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Sebastien Henry
Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

Our Ref: DV05-000550

13 October 2016

Dear Sebastien,

Re: RES Group Submission to System Security Market Frameworks Review

RES welcomes the opportunity to provide input into this important work currently being undertaken by the AEMC.

RES Australia is a subsidiary of the wider RES Group with a global presence and experience of over 30 years comprising more than 12GW of renewable energy generation across 4 continents. RES currently has 145 MW of grid scale energy storage projects under contract including 25% of the recent National Grid Enhanced Frequency Response market allocation for 2016. In Australia RES' developed projects exceed 340 MW of wind generation either installed or in construction.

RES is active in developing solutions that enable the transition to a low carbon future and participate in various working groups focussed on the integration of renewable energy relevant to the AEMC's current review including:

- National Grid GC0022 "Frequency Response", Technical Sub Group[1]
- National Grid GC0035/GC0079 "Frequency Changes during Large Disturbances and their effect on the total system"[2]
- National Grid GC0048 "Workgroup on GB Application of RfG[3]
- National Grid GC0087 "Requirements for Generators Frequency Provisions[4]
- National Grid GC0096 "Energy Storage"[5]
- Eirgrid / SONI "DS3 Advisory Council"[6]
- Wind Europe "Grid Code Task Force"
- AEMC "System Security Market Frameworks Review", Technical Working Group

RES has also recently presented its experience in energy storage technology to various parties to aid in the understanding of the capability of this technology. RES would welcome the opportunity to discuss further

[1] http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0022/
[2] http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0035-GC0079/
[3] http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0048/
[4] http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0087/
[5] http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/Modifications/GC0096/
[6] http://www.eirgridgroup.com/how-the-grid-works/ds3-programme/

any topics under consideration by the AEMC in its System Security Market Frameworks Review or more generally should this assist in advancing the AEMC's understanding of technology capability.

Yours sincerely,

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Q1 Do you consider that the issues outlined above cover the matters that need to be considered going forward in managing changes in system frequency?

RES believes the consultation report broadly captures the issues with the following clarifications and observations.

The consultation report does not discuss the frequency and RoCoF withstand capabilities / limitations of smaller distribution connected generation which might be installed in large volumes e.g. rooftop PV. Unless these risks are considered / managed in other market documents, it appears that this potentially significant risk is overlooked. RES cites the example of Germany which allowed the connection of large volumes of PV (in excess of the ENTSO-E credible contingency infeed loss risk of 3000MW) with inappropriate frequency protection settings. This required urgent and costly remedial action.

In order to reduce the costs of managing increasing RoCoF resulting from reducing system inertia, Great Britain has amended the frequency and RoCoF protection settings of >5MW distribution connected generators and is working toward this goal for <5MW distribution connected generators.[2]

For similar reasons, ESB and NIE (the distribution network operators in Ireland and Northern Ireland respectively) are working to amend frequency and RoCoF protection settings of generators connected to their distribution systems.[7]

In section 1.2 of the consultation report states *"The ability of the power system to resist large changes in frequency arising from the loss of a generator, transmission line or large industrial load is initially determined by the inertia of the power system."* The RoCoF which occurs in such circumstances is also proportional to the magnitude of the power imbalance arising from the loss of generation or load and this is discussed in the Box 2.1.

- In Great Britain the system operator National Grid presently manages RoCoF risk by limiting the size of the largest infeed / outfeed loss (typically unscheduled trip of one of the two 1000MW England-France DC Interconnectors) at times of low system inertia.
- In Ireland and Northern Ireland the system operators Eirgrid and SONI respectively (in addition to infeed / outfeed loss risk management) jointly operate a system inertia constraint by constraining on synchronous generators and constraining off DC interconnector infeed and/or wind farms, reproduced below.[8]

Operational Limit for RoCoF	X:<=	0.5 Hz/s	Ireland and Northern Ireland Power Systems	Ensures that RoCoF does not exceed 0.5 Hz/s.
Operational Limit for Inertia	N:>=	20,000 MWs	Ireland and Northern Ireland Power Systems	Ensures that all island Inertia does not fall below 20,000 MWs.

Section 2.2 of the consultation report describes how *"AEMO may restrict the operation of the power system to reduce the potential size of sudden changes in generation or load."* It should be acknowledged that this has a cost and therefore other available methods for managing this risk (e.g. fast frequency response from

[7] http://www.eirgridgroup.com/site-files/library/EirGrid/DS3-Rate-of-Change-of-Frequency-(RoCoF)Workstream-Plan-2015.pdf
[8] http://www.eirgridgroup.com/site-files/library/EirGrid/OperationalConstraintsUpdateVersion1_43_October_2016.pdf

wind farms and battery energy storage) should be investigated as they may reduce the cost of managing the risk.

Section 1.2 of the consultation report also discusses the role of the Heywood Interconnector and notes that *"Where there is an outage of this interconnector, the risks to system security in South Australia increase significantly because it must rely on inertia provided by generators within the region. If there is minimal generation capacity with the ability to provide inertia in that region, the frequency could be subject to very rapid changes."* RES notes that inertia is not the only tool to mitigate against rapid frequency changes in these circumstances. Fast acting frequency response provided by wind farms or by new service providers (e.g. battery energy storage devices) could also help.

- National Grid recently procured 220MW of "Enhanced Frequency Response" which will be delivered in less than 1 second. Part of the reasons for this procurement is mitigation of reducing system inertia and also the cost savings from significantly reducing the quantities of slower Primary Response (delivered in <10 seconds). All selected solutions were battery energy storage projects.
- Eirgrid & SONI are developing a procurement process for several new system services to assist managing reducing system inertia. These include:
  - "Synchronous Inertial Response" which will incentivise generators to provide greater inertia constants and remain connected at lower minimum operating levels;
  - "Fast Frequency Response" which is designed to allow wind farms to provide short term fast (<2 seconds) positive response to a loss of infeed frequency but without requiring wind farms to curtail their output. A number of wind turbine manufacturers have existing capabilities which they are adapting to deliver this service. Energy storage devices can also deliver this service as could HVDC interconnectors;
  - "Fast Post Fault Active Power Recovery" which incentivises wind turbines to return to pre-fault active power within 200ms of voltage recovering to normal levels (existing grid code requirement is <500ms).[9]

Section 2 of the consultation report discusses *"the value placed on reliability by customers"*. The unfortunate recent blackout of South Australia is an opportunity to review and recalibrate the value of customer reliability (unserved energy) used in the NEM and whether it is appropriate to use the same value for local, regional and state-wide incidents. The unserved energy resulting from the blackout and its aftermath may be estimated, as may the associated economic impact.

Section 2.2 states that newer technologies *"are not synchronised to the frequency of the electricity system and therefore are unable to assist in dampening rapid changes in frequency or responding to fluctuations in supply or consumption."* RES experience in other systems (USA, Great Britain and Ireland) indicates this statement is incorrect or incomplete. The power output of wind, PV and battery energy storage devices can be adjusted very rapidly in response to frequency deviations. This fast acting response can mitigate such frequency disturbances

Section 2.2 raises concerns that *"AEMO's ability to control the secure operation of the system and maintain a continuous supply of electricity across the interconnected network*" may be impaired by the presence of non-synchronous generators, connected in the distribution system and not centrally controlled. Such impairment could be mitigated by wind power and PV power forecasting systems such as employed by

[9] https://www.semcommittee.com/sites/semcommittee.com/files/media-files/SEM-13-060%20DS3%20DS%20System%20ServicesConsulation%20Paper.pdf

system operators in Great Britain and Ireland. Such forecasting systems need reasonably accurate data on the location and capacity of renewable generators.

Section 2.3.1, under heading “Current and potential future issues with controlling frequency”, discusses a number of interesting challenges.

- A potential shortfall of contingency FCAS is mentioned. RES believes the addition of faster acting frequency response may be a solution.
- Time delay in detecting frequency deviations for UFLS is mentioned. Phasor Measurement Units (PMUs) can measure frequency (and RoCoF) more quickly than relays, but would require careful application to avoid false triggering, for example by a sudden phase shift.
- UFLS is only effective when positive load is shed. Care may be required in the future to avoid shedding negative loads i.e. regions where distributed generation (e.g. rooftop PV) exceeds local demand.

Q2 What do you consider to be the issues associated with low power system strength?

When a system is dominated by and reliant upon synchronous generators, then system strength must be managed in order to keep the synchronous generators stable - so long as it is cost effective to do so for a potential small rump of synchronous generators in a future power system dominated by asynchronous generators. TNSPs may need to plan for parts of the system to operate with little or no synchronous generators if this is suggested by future power system projections.

Transition to a lower system strength is an existing trend which can be avoided or adapted. The costs and advantages / disadvantages of each path must be evaluated.

In addition to the issues bulleted in the consultation report section 2.3.2, maintaining synchronism of synchronous generators might be another challenge of low system strength. In Ireland and Northern Ireland the system operators are introducing a new system service “Dynamic Reactive Response” which is intended to mitigate such a challenge.[10]

The National Grid in Great Britain recently acknowledged for the first time that reducing system strength will be a topic in the 2016 edition of their System Operability Framework which is due to be released on 30th November.[11]

RES welcomes the propositions set out in section 3.3 and supports the principles proposed by the Commission in section 3.4 in support of the National Electricity Objective.

RES further welcomes AEMO’s ongoing investigation into *“the extent to which these technologies can act as substitutes for the reduced levels of system inertia”* and we are happy to discuss further our experience with these technologies.

10 https://www.semcommittee.com/sites/semcommittee.com/files/media-files/SEM-13-060%20DS3%20DS%20System%20ServicesConsulation%20Paper.pdf
11 http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/

Q3 Do you consider it beneficial to set a standard for RoCoF? What format should this standard take and what factors should be taken into account when setting the standard? Who should set it? Would the establishment of a new standard trigger significant additional costs to comply? Do you consider there to be a role for maintaining system strength? Who should be responsible for undertaking this role or how should the responsibility be determined?

RES believes it to be beneficial to set a standard for RoCoF. Consideration should also be made as to the extent that distribution connected generators may use RoCoF sensitive protection for detecting and disconnecting from island conditions.

The factors which should be taken into account include:

- The capabilities of generators and other rotating machines to withstand RoCoF
- The cost of AEMO actions to limit RoCOF to a particular range
- The cost of procuring services to limit RoCOF to a particular range
- The benefits of a reasonably loose RoCoF standard, such as facilitating increased penetration of renewable generators which tend to reduce marginal electricity prices and achieve government policy targets

A new RoCoF standard might incur some costs to comply for large thermal generators. Initially such generators may wish to conduct studies to confirm that they can meet the new standard which may involve time and cost. Generators in Ireland are presently conducting similar studies for a proposed change in RoCoF standard from 0.5 to 1.0 Hz/s. When wind turbine OEMs were surveyed regarding the proposed change, RES is not aware of any that expressed concern, most confirmed capability of up to 2 Hz/s and some even stated capability to 4 Hz/s measured over 500ms. Whether this capability extends backwards to older installed plant is not clear to RES. PV generators and battery energy storage devices are unconstrained by mechanical considerations and should be expected to be robust in the presence of high RoCoF.

It is RES' belief that system strength must not be left unmanaged. The long term consequences of uncontrolled decline in system strength could be disastrous (notwithstanding the ability of some inverters for battery energy storage to operate at very low short circuit ratio and the possibility of adapting network protection systems). The system strength management role is best undertaken by AEMO and distribution NSPs as the operators and planners of the transmission and distribution systems with services procured from other parties. A sensible path forward would be for further public debate regarding the proposed system strength plan or standard. As there would be a cost associated with maintaining a minimum system strength, the procurement process will require scrutiny to ensure alignment with the National Electricity Objective.

Q4 What roles do you consider services such as inertia and fast frequency response should play in maintaining system security in the NEM? How else could RoCoF be managed?

RES' view is that Inertia and fast frequency response are both effective tools for managing RoCoF in the NEM. RoCoF can also be managed by:

- Managing the largest loss of infeed/outfeed, particularly at times of low system inertia;
- Improving the speed of response of UFLS and OFGS, for example by using PMUs for frequency and ROCOF measurement;
- Managing the effectiveness of UFLS disconnection groups (net demand may be eroded or reversed by distribution connected generators);
- Procuring ancillary services to mitigate RoCoF from non-traditional sources. Examples include wind farms, battery energy storage, rotating demand and demand side management;
- Procuring fast frequency response from wind farms and battery energy storage devices, similar to the FFR procured in Ireland or EFR procured in Great Britain;
- Incentivising synchronous generators or condensers to improve their inertial performance (higher inertia constant and lower minimum operating level). An example is through an ancillary service similar to SIR procured in Ireland

Section 4.2 states *"only synchronous inertia can be used to resist rapid changes in frequency that would happen immediately upon the occurrence of a loss of generation or load*". This statement does not fully consider the purpose for resisting rapid change and may lead to inefficient outcomes. One must consider why it may be necessary to resist such frequency changes immediately and whether it might be acceptable for there to be a brief delay in some circumstances? The answer to these questions depends on the electromechanical effect of RoCoF on connected generators and loads and on the effectiveness of resources available to mitigate load imbalance and prevent frequency nadir or zenith from exceeding the extremes of the frequency standard. Such delay can be minimised by fast acting frequency and RoCoF detection devices such as PMUs and by fast acting frequency response devices including battery energy storage, wind turbines, PV inverters and demand side response.

Q5 Do you consider it beneficial to establish new mechanisms for the procurement of additional systems security services? What form of mechanism do you consider to be preferable and which services should the mechanism be targeted at?

RES believes that additional system security services do need to be procured in complement to those services already established. The new services and mechanisms for their procurement should reflect all available response technologies and be structured to promote efficient supply of the services.

Simply placing the same obligations on all market generator participants is:

- Impractical: some participants are synchronous, some are asynchronous and cannot provide exactly the same services;
- Inefficient: some participants may be better able to deliver the new services at lower cost than others
- Discriminatory: if it excludes participation by demand side response

The volumes of such services which may be required could be calculated using methodology similar to that employed by Eirgrid [12]

Development of any procurement mechanism should consider suitable contract tenor to facilitate investment in new facilities consistent with the National Electricity Objective. RES notes the proposed new Eirgrid/SONI DS3 system services for FFR and SIR and their proposed procurement methodologies as points of information for consideration by AEMC.

It is noted that the consultation report discusses procurement of services to manage a RoCoF standard but appears to neglect to consider that services may have to be obtained to manage a system strength standard.

[12] http://www.eirgridgroup.com/site-files/library/EirGrid/DS3-System-Services-Consultation-on-Volume-Calculation-Methodology-and....pdf

Q6 What form of cost recovery do you consider to be preferable in the design of a mechanism to procure additional system security services? Should the cost recovery mechanism be designed to create stronger incentives to provide the required services?

A properly designed Causer Pays methodology with the capacity for a causer to manage their exposure and hence risk is a sensible approach. RES notes that existing Causer Pays methods have room for improvement in a number of ways including:

- Historically calculated contribution factors applied to events where the causer may have no impact and no method to mitigate exposure;
- Slow and outdated communication methods resulting in time biased target values; and
- An inability to supplement third party forecasts.

RES believes incentives rather than obligations would be the most efficient method of procurement. A well designed procurement mechanism should promote competition and investor certainty in entering into capital intensive projects.