Geoff Brown & Associates Ltd

REVIEW OF WESTERN POWER'S APPLICATION FOR A TECHNICAL RULES EXEMPTION FOR MEADOW SPRINGS ZONE SUBSTATION

Prepared for

ECONOMIC REGULATION AUTHORITY

Final

20 July 2015

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DISCLAIMER

This report has been prepared for the Economic Regulation Authority to assist it in its review of Western Power's application for an exemption from clause 2.5.4(b) of its Technical Rules in respect of the maximum power transfer through Meadow Springs zone substation under normal network operating conditions. Geoff Brown and Associates Ltd accepts no responsibility to any party other than the Authority for the accuracy or completeness of the information or advice provided in this report and does not accept liability to any party if this report is used for other than its stated purpose.

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1. INTRODUCTION

The maximum allowable power transfer through Western Power's Meadow Springs zone substation (MSS) under normal operating conditions with both power transformers in service is limited by the NCR planning criterion specified in Clause 2.5.4(b) of the Technical Rules. As a result of demand growth in the Mandurah load area, Western Power anticipates that this limit may be exceeded before the power transfer capacity of the substation is increased by the installation of a third transformer. Western Power has therefore applied for an exemption from the Technical Rules so that the power transfer through MSS can be above the NCR limit.

The Authority has contracted Geoff Brown & Associates Ltd to review Western Power's exemption application and provide advice on whether or not an exemption should be granted. This report documents our review and the advice provided to the Authority.

2. BACKGROUND

2.1 NCR PLANNING CRITERION

The bulk of the electricity load in the Mandurah area is located along the southern metropolitan coastal strip served by the Mandurah substation (MH) and MSS. The rate of growth in the load served by these two substations is relatively high, particularly in the coastal corridor north of MSS. This urban residential growth is the main driver behind the emerging capacity constraints of the two substations.

It is not good industry practice to load substations up to the total rated capacity of the installed power transformers, as spare capacity must be available so that supply to consumers is maintained during unplanned transformer interruptions and also during planned maintenance outages. Clause 2.5.4 of Western Power's Technical Rules specifies planning criteria that determine the maximum allowable power transfer through a substation when all installed transformers are in service. The clause specifies a number of alternative planning criteria and the criterion that is applied to a particular substation is determined by a range of factors, in particular location and the magnitude and criticality of the load supplied.

Both MH and MSS fall into the category of substations where the maximum allowable power transfer is specified by the Normal Cyclic Rating (NCR) criterion. Western Power assigns a cyclic rating to all of its transformers, which determines the maximum cyclical load that can normally be carried by a unit. This is generally higher than the nameplate rating, which assumes a constant load that does not vary over time[1].

The NCR substation loading criterion is specified in clause 2.5.4(b) of the Technical Rules which states:

> *2.5.4(b)* ***Normal Cyclic Rating (NCR) Criterion***
>
> *(1) The NCR risk criterion permits the loss of a portion of power transfer capacity at a substation following the unplanned loss of a supply transformer within that substation.*
>
> *(2) The portion of the power transfer capacity that may be lost is the lesser of:*
>
> *(A) 75% of the power transfer capacity of the smallest supply transformer within the substation; and*
>
> *(B) 90% of the power transfer capacity of the rapid response spare supply transformer.*

The wording of this clause is unfortunate, as it does not convey its intended meaning. The intent is to specify the maximum allowable power transfer through a substation under normal operating conditions, having due regard for the need to maintain spare transformer capacity to cater for contingency situations. As interpreted by Western Power, this is determined by the total installed power transformer capacity within the substation rather than the capacity of the smallest supply transformer. For the purposes of this review we have used Western Power's interpretation of the clause, but we recommend that the wording be revised in the next revision of the Rules so that it accurately conveys its intended meaning.

The size of the transformers installed at both MH and MSS is such that the capacity of the larger rapid response spare supply transformers does not need to be considered. In

[1] 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 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.

these circumstances, Western Power interprets clause 2.5.4(b) of the Technical Rules as requiring that at all times the power transfer through a substation under normal operating conditions must not exceed 75% of the aggregated NCR of all installed transformers. An augmentation of transformer capacity or other remedial action is required if the maximum power transfer is likely to increase beyond the 75% threshold.

MH has three power transformers, two of which have cyclical ratings of 32.1MVA and one of which has a cyclical rating of 37.1MVA. Hence the total installed transformer capacity is 101.3MVA and the power transfer through the substation must not be allowed to exceed its NCR of 75.9MVA. This substation is currently operating at close to its NCR and is expected to exceed its NCR in the summer of 2017.

MSS has two power transformers with cyclical ratings of 38.6MVA and 35.5MVA corresponding to an NCR of 55.6MVA. It marginally exceeded its NCR in the 2014 summer but the load fell back to below the NCR in 2015 due to a contingency event in January that resulted in the transfer of approximately 6MVA from MSS to Waikiki zone substation. The load on MSS is expected to once again exceed the substation NCR during the 2016 summer.

Application of the NCR criterion is based on the premise that, in the event of an unplanned transformer interruption, it is acceptable for there to be some inability to supply consumer demand until a replacement transformer can be installed to replace the out-of-service transformer. If each substation was operating at its NCR, this load at risk would be 11.7MVA at MH and 20.1MVA at MSS in the worst case scenario of an unplanned interruption of the larger transformer at either site. Additional demand beyond the NCR rating would add directly to this load at risk.

Western Power has two rapid response spare supply transformers (RRSST) available to use as temporary replacements at either substation and has a target RRSST installation time of 12 hours.

In reality, the risk to Western Power is significantly less than suggested by this analysis due to the following mitigating factors.

- The calculations are based on forecast peak summer loads and at other times of the year the loads are lower and the load at risk is correspondingly lower;

- The calculated load at risk assumes a failure of the largest transformer at each substation coinciding with the peak demand period. While there may some elevated risk of failure during periods of high demand, transformer failures can occur at any time;

- Variations in load across the daily load cycle mean that the load at risk will be lower than the peak during much of the 12 hour period required to commission the RRSST;

- There is highly likely to be some load transfer capacity in the distribution network that will allow some load to be transferred to neighbouring zone substations, which can be loaded up to the full cyclic rating of their installed power transformers during the contingency. Western Power's application states that in 2011, 2013 and 2014 there were a series of staged load transfers from MH to MSS to mitigate high loadings at MH, and also that in early January 2015 there was a temporary load transfer of approximately 6MVA from MSS to Waikiki zone substation. This suggests that there is available distribution load transfer capacity to accommodate a significant proportion of any load that could not be supplied in the event of an unplanned transformer interruption at MSS. However the application does not provide an analysis of available distribution load transfer capacity;

- As noted in Western Power's application, power transformer failures are relatively rare. However, the recent loss of two interconnecting transformers at Muja power station is evidence that such events can and do occur; and

- If supply interruptions are necessary to manage transformer loads, they are introduced on a rotational basis to minimise the impact on individual customers.

2.2 TRANSFORMER CAPACITY AUGMENTATION PLAN

Western Power has a transformer capacity augmentation plan in place to ensure that both MSS and MH will comply with the NCR criterion of the Technical Rules by 2020. Few details of this plan are provided in the application. On the basis of the information that has been provided the following can be surmised.

- The augmentation plan will be implemented in two stages with the installation of a third transformer at MSS by 2016/17 and the completion of the MH extension project by 2019/20;

- While load growth is currently relatively high in the Mandurah load area, future demand forecasts have a high level of uncertainty. This is unsurprising, given the current economic situation in Australia and the fact that network peak demand declined by approximately 3% between 2013 and 2014[2]. If load growth is lower than forecast, the augmentation of transformer capacity can be deferred.

- It appears that the transformer capacity shortfall is most critical at MH. However this substation already has three transformers and transformer capacity augmentation will be difficult, with an estimated cost of $27 million. Western Power's strategy appears to be to defer this for as long as possible by installing a third transformer at MSS and transferring load to it. As already noted, this process has already commenced, without the capacity augmentation, with staged load transfers being implemented in 2011, 2013 and 2014.

[2] See p15 of Western Power's 2014/15 Annual planning Report.

3. COMMENT

3.1 NCR PLANNING CRITERION

Traditionally, network service providers have planned transmission substations to an N-1 loading criterion on the premise that supply would not be interrupted following the loss of a single power transformer. This corresponds to an NCR planning threshold of 50% for a two transformer substation and 66% for a three transformer substation (in situations where all transformers in a substation are equally rated). It is now accepted by many within the industry that the N-1 criterion is overly conservative except for the supply of critical loads.

The 75% NCR planning threshold is higher than this and appears intended to strike a balance between the risk of non supply arising from a lack of unused transformer capacity across the network and the cost of installing sufficient capacity to ensure that all contingency situations can be addressed with little risk of supply interruptions. It takes due account of the low probability of an unplanned transformer failure, the relative criticality of most urban metropolitan load and the availability and time required to install a RSST should a transformer failure occur.

When first implemented, the NCR criterion allowed each transformer in a substation to be loaded to 90% of its NCR rating. However, Western Power experienced difficulties in implementing this high threshold and higher risks were also identified, so the policy was later modified to limit transformer loading to an average of 75% of NCR rating. This is unsurprising, as 90% average transformer loading is very high by international standards. The high threshold would have left little margin with which to manage load forecasting uncertainty or unforeseen delays in the implementation of a capacity upgrade project. With such a high threshold it is not difficult to imagine a situation where a transformer could become overloaded as a result of higher than forecast load growth combined with delays in implementing a substation upgrade, particularly in the high load growth environment that existed prior to the 2008 global financial crisis.

While we consider the 75% planning threshold to be reasonable, it is nevertheless deterministic in nature. When mandated as a regulatory requirement, deterministic criteria can give rise to suboptimal outcomes by limiting the options available to a service provider to manage risk in specific situations. For example, the optimum loading at which a particular substation might be loaded could be impacted by the available distribution transfer capacity and the extent to which the transformer capacity in adjacent substations is utilised. It would be reasonable for the maximum allowable power transfer to be a higher proportion of total transformer capacity if load could be readily transferred to adjacent substations following a transformer failure than if this option was not available.

The use of mandatory deterministic planning criteria, albeit more conservative than specified in the Technical Rules, by jurisdictional regulators has been blamed for the high distribution component of electricity costs in the eastern states, particularly Queensland and New South Wales, and is now discouraged by the Australian Electricity Regulator (AER). Arguably, the deterministic planning criteria currently in the Technical Rules is not compatible with the regulatory test that Western Power would be required to apply if regulation of its network was to be based on the National Electricity Rules and administered by the AER. This test requires public consultation on all augmentations with an estimated cost of more that $5 million, including consultation on the need for the augmentation.

3.2 WESTERN POWER'S EXEMPTION APPLICATION

Western Power's exemption application and its supporting documentation focus on:

- Western Power's interpretation of the NCR criteria;
- A comparison of the 75% NCR threshold with the forecast demands at both MH and MSS substations;

- The results of Western Power's assessment of the risks to the business arising from the breach of the Technical Rules. Significantly the risk with the highest rating is the regulatory risk if no exemption is granted, which is rated high and which the application has been submitted to mitigate. All other identified risks are rated medium or low.

The application and supporting documents provide only superficial information on Western Power's plans to augment the existing transformers in the Mandurah load area. There is no detailed description of the augmentation plan and no information on the basis for the proposed timing or on why action has not already been taken to avoid a potential regulatory breach.

While the results of the risk assessment are presented, there is little discussion of the risk analysis or of the different risk mitigation strategies available to Western Power. While all risks discussed in the application (except the regulatory risk) are considered either low or medium, there is evidence that some risks may have been overstated. For example, the extract from the Works Planning Report describes the load at risk (discussed in Section 2.1 above) as being *at risk of rotational load shedding for 12 hours until a rapid response substation supply transformer is mobilised to site.* We consider this misleading as it takes no account of the potential to offload the affected substation using available distribution transfer capacity or of the probability that the actual substation load will be lower than the estimated peak demand for much of the 12 hour risk period.

Interestingly, the financial risk that Western Power would be exposed to if the exemption is not granted is described in the extract form the Works Planning Report as follows:

> *Operating without an exemption may impact investment decisions leading to the requirement for additional network expenditure.*

Insufficient information has been provided for us to undertake a full analysis, and we would like to have seen more information on the detail and timing of Western Power's planned augmentations and also on the available risk mitigation options. However there is sufficient information in the application for us to be satisfied that the risk in granting the exemption application is low and is likely to be overshadowed by the potential for suboptimal or inefficient investment if the exemption is not granted.

4. RECOMMENDATION

We recommend that:

- The Authority grant Western Power's exemption application; and
- If the NCR planning criterion is to be retained when the Technical Rules are next revised, the wording of clause 2.5.4(b) of the Rules be revised to more accurately reflect the way the criterion is applied.