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16 May 2019

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Dear Sebastian,

Re: AER Follow-up Information Request- SAET RIT-T Dispute

Thank you for your letter dated 7 May 2019, which provided an overview of the current dispute to the South Australia Energy Transformation (SAET) RIT-T. Your letter requested information on the following:

1. Details on the processes undertaken by AEMO and ElectraNet to assess the feasibility of the proposed Interconnector Special Protection Scheme (SPS).
2. Details on the findings of AEMO's feasibility studies that demonstrate the capability of the SPS to achieve interconnector transfer levels modelled in the SAET.
3. Details and references to international examples that demonstrate that an SPS can be designed to operate in the timeframe required.
4. The likely maximum load shedding requirement and information provided by ElectraNet to demonstrate the feasible to trip sufficient load within the required timeframe.

As outlined in my previous letter, AEMO is confident that the proposed solution in the SAET is robust and in the long-term interests of consumers. The following sections provide further evidence, based on AEMO's independent review of ElectraNet's work, to support the AER's evaluation of the SAET dispute.

1. Details on the processes undertaken by AEMO and ElectraNet to assess the feasibility of the proposed Interconnector SPS

There have been three main processes through which AEMO has interacted with ElectraNet which have determined AEMOs assessment of the feasibility of the proposed special protection scheme:

1.1 Joint Planning Activities

1.2 Collaboration on the SPS design

1.3 Work stemming from the Power System Frequency Risk Review

1.1. Joint planning activities

There has been extensive interaction between ElectraNet, AEMO, Powerlink, and TransGrid throughout the SAET RIT-T studies. Many technical assumptions with respect to interconnector options, cost, study cases, models, and other study inputs have been shared and reviewed within this group. Technical discussions and analysis within this group included special protection schemes and their feasibility, as well as the choice of technology, required operating timings and a comparison of study outcomes.

The scope of the control scheme proposed by ElectraNet has been reviewed internally by multiple technical teams across AEMO, including the relevant Victorian Planning, National Planning, and Operations teams. AEMO has also undertaken internal feasibility studies to validate the reasonability of the limits used in the SAET RIT-T. The outcomes of these studies are discussed further in section 2.

1.2 Collaboration on the SPS design

In parallel with the SAET RIT-T, AEMO and ElectraNet undertook a significant amount of work to design and implement the System Integrity Protection Scheme (SIPS). The Interconnector SPS proposed under the SAET is an evolution of the SIPS. Detailed studies and reviews were led by ElectraNet in order to assess:

- The choice of the most appropriate loads available for tripping
- Real-time monitoring of load and BESS to determine the available response at any given time
- Protection and communication requirements and time required to respond to events
- The response of the control scheme to mitigate the impact of non-credible loss of generation
- Actual hardware and technology capabilities through pilot projects, bench-testing, and commissioning tests.

The need for the SIPS was initially determined following the SA blackout event in 2016, and the requirements of the scheme were subsequently detailed in AEMO's Power System Frequency Risk Reviews (PSFRR)[1]. This review provided the following background:

> *"…the interim EFCS will need to shed load, potentially along with power injected from batteries (if technically feasible), very rapidly (nominally within 200 ms).*
>
> *The load tripped needs to be sufficient to avoid flows on the Heywood Interconnector rising to unsatisfactory levels that would cause it to suffer loss of synchronism and trip. Based on the initial studies, the scheme will be designed to trip approximately 200 MW of load (with a range of 140 MW to 250 MW), as well as potentially instructing a number of grid connected batteries to rapidly inject power into the grid.*
>
> *ElectraNet and AEMO will investigate the technical feasibility of a future enhancement to the EFCS in which the early triggering of grid connected batteries could reduce the*

[1] AEMO. *2017 PSFRR – Non-credible loss of multiple generating units in South Australia*, available at http://www.aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/Electricity_Consultations/2017/Power-System-Frequency-Risk-Report---Multiple-Generator-Trips---FINAL.pdf.

need for or the amount of load shedding required. ElectraNet and AEMO are considering a number of options for the loads to be tripped, and evaluating these options against a range of selection principles including:

- *Ability to provide the required relief for different periods of the year.*
- *Ease of load disconnection of loads (number of circuit breakers to open).*
- *Ease of restoration of loads (avoiding complex and time consuming distribution switching).*
- *Loads further from the interconnection points provide additional relief as they include transmission losses.*
- *Loads connected to South East region and Riverland region will affect the transfer capacity via the interconnector paths and tripping of these loads needs to be avoided.*
- *Targeted loads, such as SA Water pumping loads or air-conditioning compressors, are not suitable as they are not always online.*

The South Australian Government has announced the results of its tender for the development of 100 MW of battery storage in South Australia, and said that 70 MW of this capacity will be reserved to provide grid stability and power system security. To the extent technically possible, the interim EFCS will include this and other grid-scale batteries into the scheme."

As a part of our role in approving the Emergency Frequency Control Scheme (EFCS) settings schedule for the SIPS, AEMO has also undertaken extensive reviews, detailed power system simulation studies which were used for bench testing of the scheme, and been involved in the commissioning tests for this scheme. AEMO has also been involved in discussions with the South Australian Office of Technical Regulator (OTR) and SA Power Networks (SAPN) with respect to loads included in the SIPS trip list.

The SIPS is now in service. The operating times obtained from actual commissioning tests confirms the accuracy of simulation models used to design the scheme.

The concepts and requirements for the Interconnector SPS have evolved from the work undertaken on the SIPS. AEMO anticipates significant further work is required in the detailed design of the proposed interconnector control scheme and its settings. The work to date has been primarily to gain a high level of confidence in the feasibility, costs and technical requirements of such a scheme to ensure assumptions used in the RIT-T analysis are robust.

<u>1.3 Work stemming from the Power System Frequency Risk Review (PSFRR)</u>

As part of the PSFRR and subsequent ongoing investigations, alternative control scheme options have and are still been investigated in order to improve on the reliability of the SIPS scheme. This has had close involvement with equipment manufacturers that have experience in installing similar schemes. This included reviews of state-of-the art control schemes, and assessment of other installations from around the world. Some examples of other existing schemes are detailed in section 3.

As part of the AEMC's Protected Event consultation relating to the proposed enhancements to the SIPS, independent assessment of technical viability was also undertaken by GHD[2]. The upgrades currently under investigation to be applied to the SIPS are anticipated to be migrated to the Interconnector SPS.

2. Details on the findings of AEMO's feasibility studies that demonstrate the capability of the SPS to achieve interconnector transfer levels modelled in the SAET.

The detailed feasibility studies undertaken during the SAET RIT-T were used to determine the combined interconnector limits, as included in the market modelling. The results and outcomes from these studies undertaken by ElectraNet are detailed in the Network Technical Assumptions reports published as part of the SAET.[3]

The study scope agreed between ElectraNet and the other TNSPs involved in the joint planning activities included a range of demand and dispatch scenarios, including multiple base cases and contingencies to be studied.

In the absence of an SPS, these studies demonstrated that the non-credible loss of either the Heywood interconnector or the proposed SA-NSW interconnector could result in cascade tripping of the parallel interconnector at periods of high transfer. This is due to the resultant high flows and angular separation across the remaining interconnector.

Studies showed that the critical non-credible contingency was the loss of the Heywood interconnector, and resultant high flows on the new interconnector, primarily due to the longer distance and higher impedance of this interconnector corridor. These studies also demonstrated that a high-speed control scheme, making use of load or generation tripping along with some battery response, could be used to quickly reduce flows on the remaining interconnector back to satisfactory levels, and thereby prevent the cascade tripping of the remaining interconnector. This concept is fundamentally quite similar to how the existing SIPS operates.

The studies accounted for the expected achievable timings of the control scheme and amount of load and generation expected to be available for tripping. The purpose of this was to test the stability of the South Australian power system following non-credible contingencies and control action.

The combined individual limits of the two interconnectors outlined in the SAET PACR is 1,550 MW (i.e. 800 MW + 750 MW). However, due to the timings required for the control action and the amount of load available to be tripped, a lower combined import limit of 1,300 MW was applied in the economic modelling[4] to ensure that an SPS could mitigate the risks of a double-circuit failure.

[22] GHD, *AEMC Protected event consultation*, available at https://www.aemc.gov.au/sites/default/files/2019-04/GHD%20final%20report.pdf.

[3] ElectraNet. *SAET PADR – Network Technical Assumptions, section 3.4 – Combined limits,* available at https://www.electranet.com.au/wp-content/uploads/projects/2016/11/SAET-RIT-T-Network-Technical-Assumptions.pdf, ElectraNet. SAET PACR – Network Technical Assumptions, section 3.2.2*, available at* https://www.electranet.com.au/wp-content/uploads/projects/2016/11/Network-Technical-Assumptions-Report.pdf.

[4] ElectraNet. *SAET Network Technical Assumptions Report*, available at https://www.electranet.com.au/wp-content/uploads/projects/2016/11/Network-Technical-Assumptions-Report.pdf.

AEMO undertook independent due diligence of the combined limits for the preferred option shown in the SAET PACR using power system base cases independently set up. AEMO can confirm that these study results were consistent with the limits published by ElectraNet.

3. Details and references to international examples that demonstrate that an SPS can be designed to operate in the timeframe required.

As part of the investigations into potential upgrades to the existing SIPS scheme, a number of controls scheme technology manufacturers were consulted by ElectraNet and AEMO in order to determine capabilities and costs, and to provide examples of schemes installed internationally.

One example of a control scheme that operates in response to a non-credible contingency and transient instability was provided by NR Electric for the Ecuadorian Power System[5]. Design requirement timings for this scheme were that all actions are completed in under 200 ms. This timing includes all control action being completed, including circuit breakers opening.

Schweitzer Engineering also provided an example of an emergency control scheme installed in the Georgian power system[6] where shedding of loads and generation was required in under 100 ms (excluding breaker operating time in this instance)[7].

Feasibility studies for the SAET Interconnector SPS were undertaken based on the assumption of the Interconnector SPS action being able to be completed within 370 ms (complete time from fault initiation to circuit breaker opening). Studies showed that with this control scheme timing, and with maximum load and generation amounts tripped, and interconnector flows limited to the published limits, then the South Australia power system would be able to remain stable and connected to the rest of the NEM.

Timing tests undertaken as part of the SIPS scheme commissioning have demonstrated timings consistent with the assumptions made in the feasibility system studies.

AEMO considers that the control action timings assumed for the SAET Interconnector SPS are realistic and achievable.

4. The likely maximum load shedding requirement and information provided by ElectraNet to demonstrate the feasible to trip sufficient load within the required timeframe.

The results of load shedding requirements determined in the AEMO feasibility review are consistent with the results from ElectraNet's studies – for the combined import of 1300 MW, approximately 400 MW of load and 100 MW of battery injection would be required. Studies also showed that an increase in availability of utility scale batteries in the control

[5] An overview of the NR Electric scheme is available at: http://www.nrec.com/en/news-content-279.html.
[6] An overview of the control scheme in Georgia is available at: https://selinc.com/Solutions/Success-Stories/Republic-of-Georgia/.
[7] Details of the timeframes achieved are available at: https://cdn.selinc.com/assets/Literature/Publications/Technical%20Papers/6529_DesignImplementation_DR_20120216_Web.pdf?v=20170306-182012.

scheme, or a reduction in transmission impedance[8] can be used to reduce the total amount of load shedding required.

As part of the SIPS implementation, ElectraNet undertook an assessment of a number of transmission-connected load points to determine actual availability of load for tripping under a wide range of operating conditions. Transmission connected load points were initially selected where high speed communication systems were already available. Following discussion with SA Power Networks and the Office of the Technical Regulator (OTR), ElectraNet were able to achieve 180 to 250 MW of load to be available for tripping for the SIPS scheme.

The OTR was satisfied that for the SIPS, given the low probability of the non-credible events occurring and the high consequence of there not being sufficient load in the control scheme, that this amount of load shedding is warranted.

The Interconnector SPS would also only have a low probability to be required to operate as it is also only required for non-credible contingencies. For the Interconnector SPS to actually be required to operate, both interconnectors would need to be operating at high levels of flow, and one of them would need to experience a non-credible trip of double circuit transmission line. This would also have to occur outside of a period where a reclassification was in place e.g. due to bushfire, lightning or damaging windspeed conditions.

These existing SIPS-enabled loads would be transitioned to the Interconnector SPS, as the SIPS would be de-commissioned as part of the upgrade. ElectraNet have advised that, based on discussions with the OTR for the SIPS and the available loads in the system during times of high power transfers, sufficient additional load tripping points are expected to be available to ensure the 400 MW of required load can be met.

It is important to note that for there to be a need to trip loads at high import levels, average to high South Australia demand levels would be required (> 1300 MW). Therefore, concerns regarding sufficient demand being available for tripping under minimum demand scenarios are not substantiated.

The same processes used for engagement with SAPN and the OTR by ElectraNet and AEMO will be followed when selecting any additional loads required for the Interconnector SPS.

The final amount of load required in the tripping scheme will be dependent on a number of factors, including:

- Actual impedances of new lines and transformers
- Actual control scheme operating timeframes
- Availability of battery injection for the scheme
- Redundancy requirements

In summary, it is AEMOs view that the studies completed to date by both ElectraNet and AEMO have used reasonable assumptions in determining the capabilities of an

8 This was an option explored in the SAET PADR – see table 5 in the Network Technical Assumptions report https://www.electranet.com.au/wp-content/uploads/projects/2016/11/SAET-RIT-T-Network-Technical-Assumptions.pdf.

interconnector control scheme, and that the combined interconnector limits used in the economic analysis in the SAET RIT-T are appropriate.

Based on these interactions, AEMO is confident that the proposed solution in the SAET and the approach taken to design the SPS is robust and in the long-term interests of consumers. Should you have any questions, please contact Craig Price, Group Manager System Planning on (03) 9609 8590.

Your sincerely,

Dr. Alex Wonhas

Chief System Design and Engineering Officer