility to transfer load between interconnected substations. In particular Appendix 1 of the Consultation Paper states:

"Note: In early January 2015, a contingency event occurred resulting in a temporary load transfer of approx. 6 MVA from MSS to Waikiki Zone Substation. This transfer potentially understates the summer 2015 peak at MSS"

Also, a corrected section (corrected due to incorrectly stating that NCR capacity had been exceeded) from the same document notes:

"in 2011, 2013 and 2014, a series of staged load transfers from MH to MSS were made to reduce the impact of the capacity shortfall"

Reviewing the NCR capacities determined by Western Power, it does not appear that this flexibility is included in the calculation of the total power transfer capacity of the substation. Such a calculation would require a detailed assessment of capacity within the distribution system and the capacity available at substations that can connect to the distribution network currently supplied by Meadow Springs substation. The trade-off, however, would result in the optimised use of the installed assets until such time that the system (or rather the interconnected region) required augmentation (as opposed to the substation alone). These benefits are discussed further in the Geoff Brown & Associates (GBA) review of Western Power's original exemption application, dated 20th July 2015.

[3] This definition of connection points is a necessary simplification and at certain times may not be accurate. It is however accurate during the periods of high transfer from 132kV to 22kV specifically contemplated by the planning criteria.

The question of whether the distribution transfer capacity (DTC) should be included in the determination of *power transfer* capacity within the NCR criteria requires consideration of the definitions detailed in section 2.1.1 of this report. Does DTC represent a **transfer through a substation** from a 132kV connection point to the connection points on the distribution system? One interpretation is that it does represent a capacity to move power from the 132kV connection point to the distribution connection points. However, DTC does not technically represent a flow "through" a substation but more an ability to move this flow to another substation. Clarity on the treatment of DTC in the application of transmission planning criteria within the Technical Rules would be helpful. This is discussed further in section 3 of this paper.

DTC can be detailed alongside peak load forecasts, rather than incorporating them into an NCR capacity limit. In this way the DTC would assist in informing the timing of prudent investment in augmentation. The discussion in section 2.2 of this report details why Merz believes Western Power has the flexibility to consider DTC in the timing of an investment response under the Technical Rules.

For the purposes of this assessment, DTC has not been directly included, however its operational flexibility should be considered prior to the commitment to investment in any augmentation works.

2.1.3 Forecast and Actual Peak Loads at Meadow Springs

The actual peak loads at Meadow Springs Substation, as advised by Western Power (in response to a Request for Information from the ERA), are detailed below[4]. It should be noted that these figures are presented in 30-minute average intervals and hence instantaneous peak values may be greater (i.e. 2018 peak was observed to be 58 MW as noted in Appendix 5 – NCR Substation Capacities, Load Forecasts and Investment Data (dated 24th January 2019)):

TABLE 1: HISTORIC PEAK LOADS AT MSS (30 MINUTE AVERAGE INTERVAL)

Units	2018	2017	2016[5]	2015	2014
MW	54.7	51.0	60.4	51.1	57.8
Corresponding MVAr	1.5	1.3	4.1	5.4	7.2
MVA	54.7	51.0	61.1	51.4	58.3
Determined Power Factor	1.00	1.00	0.99	0.99	0.99

Based on these figures, the average power factor through the substation is 0.995, hence a Power Factor of 0.99 shall be used for the calculation to be conservative.

The forecast loads at Meadow Springs Substation, as advised by Western Power in Appendix 5 – NCR Substation Capacities, Load Forecasts and Investment Data (dated 24th January 2019), are:

TABLE 2: FORECAST PEAK LOADS AT MSS

Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
MW (POE10)	75.89	79.81	82.60	84.23	85.67	87.11	88.39	89.55	90.61	91.59

[4] Merz notes that these figures differ from previously reported values. Merz has used the most up-to-date data available for this assessment. The source of the variance is detailed in Appendix A.
[5] Merz notes that the 2016 figures provided by Western Power do not equate as expected according to the power triangle, where MVA is anticipated to equal 60.54MVA.

Merz has not been engaged to conduct a detailed assessment of the forecasts developed by Western Power. The methodology used by Western Power[6] undergoes a regular review as part of the Access Arrangement process, the latest version of the methodology was reviewed during the AA4 review[7]. Western Power has provided confirmation that the forecasts presented throughout the Technical Rules Exemption Application submissions have been developed consistent with this methodology. Therefore, Merz is comfortable that sufficient external oversight exists in Western Power's forecasting process and by extension the forecasts themselves are reasonable

The POE10% forecasts relate to a 1 in 10 chance of the peak load exceeding the estimate . While adopting these forecasts alone may portray a greater need for action (as opposed to say an average or expected POE50% forecast), their use in network planning activities is standard Western Power practice that has been externally reviewed on multiple occasions.

Given the trend of the historic peak loads, Merz is of the position that forecast loads in excess of 55 MW are appropriate.

2.1.4 Calculation of NCR Criteria Capacity at Meadow Springs

Calculation of the NCR Capacity requires two elements:

- The power transfer capacity of the installed supply transformers at the substation; and
- The power transfer capacity of the rapid response spare transformers (RRSTs).

As discussed by GBA in their review of Western Power's original application for the exemption, operational use of supply transformers typically uses power transfer capacities higher than their nameplate ratings:

"The limiting factor that determines transformer capacity is temperature rise, which is a function of the heat transferred into the unit due to electrical losses within the transformer. These losses vary with load. As transformers have a high thermal inertia, they are capable of operating at loads higher than their nameplate rating for short period if this is offset by period of low load operation when the heat transfer is lower. As distribution network demand varies across a day, peak demands higher than the nameplate rating can safely be applied without damaging the transformer."

Western Power's assigned cyclic rating of the 132 kV RRSTs are detailed in the below table:

TABLE 3: RRST NCR RATINGS

Designation		NCR Summer		NCR Winter	
Equipment Name	**Voltage (kV)**	**HV (A)**	**LV (A)**	**HV (A)**	**LV (A)**
EETT81 TX	132	186	1052	216	1225
RRTT82 TX	132	187	1057	216	1225

[6] https://www.erawa.com.au/cproot/18337/2/24.%20Attachment%207.3%20-%20Peak%20demand,%20energy,%20customer%20forecasts%20-%20REDACTED.pdf

[7] https://www.erawa.com.au/electricity/electricity-access/western-power-network/western-powers-network-access-arrangements/western-power-access-arrangement-period-2017-2022

Taking the conservative summer ratings and utilising the average power factor determined in Section 2.1.3, the transfer capacity of the RRSTs were determined as (noting this is a 3-phase system):

- Power = 3 x V_{P-E} x I_{P-E}
- V_{P-E} = V_{P-P} / sqrt(3)
- Hence, Power = 3/ sqrt(3) x V_{P-P} x I_{P-E}
- Using EETT81 TX as an example: 3/sqrt(3) x 132,000 V x 186 A = 42,525,311 VA = 42.53 MVA
- Converting to units of MW = MVA x PF = 42.53 x 0.99 = 42.10 MW

This is summarised for both RRSTs in the below table.

TABLE 4: RRST POWER TRANSFER CAPACITIES

Equipment Name	Voltage (kV)	MVA	Average PF	MW	0.9 MW
EETT81 TX	132	42.53	0.99	42.10	37.89
RRTT82 TX	132	42.75	0.99	42.33	38.09

The capacity of the transformers installed at Meadow Springs Substation, as advised by Western Power are:

TABLE 5: MSS SUPPLY TRANSFORMER POWER TRANSFER CAPACITIES

Transformer	NCR Rating (MVA)	Average PF	NCR Rating (MW)
T1	38.64	0.99	38.25
T2	35.51	0.99	35.15

According to the Technical Rules 2.5.4.(b)(2), the maximum power transfer through Meadow Springs Substation is therefore the lessor of:

1) 75% x (T1 + T2) = 75% x (38.25 + 35.15) = 55.06 MW[8]
2) (T1 + T2) - (Max T) + 90%(RRST) = (38.25 + 35.15) - 38.25 + 37.89 = 73.04 MW

Hence the NCR Capacity of Meadow Springs Substation is noted to be 55.06 MW[8] (or 55.61 MVA as previously stated by Western Power in Appendix 5 as published on the ERA website).

[8] Using the figures presented here results in an NCR Capacity of 55.05 MW. This discrepancy arises due to cumulative rounding resulting from the MVA to MW conversion.

2.1.5 Determination of Requirement for Action

Graphically depicting the loads against the NCR Capacity determined in 2.1.4 shows a clear actual and forecast exceedance of the NCR Capacity:

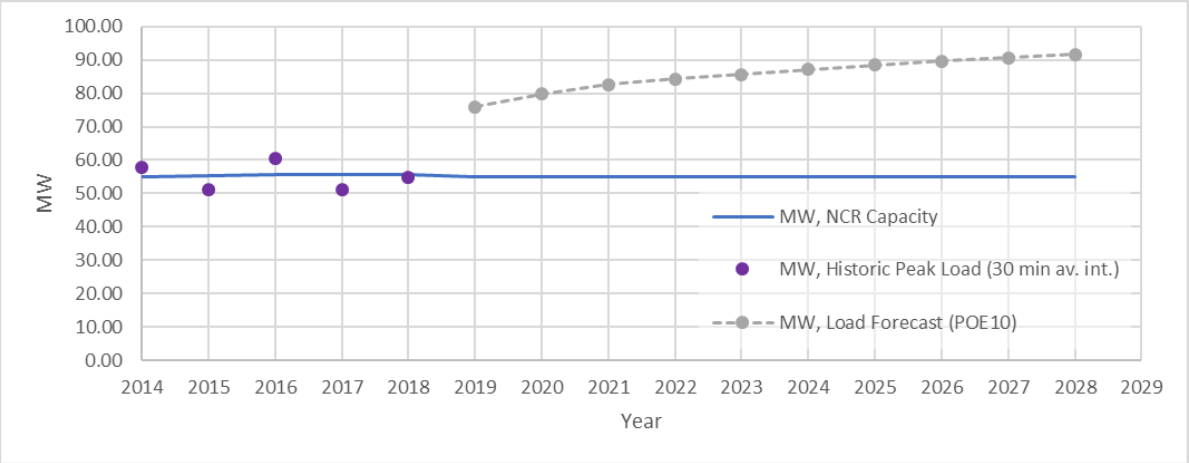

FIGURE 1: MEADOW SPRINGS SUBSTATION NCR CAPACITY AND PEAK LOADS

Notwithstanding the treatment of Distribution Transfer Capacity, based on this information, there is an obligation for action by Western Power under the Technical Rules given the actual load and load forecasts. The following discussion pertains to what the required action is required by the Technical Rules.

Through this review a range of discrepancies have been identified in the information provided by Western Power. These discrepancies do not alter the conclusions of the discussion above and are summarised in Appendix A for completeness.

2.2 Required Response to Expected and Actual Exceedance of NCR Capacity

Clause 2.5.2 of the Technical Rules requires Western Power to do the following

"The Network Service Provider must design the transmission system in accordance with the applicable criteria described below."

Within the above definition the NCR detailed in section 2.5.4.(b)(2) is the relevant criteria applicable to the Meadow Springs Substation.

This clause clearly requires an action from Western Power to take design activities consistent with the defined criteria. Further, these design activities must be completed consistent with Good Electricity Industry Practice as required by clause 1.8.1 (4) of the Technical Rules.

2.2.1 Exploration of the term "design"

Neither the term "design" nor "design the transmission system" are defined terms within the Technical Rules. The following discussion details Merz's understanding of the term "design the transmission system" and how planning criteria are relevant to this process.

Prudent design of the transmission network would involve, at a minimum, the following steps:

1) Periodically and / or in response to new significant connections, a network service provider must investigate[9] the load of each element on its network to determine if it is, or is likely to, operate outside its capability, or technical parameters detailed in the Technical Rules, under a range of pre-defined conditions. These pre-defined conditions are typically described by a set of criteria referred to as "planning criteria". In the Western Power Technical Rules these planning criteria are described by the loss of, or reduction in capacity, of elements of the network. Effective planning criteria, in concert with appropriate load forecasting, trigger a subsequent design processes (discussed below) in sufficient time to allow for the design process to be completed and the resulting investment to be made, in order to maintain appropriate levels of reliability on the network. The following design process describes the minimum activities that would be expected in response to issues identified at a network element by the network planning process detailed above.
2) A range of options are defined to address the issue(s) identified by the application of the planning criteria. These options may not be limited to investment in network elements. The definition of these options requires enough specification and engineering to allow:
   a) Cost estimates to be created for each option with enough accuracy to allow comparison between the effectiveness of the options.
   b) The technical benefit of each option to be defined.

   Importantly, the design options should address the issues identified by the application of the planning criteria. In this way the planning criteria performs two roles in the design of the transmission system, the first being to trigger when augmentation design should be commenced and the second in the assessing the effectiveness of the options to address the issues identified.
3) The options are compared based on the cost and technical benefit information established for each option. Typically, the different options may incur costs or deliver benefits on different time scales. For this reason, the analysis between options typically involves analysis methods that can account for the time value of money. Through this process a preferred option is selected.
4) For larger cost options, the cost estimates that are prudent for options analysis are not typically acceptable to support prudent governance around the final investment decision. Therefore, further engineering and design would be completed to support a more accurate cost estimate. This engineering and design may also support other mechanisms within a prudent capital governance framework such as development of project delivery strategies and plans. The completion of this element of the design process would be a final case for investment to address the issue identified by the application of the planning criteria detailed in item 1.
5) Importantly, Merz does not consider the decision to invest, or the process of making an investment, as part of the requirement to "design the transmission system". The prudent timing of an investment should consider a range of issues beyond those considered in the planning criteria.

In summary, the application of planning criteria within the process of designing the transmission system delivers acceptable levels of network reliability through triggering prudent and timely design and through providing a structure for the consideration of augmentation options.

2.2.2 Is an exemption required to avoid an obligation to invest?

[9] This investigation is typically undertaken using a detailed model of the network within suitable power system modelling software.

In its most recent submissions, Western Power's requirement for an exemption request appears to be that if it had not made the investment in Meadow Springs Power Transfer Capacity before this capacity was exceeded it would be in breach of the Technical Rules. This is summarised in Western Power's submission to the ERA Discussion paper dated 15th March 2019.

"*Therefore, without the exemption Western Power would have been found non-compliant to the Technical Rules and an investment to address the non-compliance would have had to be brought forward."*

Merz does not accept that the obligation in the Technical Rules to design the transmission system consistent with defined criteria translates to a positive obligation[10] to invest consistent with that design in a particular time frame. The reasons for this position are detailed below.

1) The obligation in the Technical Rules is limited to the phrase *"design of the transmission system".* Given the level of financial investment a positive obligation in the Technical Rules would drive, Merz would expect any requirement to invest in capacity would be clearly and unambiguously detailed if this was the intent of the Rules.

   For reference, different obligations are used for different requirements of the Technical Rules, for example the obligation 2.5.5.1(a) relating to the N-0 distribution criteria clause states that Western Power:
   "*may, unless good electricity industry practice dictates otherwise,* ***design and operate*** *the distribution system to the N-0 criterion."*

   More stringent is the obligation relating to the performance of Users, which is detailed in clause 3.3.1(a) as follows:
   "A Generator ***must comply at all times*** *with applicable requirements and conditions of connection for generating units as set out in this clause 3.3.*"

   It is Merz's view that if the intent of the NCR criteria was intended to be applied such that Western Power needed to design, invest and operate the transmission system consistent with the criteria at all times, it would have been worded consistent with the obligation on Users detailed above.

2) A regulated monopoly (such as Western Power) is commercially incentivised to make investments in the network that can be included within its Regulated Asset Base. Regulatory mechanisms typically seek to confirm that this investment is undertaken in a manner (including timing) that delivers customers a reasonable (and often defined) level of reliability and safety at the most efficient possible cost. Within the Western Australian regulatory environment, the mechanisms to deliver these outcomes are defined in the Electricity Network Access Code 2004 (ENAC) formed under the Electricity Industry Act 2004 (EIA). Of these mechanisms the most notable is the New Facilities Investment Test (NFIT). Guidance on acceptable levels of service, particularly safety, quality and reliability, is provided in the relevant regulations and Codes under the (EIA)[11]. The

[10] The term positive obligation means an obligation in the Technical Rules that if not met would result in Western Power being in breach of its obligations.
[11] Specifically, the Electricity (Network Safety) Regulations 2015 and Electricity Industry (Network Quality and Reliability of Supply) Code 2005.

Technical Rules are established within the context of this broader EIA defined economic regulatory environment.

In this context it would be unusual to have a positive obligation for investment in the Technical Rules without links supporting this obligation within the ENAC and the supporting regulations. To not have this link increases the risk that the mechanisms in the ENAC and supporting regulations (that deliver the Objectives of the ENAC) could be over-ridden by a simplified planning criteria or other technical guidelines in the Technical Rules. No such link within the referenced Codes and Regulations has been identified.

A case could be made that investing consistent with the NCR planning criteria meets the requirements of the ENAC (in particular, the reliability leg of the NFIT) and the supporting Regulations and Codes. Merz have not reviewed any such analysis or case.

Such a case would represent an assertion that investment on the basis of deterministic planning criteria alone was consistent with the Objectives of the ENAC. Merz is aware that industry practice has been moving away from this approach to more probabilistic approaches to demonstrating investments are consistent with the objectives of regulatory instruments.

In any case, if such a case was successfully made, it would not represent a positive obligation within the Technical Rules on Western Power to invest consistent with the relevant planning criteria. It would, however, allow Western Power to include investments made consistent with the planning criterion in its Regulated Asset Base.

2.2.3 Is an exemption required to allow for design solutions that may not meet the planning criteria at all times?

In taking action to rectify the forecast NCR exceedance, Western Power investigated a range of options for the Mandurah load area, as outlined in its works planning report V5, dated November 2014. The proposed option contains a solution (deemed most prudent by Western Power) that complies with clause 2.5.2 of the Technical Rules at the completion of all design activities. This solution has been proposed to be implemented in a staged approach where various augmentations will be applied to several substations, including Meadow Springs Substation. Following the augmentation at Meadow Springs Substation in isolation, the POE10% forecasts exceeds the NCR defined capacity of the substation in some earlier years until the design reaches a later stage of completion. It could be argued that the design is not compliant with the planning criteria detailed within the 2016 Technical Rules in the years the NCR defined capacity detailed by the design is not sufficient to meet the forecast demands.

If the exemption sought by Western Power was on the basis that the temporary exceedance of the NCR capacity within its design may have otherwise inadvertently resulted in non-compliance with the Technical Rules, Merz does not foresee any issues with the ERA having granted and maintained the requested exemption under this context. The only drawback of this approach is the administrative burden resulting from the application given the Technical Rules do not bind Western Power to necessarily invest consistent with the design.

2.3 Recommendation

The review of the calculation of the NCR criteria capacity of the Meadow Spring Substation has concluded that there is an obligation for Western Power to further advance the design of the transmission system to address the capacity issue identified by this criterion. The process of designing the transmission system in response to this obligation must be completed consistent with Good Electricity Industry Practice and this process requires at a minimum certain activity.

The Technical Rules temporary exemption granted to Western Power for Meadow Springs Zone Substation is not required to avoid an obligation on Western Power to make investments in a set time frame as asserted by Western Power in its submission dated 15th March 2019.

Based on specific needs of the Mandurah load area Western Power may have, for proper and prudent strategic reasons, chosen to implement a staged design that does not satisfy the requirements of clause 2.5.2 of the Technical Rules at all points in time, but does following completion of the overall design. If the exemption sought by Western Power was on the basis that the temporary exceedance of the NCR capacity within its design may have otherwise inadvertently resulted in non-compliance with the Technical Rules, Merz has not identified any issues with the ERA having granted and maintained the requested exemption under this context[12]. This view is supported by a statement made by Western Power in their original exemption application, dated 15th May 2015:

"***This revised strategy represents a pathway towards compliance as Western Power aims to minimise the risk of over-investment in the face of potential variability in forecast demand. However, Western Power would be exposed to the risk of breaching Technical Rules compliance at MSS during the investment period (2015/16 to 2019/20). Therefore, Western Power seeks a temporary exemption from compliance with the NCR Criterion for the MSS substation.***"

If this is the basis for the exemption request and it remains, we do not see a case for the ERA to revoke this exemption.

Clarity within the Technical Rules regarding whether the "design of the transmission system" must meet the planning criteria in every stage or simply at the conclusion of the design may avoid the need for similar exemption applications in the future. This is discussed further in Section 3.1.3.

[12] There is some ambiguity in Western Power's submission given, as Mr Davidson has noted in his public submission dated 15th March 2019, the proposed design for Mandurah Substation is also expected to encounter the same NCR exceedances until the final design is implemented.

3. Review of NCR Determination

3.1 Opportunities for Increased Clarity

In seeking to undertake calculations consistent with the definitions in the Technical Rules the following challenges were identified in the drafting of the NCR criteria:

1) Active Energy measured in watt hours is not a measure of transfer capacity. Capacity refers to an instantaneous capability that is better reflected in the definition of *active power* within the Technical Rules (measured in Watts).
2) The identification of the relevant connection points to apply to the application of the NCR criteria for a substation.
3) The lack of a definition of the term *design* and therefore the interpretation of what is required for a "design of the transmission system" to be done consistent with the planning criteria.

3.1.1 Definition of Power

For the calculations in Section 2 of this paper the definition of *Active Power* was adopted as it best aligned to the definition used in the clause. However, Western Power has provided much of the data for this analysis on the basis of power transfer capability measured in MVA, defined in the Rules as *Apparent Power*. The capability of most network elements is typically defined with respect to Apparent Power as it is most closely related to the current (measured in Amps) throughput that is the limiting factor of many network elements. It is recommended that if the definitions are to be refined that the definition of *Apparent Power* is used to replace *Active Energy*.

3.1.2 Transfer between Connection Points

The existing definition of *power transfer through a substation* requires consideration of connection points, being the points where users are connected to the Western Power system. However, it is unusual to have connection points either side of a substation so the concept of transfer between connection points, through a substation results in some confusion. Merz believes the definition as it is drafted most likely would include distribution transfer capacity as this capacity can be used to transport power between the connection points directly up stream and downstream of a substation. If this is the intent of this clause Merz would recommend re-drafting the clause as follows:

> *The maximum **power transfer for** a substation subject to the NCR risk criterion must be the lesser of:*
>
> *1) 75% of the **total power** transfer capacity of the substation, with all supply transformers in service.; or*
> *2) the **power transfer** for which the maximum unmet demand for power transfer capacity following the loss of the largest supply transformer in the substation is equal to 90% of the power transfer capacity of the rapid response spare supply transformer.*

A clarifying note could be included to detail that this definition includes distribution transfer capacity.

This approach is preferred as it provides more flexibility to consider existing capacity within the distribution system as part of the transfer capacity of a substation.

Alternatively, the definition could remove the italicised reference of the defined term and change the wording to make it clear that the planning criteria applies only to power transfers / flows through the substation.

> *The maximum **power flow** through a substation subject to the NCR risk criterion must be the lesser of:*
>
> *1) 75% of the total **power flow** capacity of the substation, with all supply transformers in service; or*
> *2) the **power flow** for which the maximum unmet demand for power transfer capacity following the loss of the largest supply transformer in the substation is equal to 90% of the power transfer capacity of the rapid response spare supply transformer.*

A clarifying note would identify that distribution transfer capacity is not included in this definition. In this case distribution transfer capacity should still be considered when considering the timing of investments defined by the design process.

3.1.3 Application of the phrase "design the transmission system"

Consideration could be given to providing a definition for the term design in the Technical Rules. Given the broad usage of this term within the Technical Rules the wording of any such definition would require significant consideration and is outside the scope of this paper.

Alternatively, a statement that clarifies that any prudent design that ultimately meets the requirements of the planning criteria would satisfy the requirements of section 2.5 of the Technical Rules, even if it does not meet the requirements of the planning criteria for periods of time, would be helpful in reducing administrative burdens moving forward.

Given the statements by Western Power it may also be helpful to clarify in the Technical Rules that an obligation to design consistent with the planning criteria does not directly translate into an obligation to invest. The timing of investments may, for a range of efficient and prudent reasons, be delayed or accelerated from that identified within the design.

3.2 Probabilistic Analysis

Some rudimentary analysis has been undertaken on the various forms of the NCR criteria considered in the 2011 version of the Technical Rules and the 2016 version of the Technical Rules. The first analysis compares the maximum substation utilisation available under the N-1 criteria (as a reference), the 2016 planning criteria and the 2011 planning criteria. A modified version of the 2011 planning criteria is provided for reference and further discussion. This analysis is provided in the following figure.

The N-1 criteria has been adopted as a reference as it is the most likely planning criteria that would apply to a substation immediately preceding the investment in the capability to connect the Rapid Response Spare Transformer that allows a substation to be designed under the NCR criteria. Thus, any improvements in capital efficiency or reliability generated by this investment are best considered from the base of the N-1 criteria.

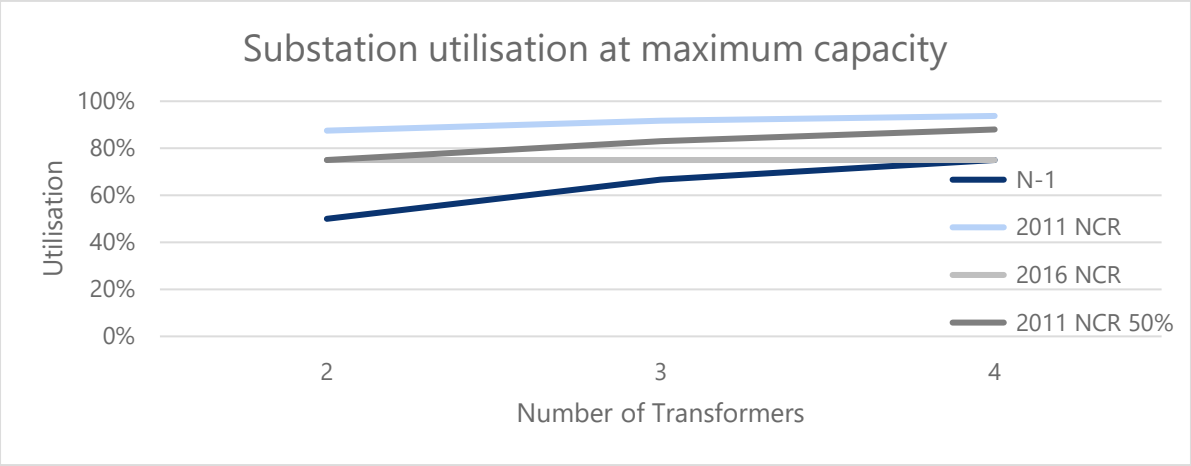

Figure 1: Substation Utilisation under different planning criteria

Utilisation is the maximum permitted substation throughput under the planning criteria divided by the total permanent installed capacity at the substation. Utilisation can be used as a proxy for capital efficiency.

Number of transformers is the number of transformers installed at a substation. Figure 1 assumes all the transformer are the same size.

Figure 1 demonstrates the significant improvements in utilisation and capital efficiency delivered by the NCR criteria and the supporting investment in the application of the Rapid Response Spare Transformer.

The 2011 NCR criteria resulted in utilisations above 90%. Its Merz's position that substation utilisations this high are very hard to manage from an operational perspective. This is because each transformer in the substation often must address a discrete component of the total load as a result of fault level increases resulting from operating the transformers in parallel (sharing the supply of the load). Segmenting the total load into discrete packets across the transformers results in an operational limitation on the total percentage of the total transformer load that can be applied to the load.

However, the 2016 criteria do not demonstrate a consistent utilisation margin above the N-1 criteria for all substation configurations. Indeed, under this application of the NCR criteria there is no capital efficiency benefit above the N-1 criteria for a four-transformer substation. This would suggest that the expenditure on implementing the Rapid Response Spare Transformers could not be justified under this application of the criteria. This would not appear to be an entirely prudent outcome.

As an alternate the 2011 mechanism with a modified percentage (50%) applied to the smallest transformer has been included. This maintains utilisation below 88% whist maintaining a utilisation / capital efficiency benefit across the different substation configurations when compared to the base N-1 criteria.

Consideration was given to the consistency of reliability outcomes across the different planning criteria and substation configurations. This consideration was undertaken using a highly simplified probability based unserved energy analysis. The results of this consideration are provided in Figure 2.

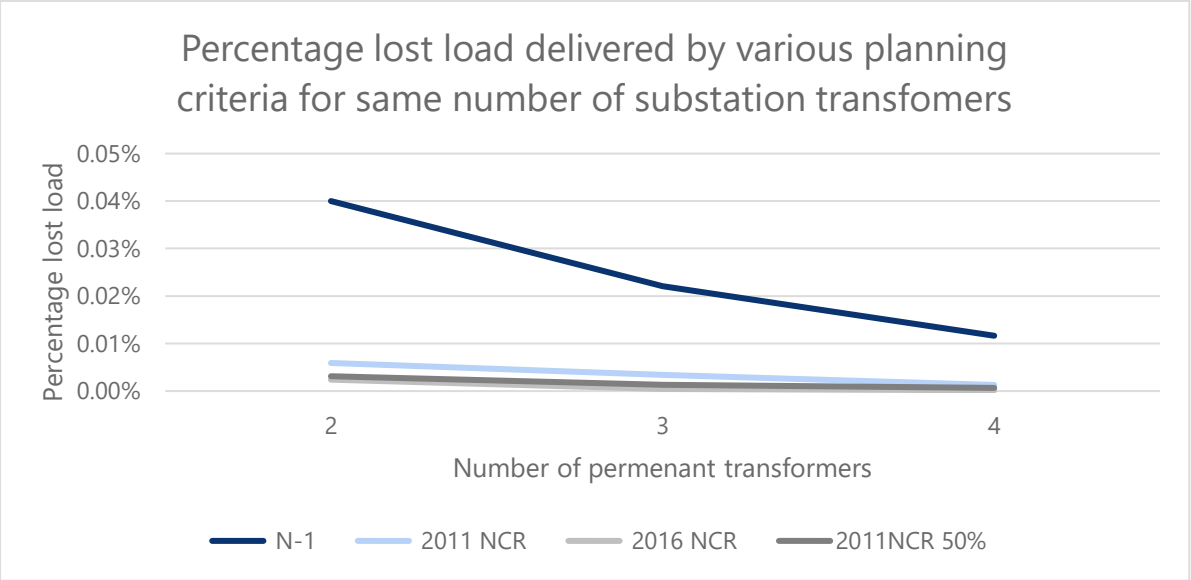

Figure 2: Percentage unserved energy for different planning criteria and sun station configuration

Percentage unserved energy is the average energy not supplied due to outages. The analysis adopted a total outage rate of 2% and a simple load duration curve.

Examination of Figure 2 identifies the following rudimentary observations:

- The additional capacity available through the rapid response spare transformer under all the NCR criteria results in significantly better reliability outcomes, even when the 12 hour change over requirement is taken into consideration.
- The reliability outcomes improve with increasing transformer number in the substation whilst the utilisation is also improving.
- The 2011 NCR criteria outcomes fall between the 2016 NCR outcome and the reference N-1 criteria.

3.3 Summary

In modern transmission system design, planning criteria, in concert with load forecasting, are used in the following manner:

- as a trigger within system studies, completed periodically and in response to step load changes, for further design activities to commence; and
- to support assessment of options within these further design activities.

In the course of this review, three opportunities to improve clarity within the Technical Rules have been identified. These opportunities would not warrant a standalone change process but could be considered further if packaged with other Technical Rules changes.

Rudimentary analysis suggests that the 2011 NCR planning criteria would likely result in substation utilisation beyond that which can be typically delivered operationally. However, the 2016 criteria does not deliver a consistent capital efficiency benefit above the N-1 criteria across all substation configurations. This could impact any decision to implement the Rapid Response Spare Transformer at substations with 4 transformers. This would be unfortunate as the NCR criteria theoretically delivers significantly better reliability outcomes whilst delivering improved capital efficiency.

Appendix A – Submission Discrepancies

Non-consequential discrepancies identified in Western Power's recent submissions are noted below:

TABLE 6: NOTED DISCREPANCIES

Items	Discrepancies/issues	Dated	Document	Merz Comment
1	No explanation is provided as to why the NCR capacity determined under the 2016 Technical Rules drops for the MH substation between 2012-2014. Potentially due to a different power factor?	24/01/2019	Appendix 3 - Western Power - Update to Technical Rules exemption request	While there is a minor deviation in the plotted value of the NCR capacity at MH substation, the deviation is not in relation to the determination of the MSS NCR capacity value used in this report.
2	All transformer ratings have been provided in MVA units while load forecasts and 2018 actual data is provided in MWs. This does not enable the reader to readily compare the two datasets.	24/01/2019	Appendix 5 - Western Power - NCR substation capacities, load forecast and investment data	In the assessment presented in this report, a consistent approach has been taken to presenting loads and capacities consistent with the definitions in the Technical Rules.
3	The statement "under this requirement all NCR substations can be loaded up to approximately 90% of its transformer name plate rating". This is misleading as it infers the worst case scenario for all substations. The actual capacity is dependent on the configuration of the substation and ranges from 75% - 91.3%. Taking an average of all substation loading results in an average loading of 85%.	15/03/2019	Public Submission - Western Power	While this statement infers a worst case scenario under the 2011 Technical Rules definition of the NCR, as discussed in this report, the operational loading of a substation is only one factor in the overall network planning assessment (along with the ability to transfer load through DTC). A review of several NCR options has been provided in Section 3.
4	The peak load at MSS reported in this document is noted to differ by roughly 5% from the information provided by Western Power as part of this review.	24/01/2019	Appendix 3 - Western Power - Update to Technical Rules exemption request	Western Power have advised that the variance is due to Western Power conducting a data cleansing exercise of the substation historic peak load data across the SWIS. Periodically, Western Power reviews the data that is generated by their automated 'Plant Information

Items	Discrepancies/issues	Dated	Document	Merz Comment
				(PI) validate process' to ensure the peaks recorded are a true reflection of the conditions at the substation, instead of recording non-credible values arising from temporary spikes (due to abnormal conditions on the network), IT or communication glitches or due to temporary load switching between substations or any other unusual condition. This review adopts the most recent load data.
5	Mr Davidson raised concerns that WP was expecting the load to suddenly increase within the reporting year (i.e. >18% increase in 2019 based on the data presented in Appendix 5).	15/03/2019	Public Submission – Mr Stephen Davidson	This is not the case. The POE10% forecasts are considered to be on the conservative end of the scale for that year (only 10% chance of exceeding that estimate). Granted they could have been revised prior to submitting the report based on loads already experienced within that year. However, it is not unreasonable for WP to have used readily available forecasts in their application.
6	Appendix 2 (WP resubmitted Application with the 2011 NCR limits) Mr Davidson is concerned that WP used the historic forecasts, as opposed to actual loads.	15/03/2019	Public Submission – Mr Stephen Davidson	Merz's understanding is that the document was updated, not for the purposes of resubmitting from today's point of view, but rather what the application should have looked like if the literal 2011 NCR capacity calculation had been used. Western Power's attempt at clarifying the actual experienced loads during the last few years has muddied the intent of that document, resulting in a mixture of incomplete current clarification data against outdated forecasts. It is understood how this process may have created confusion. With regards to Merz's assessment presented in this document, this discrepancy does not influence the determination as a review was performed on the

Items	Discrepancies/issues	Dated	Document	Merz Comment
				latest data available in 2019, which includes actual load information for the period.
7	The more recent submission from WP (dated 24th Jan 2019). MR Davidson notes an 11MW load transfer from MH to MSS.	15/03/2019	Public Submission – Mr Stephen Davidson	Merz are of the position that this was not intended to deceive stakeholders, rather it is a deliberate part of WP's network planning and design and has been noted in their Works Planning Report dated November 2014, under Option 5. The POE10% forecasts included in this document for 2019 onwards also do not indicate an 'expected' surge in load, rather it is showing the 10% probability of exceedance forecast. Granted these are conservative estimates.
8	Mr Davidson notes that the NCR values determined in the Non-Network Options Report (dated 03/06/2016) are significantly more conservative than other calculation sources.	15/03/2019	Public Submission – Mr Stephen Davidson	Merz has not reviewed the Non-Network Options Report described by Mr Davidson as it was not included in support of the exemption request. Based on Mr Davidson's comments, there does appear to be errors with that report.
9	Mr Davidson notes "From 2012 to 2017, all Annual Planning Reports forecasted the NCR capacity of zone substation in the Mandurah Load Area would be exceeded in the next five years. In other words, all Annual Planning Reports from 2011 to 2017 reported that the NCR capacity of Meadow Springs (MSS) zone substation, as well as that of any other substation in the Mandurah load area, had not been exceeded (at the time of publication)."	15/03/2019	Public Submission – Mr Stephen Davidson	The historic loads experienced by MSS detailed in Table 1, show that the NCR capacity (55.06MW) has been exceeded on a number of occasions. Merz is not aware of any requirement for Western Power to explicitly call out historic overloads in their Annual Planning Report. The intent of the Annual Planning Report is a forward looking assessment. Historic loads will feed into the revised forecasts for each planning report but may not necessarily be specifically referenced in the case for investment made in this report.