Government of South Australia
Department of State Development

In reply please quote #A848633

Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

System Security Market Frameworks Review – Consultation Papers

Dear Madam/Sir

The Energy Markets and Programs Division of the Department of State Development, South Australia (Division) welcomes the timely System Security Market Frameworks Review (Review). Please find attached two submissions; a submission on "System Security Market Frameworks Review and related rule change requests" (1st consultation paper) and another submission on "Emergency under frequency control schemes and emergency over frequency control schemes rule change requests" (2nd consultation paper).

As mentioned in several places in both consultation papers, South Australia in particular is experiencing a steady change in generation mix presenting challenges to the management of power system security in the region under certain conditions and at different locations within the region. The characteristics of the increasing levels of non-synchronous intermittent generation and the 'blocked-size' exiting of conventional synchronous generation across the State have already presented challenges that are expected to continue into the foreseeable future.

As a result, the South Australian Government is keen to see the advance of the related four rule change requests it submitted on 18 July 2016. The Division sees a pressing need to have the necessary flexibility in the National Electricity Rules (Rules) for the Australian Market Systems Operator (AEMO) to be able to manage system security challenges in both the short and long terms. In this regard, the Division considers that any proposed immediate solutions should not necessarily overshadow the desired medium and long term outlook for South Australia and the National Electricity Market (NEM) as a whole.

In each submission, the Division addresses the different questions and issues presented in the consultation paper under the relevant project reference code (as per the instructions in the consultation paper). The submission on the 1st consultation paper has a special focus on the two relevant South Australian Government rule change proposals covered by this Review (referred to 'SA A' and 'SA D' in the first consultation paper). The two other rule change requests by the South Australian Government regarding Emergency Frequency Control Schemes (referred to 'SA B' and 'SA C' in the 1st consultation paper) are covered under the submission to the 2nd consultation paper for Emergency Frequency Control. However as discussion topics are often interrelated, some references to the topics related to rule changes in one submission will inevitably be cross-referenced in the other submission.

The Division hopes that its submissions will help the Australian Energy Market Commission (AEMC) facilitate the consultation on the rule change requests and will assist with the progress of its system security work program.

Should you wish to discuss the details of the submissions further, please feel free to call Ms Rebecca Knights, Director - Energy Markets and Programs Division, on (08) 8226 5500.

Yours sincerely

Vince Duffy
EXECUTIVE DIRECTOR

21 October 2016

National Electricity Amendment (Emergency under-frequency control schemes) Rule 2016

National Electricity Amendment (Emergency over-frequency control schemes) Rule 2016

Submission to Consultation Paper

Energy Markets and Programs Division, Department of State Development

South Australia

October 2016

5.1 Materiality and effectiveness of current frameworks

5.1.1 Materiality of issues impacting management of extreme frequency events

Question 1 Materiality of issues impacting management of extreme frequency events

(a) **Are the issues identified by the proponent likely to have a material impact on the NEM, over the medium to longer term?**

The Division agrees with the issues listed in the consultation paper in relation to under-frequency management and currently see no indication that the materiality of those issues will change in the near future. However, the *intensity* of such issues may change and most likely increase as the characteristics of the power system change. Taking South Australia as an example for a region directly exposed to these issues, contributing factors impacting management of extreme under-frequency events are explained as follows:

<u>Higher levels of Rate-of-Change of Frequency (RoCoF)</u>

The two factors causing high levels of RoCoF, the decreasing levels of system inertia and the increasing size of contingency following the islanding of the region, are thoroughly addressed in the consultation paper for the System Security Market Frameworks Review.

The first factor of low inertia represents a material issue that is unlikely to disappear but rather intensify as the retirement of large synchronous generation is expected to increase, in addition to more wind and solar generation coming online. It is not expected that the trend of decreasing levels of inertia will reverse, unless a new interconnector is built to offer a redundant source of AC connection to the rest of the NEM.

The second factor of contingency size is now reaching its maximum level as the capacity upgrade of the interconnector between Victoria and South Australia is nearing completion with a maximum transfer limit of 650 MW in both directions. The loss of high import power is considered to be the highest risk for a non-credible contingent event, albeit materiality of this risk remains stable.

<u>Increasing levels of Distributed Energy Resources (DER)</u>

The high penetration of domestic rooftop photo-voltaic (PV) solar panel generation during certain times of the day represents a high penetration of DER in South Australia. As the current Under-frequency Load Shedding Scheme (UFLS) relies on the tripping of load at feeder level in staggered load blocks triggered by prescribed frequency levels, changes in operational consumption per feeder (total load minus local generation) is a cause of variability. Load variability is a an issue because less load is made available for UFLS to utilise at times of high rooftop PV generation, meaning more blocks of load need to be shed at lower frequencies. The delayed response to arrest frequency decline may result in higher RoCoF that cannot be managed by UFLS. The effect of high RoCoF could be exacerbated if one or more distribution feeders exporting power to the grid are disconnected and valuable generation is severed when it is most needed during frequency disturbances.

By observing the penetration trends, the issue of increasing DER is likely to intensify as more rooftop PV solar panels are installed. A redesign of the UFLS for a more granular approach of only shedding load (and avoiding the disconnection of embedded generation) is unlikely to be implemented in the near future and hence the materiality of this issue will remain in the medium to long term.

Suitability of the current UFLS

The UFLS uses current technology of under-frequency relays which have inherent delays in responding to frequency disturbances. These delays may limit the effectiveness of the scheme in cases of high RoCoF of a non-credible contingent event of regional separation.

Recent reviews by AEMO confirmed that the allocation of load blocks (as per the 2007 design) is still met and adheres to the requirement in the Rules that 60% of customers' load is to be available for shedding. However, it was found that the current UFLS sheds more load at the lower frequency settings (less than 47.9 Hz) than in the initial load blocks (49 Hz – 47.9 Hz), inconsistent with the design that requires more load to be shed in the initial blocks.[1]

The issues with latency in deployed technology and the dated design of the UFLS mean that more stringent measures need to be adopted to face the more severe present conditions (compared to the conditions upon which the 2007 design was established).

Current collaborative work between the Jurisdictional System Security Coordinator (JSSC), AEMO, TNSP and DNSP of investigating and identifying alternative mechanisms in addition to, or in place of, the UFLS may go a long way in mitigating the above issues.

It is worth noting that while the material impact of any of the above issues may change in the medium and longer term, the issues experienced currently by South Australia may eventually present themselves in other regions and ultimately have an overall impact on the NEM. This is because the generation mix is shaping towards the same pattern in all regions and it is a matter of time before a unified approach would be required for the interconnected system.

5.1.2 Ability of current frameworks to deliver effective emergency frequency control schemes

With regards to the statement in the consultation paper regarding the NER frameworks not providing an appropriate framework for effective and efficient mechanisms to meet the requirements of a secure power system, the Division wishes to clarify that, according to AEMO's related studies, the current under frequency load shedding scheme may not be sufficient at higher RoCoF levels only. This conclusion by the Division is technically confirmed by the joint AEMO-ElectraNet report[2] that outlines the conditions under which the current UFLS will not be sufficient when the maximum import of 650 MW into South Australia is in place and an interconnector failure follows resulting in high RoCoF. It is acknowledged that under such conditions, there are no provisions under the Rules for AEMO to put extra measures in place to mitigate the risk, as these conditions fall under a non-credible contingent event.

[1] Renewable Energy Integration in South Australia, AEMO and ElectraNet, February 2016, p.29
[2] Ibid.

Question 2 Ability of current frameworks to deliver effective emergency frequency control schemes

(a) Do current frameworks, including currently allocated responsibilities of different parties, allow for the effective consideration of all physical solutions to extreme frequency events?

It would be difficult to determine if current frameworks are able to deliver effective emergency frequency control schemes covering all physical solutions until all such solutions have been identified. The outcome of current studies led by AEMO should give some indication of what frameworks are needed for implementation of the best solution. As the rule change request states, following AEMO's consideration of potential future schemes, amendments to current frameworks may be required.

However, with regards to allocated responsibilities of different parties, as highlighted in the related rule change request by the South Australian Government, there are areas in the Rules which need amendments around certain areas of responsibility, briefly summarised as follows:

- Responsibilities on Network Service Providers (NSPs) should be well defined regarding the operation of emergency under frequency control schemes in the areas of network performance requirements and network planning and reporting obligations;
- Responsibilities on NSPs should be clearly defined regarding investment in new load shedding relay technologies in order to be able to adapt to changing system conditions and meet their obligations towards maintaining power system security. In this regard, the Rules governing the approval of such investments should be reviewed to ensure the Australian Energy Regulator has the necessary authority to approve these types of investments;
- Market Customer obligations regarding providing interruptible load for UFLS in the Rules should be reviewed and amended to reflect current practice for load shedding arrangements, which are currently determined and managed by AEMO, the JSSC and the NSPs; and
- Flexible provisions in the Rules that would allow an independent body, such as the Reliability Panel, to nominate specific system events, such as the non-credible loss of interconnectors under particular conditions, for which the Frequency Operating Standard (FOS) should be maintained.

5.2 Potential changes to emergency frequency control schemes

5.2.1 New technologies to manage extreme frequency events

5.2.2 Redefining non-credible contingencies

Question 3 Potential changes to emergency frequency control schemes

(a) Do the current NER frameworks already allow for, actively prevent, or fail to account for, new technologies that could be used to provide more effective emergency frequency control schemes? How would these new technologies work and what kind of solutions can they provide?

(b) Is there a need for a framework to identify specific non-credible contingencies that AEMO should develop emergency frequency control schemes to address?

(c) Could this issue be addressed by AEMO reclassifying certain currently non-credible events as credible, under NER clause 4.2.3A?

(a) NER Frameworks and new technologies

Similar to the answer to the previous question on current frameworks allowing all possible physical solutions, it will only be possible to assess if current NER frameworks allow for new technologies for providing more effective emergency frequency control schemes once the most suitable and commercially available technologies are identified. According to the assessment approach of "effectiveness of framework" stated in the consultation paper, any new framework should be technologically neutral.

It is however worth noting that the *mechanism* of shedding load is not prescribed in the Rules, but rather the frequency band when load shedding can be activated in manageable blocks spread over a number of steps (clause 4.3.5(b)).

As mentioned in the rule change request, the nature of the current relays is that they are located at feeder level and are pre-set with specific frequency levels that when system frequency falls below, they trigger the tripping of the feeder circuit breaker. This mechanism instantly presents an issue with also tripping generation embedded with the load. There is also the problem of the delayed response of the relays not being able to cope with events of high RoCoF in a timely manner.[3]

Several options for new technologies have been discussed in the past. As mentioned in the consultation paper, relays that can dynamically respond (at different frequency levels) to changes in load may be able to 'sense' the load it is carrying and trip at a higher or lower level of frequency. Other options would be relays that would respond at a frequency level as well as a RoCoF limit.

Alternatively, a more granular approach to trip only the load and not generation is to deploy frequency-sensitive relays at micro-load levels using emerging smart technologies.

(b) Non-credible contingencies

A certain set of non-credible contingency events will most likely result in high RoCoF. As stated in the consultation for the System Security Market Frameworks Review, setting a RoCoF standard would recognise the low probability and the high consequences of such events.

Whilst not *all* non-credible contingencies can be accounted for in an emergency frequency control scheme, some non-credible contingencies that are more likely to occur will determine the highest level of RoCoF that can be managed by the under-frequency load shedding scheme.

In South Australia, given the current configuration of the power system in the region, the single most likely event that would result in very high RoCoF levels is the loss of the interconnector to Victoria during high levels of flow into South Australia. Under certain conditions, simulation studies by AEMO have shown that there is a calculated limit of interconnector import MW flow above which the UFLS would not be able to cope, depending on the ability of wind turbines to stay online at high

[3] Discussion on managing the issues of high RoCoF can be found in the submission to the consultation paper for the System Security Market Frameworks Review.

RoCoF. This limit is based on quantified conditions of minimum operational consumption, low inertia level and high rooftop solar generation. Estimates of those conditions are also calculated for the three financial years from 2015-2016 to 2017-2018 with a trend showing a steady increasing likelihood of occurrence.[4]

Actual metered interconnector flows for the last 26 months (1 July 2014 to 31 August 2016) are shown Figure 1 in the Appendix. As the interconnector upgrade work is nearing completion, the rising trend in frequency and volume for import figures can be seen in graph (a) at the most recent end of the time-series trend of power from Victoria to South Australia. By observing the time distribution in graph (b), the percentage of time when import levels from Victoria is 400 MW and above represents around 20% of the time, as calculated over the period of analysis.

With the imminent full-commissioning of the upgraded interconnector, the likelihood of high power imports are set to increase, especially at times of low intermittent generation levels. Should a separation event for the region occur during times of these high flows, the impact of even one such event is a concern if the UFLS is not able to maintain the frequency above the extreme low frequency excursion tolerance limit within the prescribed time, as stated in the Rules.

(c) Re-classifying contingency events

The provisions under clause 4.2.3A in the Rules are based on abnormal conditions.

Referring to the example discussed in the above section regarding high power flows across the interconnector, the consequences of a regional separation event in South Australia would be more prevalent at increasing time durations in the future, but it is acknowledged that there is no predictable indication that there is an increasing risk of failure of a dual redundant connection between regions (such as the Heywood Interconnector) under normal operating conditions.

Hence, the Division recommends that the applicability of clause 4.2.3A should be addressed in the context of non-credible contingency events causing (directly or indirectly) a major disturbance that would result in cascaded failure if not accounted for in the design of the emergency frequency control scheme.

5.3 Governance arrangements

5.3.1 Roles and responsibilities

5.2.2 NSP responsibilities and incentives

Question 4 Governance arrangements

a) What roles should be played by different parties, including AEMO, NSPs, JSSCs, market participants and the Reliability Panel, in the framework for emergency frequency control?

b) What would an appropriate incentive regime for NSPs look like if they were tasked with additional roles in developing, monitoring and adapting emergency frequency control schemes?

[4] Renewable Energy Integration In South Australia, AEMO/ElectraNet, February 2016, p.29

As stated in the rule change request by the South Australian Government, the Rules concerning the monitoring of load and emergency frequency control schemes should be reviewed, being a core part of network planning and network performance requirements. Current technologies that shed load are not designed to adapt to changing system conditions. No framework is available within the Rules for current technologies to be replaced by updated reliable technology to shed load efficiently.

It is proposed in the rule change request that AEMO and the JSSC, in consultation, have the ability to direct NSPs to invest in new technologies, in case NSPs have not done so, so that AEMO can rely on both the load nominated for shedding and the suitability of mechanisms to shed the load when designing an emergency load shedding scheme.

In addition, the NSPs should have planning and reporting obligations with respect to the operation of load shedding and emergency frequency control schemes, in accordance with their role in maintaining power system security.

The role of Market Customers in providing load that is able to be automatically interrupted, according to current clauses in the Rules should be clarified and amended if necessary to reflect the adopted practice for emergency under frequency load shedding.

With regards to an appropriate incentive regime, NSPs should be encouraged to invest in updated technology for load monitoring and load shedding if such investments will enhance their network performance under *all* conditions. Rules for the investment in new equipment by NSPs should be reviewed to ensure that such investments are justified under the premise of power system security requirements and fall within the approval process conducted by the Australian Energy Regulator (AER).

5.4 Costs to participants

Question 5 Costs to participants

(a) **What kinds of costs are likely to be faced by participants if a new framework for emergency frequency control schemes is introduced?**

The Division agrees with the range of potential costs outlined in the consultation paper. However, for the assessment of costs to be complete, two important points need to be added to the discussion as follows:

- Costs for developing new or updated emergency frequency control schemes cannot be treated in isolation from the cost of procuring services to manage high RoCof, as discussed in the consultation paper for the System Security Market Frameworks Review. For example, more costs associated with the setting of a new RoCoF standard and compliance of market participants with such a standard (making it harder for frequency to deviate beyond its extreme tolerance limit) will likely result in lower costs for upgrading the current UFLS scheme as the last line of defence before a power system cascaded failure. Alternatively, setting less stringent standards for RoCoF (allowing the frequency to deviate at a higher rate of change) will likely result in higher costs to develop a reliable UFLS scheme as a backstop to potential extreme frequency excursions.

- Calculation of costs should include the cost of shedding load by emergency control schemes, expressed as the economic cost to consumers, whether they are residential customers, business customers or customers directly connected to the grid. Work conducted by AEMO to determine the Value of Customer Reliability is a valuable resource regarding the approach taken to calculate the value of lost load or how much the customer is willing to pay for reliable electricity supply.[5] In order to place a value on the cost to customers when their load is interrupted during an emergency, the AEMC may wish to apply its own approach or other agreed approaches suitable for a regulatory framework.

[5] Value of Customer Reliability - Application Guide, AEMO, December 2014. Available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Value-of-Customer-Reliability-review.

5.5 Managing extreme over frequency events

Many of the issues discussed under the ability of the UFLS scheme to withstand extreme generation deficit events are common with the issues underlying the ability of the power system to dynamically respond to *excess* generation events, where frequency abruptly rises to extremely high levels. In the case of over-frequency, the causes of these issues are in effect the same for extreme under-frequency, namely less synchronous generation and more non-synchronous semi-scheduled and unscheduled generation, such as wind and domestic rooftop PV, respectively.

(a) Materiality of issues impacting management of extreme frequency events

Similar to the case of under-frequency management, the high RoCoF and increasing levels of DER are the same issues impacting the management of extreme over-frequency event. It is considered unlikely that the materiality of those issues will change in the foreseeable future as the energy market goes through its transformation. In addition, the factors affecting the intensity of those issues are likely to persist in varying degrees, as compared to under-frequency issues.

The only difference in the context of over-frequency is the lack of any coordinated scheme to arrest over-frequency during high power export from South Australia to Victoria over the Heywood interconnector. If generation protection systems, designed to trip on detection of over-frequency, collectively disconnect too much generation, there is a material risk of the frequency reversing to an extreme under-frequency event, which would require emergency load shedding (by the installed UFLS scheme), thus repeating the concerns during extreme under-frequency conditions about the possibility a subsequent cascaded failure if RoCoF is too high.

(b) Ability of current frameworks to deliver effective emergency frequency control schemes

Current measures to manage over-frequency are reliant on several mechanisms as follows:

- Minimum performance of generating unit standards require generators to reduce their output by at least half within three seconds once the frequency exceeds a level nominated by AEMO;
- The minimum access standards requires generating units to remain connected for 1 second if RoCoF exceeds +/- 1 Hz/sec or such other range determined by the Reliability Panel from time to time; and
- The standard access standards requires generating units to remain connected for 0.25 second if RoCoF exceeds +/- 4 Hz/sec or such other range determined by the Reliability Panel from time to time.

However, the specifications stated above are only applicable to generators connected since 2007. As a result, in the absence of a coordinated over frequency emergency control scheme it is difficult to predict when synchronous online generating units may trip too early before they have the chance to provide the necessary inertia to arrest and recover the frequency deviation.

The outcome of AEMO's current work under the Future Power System security (FPSS) program for the design of an Over-frequency Generation Shedding scheme (OFGS) will most likely determine if current frameworks are able to accommodate such a scheme, or alternatively if some amendments to the frameworks are required.

(c) Non-credible contingencies

Similar to the discussion for under-frequency events, the single most likely event that would result in very high RoCoF levels is the loss of interconnector to Victoria at high levels of export power flow from South Australia. Modelling and simulation studies should be able to determine the maximum RoCoF (corresponding to a maximum export flow) that an OFGS scheme can withstand without the frequency breaching its extreme high frequency excursion tolerance limit.

Figure 1 in the Appendix shows the reliance on the interconnector for exporting power to Victoria is not as high as importing power from Victoria, as demonstrated in the lighter density of the –ve MW bars compared to the +ve MW bars in graph (a). Hence the likelihood of an extreme over-frequency event is less likely than an under-frequency event. This fact is reflected by the time distribution in graph (b) where an export of more than 200 MW only occurs about 4% of the time, as calculated over the period of the analysis.

(d) Governance arrangements

As stated in the rule change request, it is essential that roles and responsibilities are clear for any established OFGS or generator run-back schemes. In essence, the arrangements are to have:

- AEMO prepare, maintain and update the scheme guidelines;
- AEMO, in accordance with the established guidelines, develop procedures on the manner on which generation will be shed; and
- Mechanisms to oblige generators to comply with the scheme established by AEMO.

In addition to the above arrangements, the cooperation of generators with AEMO regarding the provision of technical information of plant performance characteristics will help in developing detailed models of the setting and configuration of the (over frequency) RoCoF protection systems in place.

(e) Costs to participants

It is important to note that any established OFGS scheme is considered as an emergency frequency control scheme that would fall under the same category of a UFLS scheme. In other words, similar to the UFLS scheme, costs of implementing a new OFGS should always be considered in conjunction with procurement costs for meeting a new RoCoF standard, albeit in a reverse direction so that frequency does not deviate beyond the extreme high frequency excursion tolerance limit.

Question 6 Managing over frequency events

(a) What should a framework for managing extreme over frequency events look like?

As stated in the rule change request, the South Australian Government is seeking that the Rules explicitly provide a framework for the establishment of flexible emergency frequency control schemes that are able to maintain FOS should a non-credible excess generation event occur.

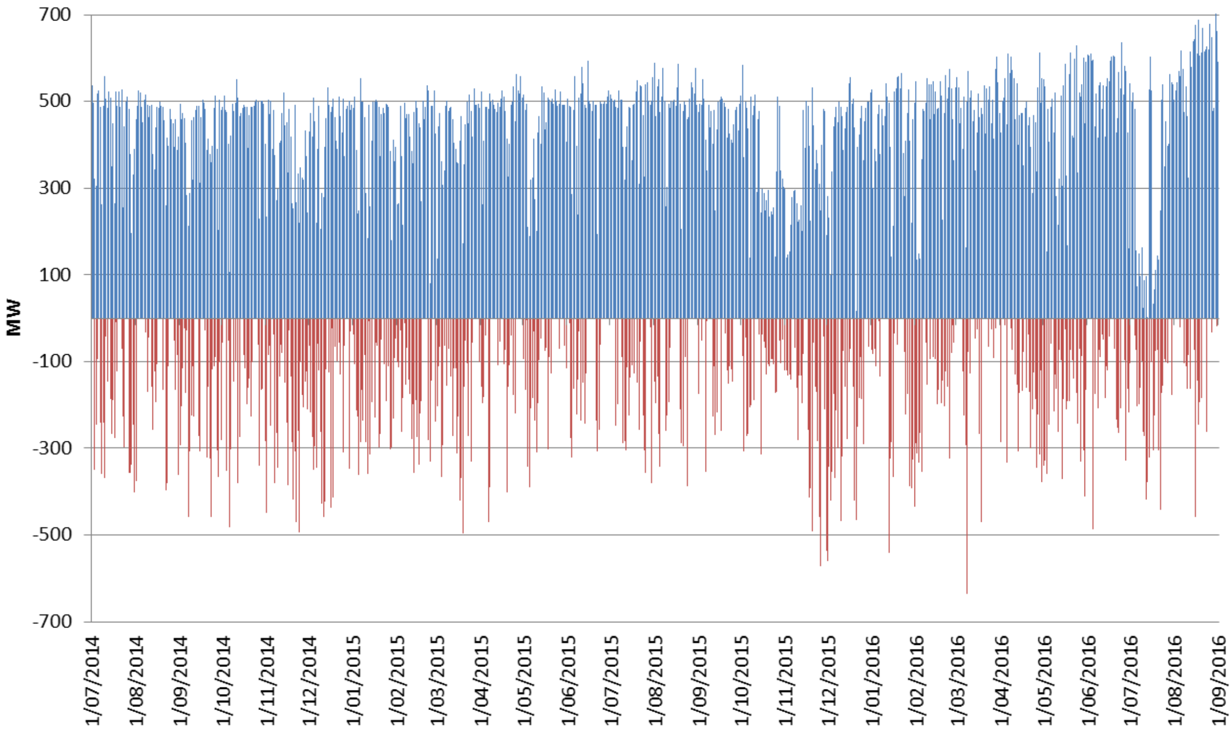
Although the details of any framework are to be determined after AEMO completes the development of the settings for an OFGS or a similar scheme, the main principles should have at a minimum:

- Minimal (optimal) amount of generation loss necessary to arrest over-frequency;
- Type, quantity and order criteria for how generation will be reduced;
- Sufficient redundancy built in the scheme to be effective under a range of operating conditions; and
- High availability factor for generators participating in the scheme.

APPENDIX

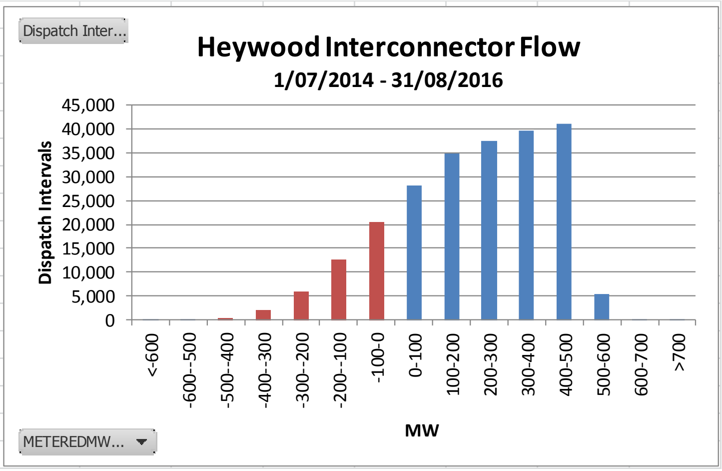
Figure 1: **Heywood Interconnector Flow (Victoria to South Australia)**

(a) Running Trend



(b) Time Distribution

MW Range	ispatch Intervals	Hours	% of Time
<-600	1	0.08	0%
-600--500	18	1.50	0%
-500--400	495	41.25	0%
-400--300	2044	170.33	1%
-300--200	5921	493.42	3%
-200--100	12497	1,041.42	5%
-100-0	20518	1,709.83	9%
0-100	28098	2,341.50	12%
100-200	34860	2,905.00	15%
200-300	37525	3,127.08	16%
300-400	39589	3,299.08	17%
400-500	41114	3,426.17	18%
500-600	5486	457.17	2%
600-700	206	17.17	0%
>700	12	1.00	0%
Grand Total	**228384**	19,032.00	100%



Source: Interconnector flow Data 20140701 - 20160831, AEMO, September 201. Available at: [*http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS/Dispatch*](http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS/Dispatch).