School of Electrical Engineering and Telecommunications
Real-time Digital Simulations Laboratory

Submission to the Discussion Paper:

Coordination of Generation and Transmission Investment

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We appreciate the opportunity to make a submission to the 2018 Australian Energy Market Commission's (AEMC) consultation regarding coordination of generation and transmission investment. We also welcome AEMC's initiative to request feedback from the greater community. This kind of process – together with the Integrated System Plan (ISP) consultation carried out by the Australian Energy Market Operator (AEMO) – are critical in identifying alternative pathways and solutions and also in the decision-making process for the future development of transmission in the National Electricity Market (NEM).

Given the rapid technological changes, we believe that it is imperative to improve upon existing processes and regulatory framework in order to incentivise appropriate, timely and efficient investments in transmission and generation projects. Our comments related to Renewable Energy Zones (REZs) of the consultation document are the following.

On the definition of renewable energy zones

The AEMO definition of a REZ in the ISP consultation document, as an:

"*area in the NEM where clusters of large-scale renewable energy can be developed to promote economies of scale in high-resource areas and capture geographic and technological diversity in renewable resources*" [1]

is in good agreement with similar definitions of REZs from around the world, for example the U.S. National Renewable Energy Laboratory (NREL) which defines a REZ as

"*a geographic area that enables the development of profitable and cost-effective grid-connected renewable energy. A REZ has high-quality renewable energy resources, suitable topography and land use designations, and demonstrated interest from developers, all of which support cost-effective renewable energy development*" [2]

or the International Renewable Energy Agency (IRENA) that defines a REZ as

" *a contiguous or semi-contiguous area of high potential renewable energy with enough generation capacity to warrant the construction of high voltage (>132 kV) interconnection line. Renewable energy zones typically are created on the basis of within-zone similarity in cumulative suitability scores*" [3].

Given the consistency among the aforementioned definitions, we believe that AEMO's one is sufficient to allow the insertion of this kind of alternatives (renewables) to the generation pool of the NEM. It includes the essentials aspects stated by the other two entities, with the aim of promoting economies of scale.

Although not explicitly mentioned in the AEMO definition of a REZ, AEMO identifies transmission planning as an important factor when defining (connecting) a REZ. AEMC also recognizes this aspect but only provides economic considerations without further consideration of technical options and scope. We suggest to expand the scope of a REZ by considering a joint approach (i.e. REZs development and the associated transmission expansion/augmentation), considering both financial and technical factors.

An approach which can help policymakers ensure developing REZs within a transmission planning process is presented by NREL in [2]. Moreover, an example from the Western Electricity Coordinating Council (WECC) system can be found in [4]. In this initiative, the Western Governors' Association (WGA) in collaboration with relevant U.S. departments, the US Federal Energy Regulatory Commission (FERC), Canadian provincial Premiers and a diverse group of stakeholders, provided a plan to facilitate the development of new REZs and any needed transmission infrastructure to deliver the generated energy.

Defining a set of technical criteria for generation and transmission capacity to the definition of REZ will also help clarify design requirements. For instance, the WECC initiative [4] states that a REZ should have a potential generating capacity of $1,500$ MW for solar or wind, or 500 MW for biomass, geothermal or hydropower technology. It is important to notice that values as such should be defined accordingly to the requirements of the NEM. IRENA specified that a REZ should have enough potential to justify the construction of a high-voltage line (> 132) kV [3]. Since potential REZs in Australia are at the edges of the existing network [5], transmission planning plays a major role and setting a voltage level for new infrastructure could be considered.

A clear and detailed definition and scope of a REZ that considers generation and transmission investment, technical requirements and all existing technical solutions, economical and regulatory factors should allow selection of areas with the highest potential and identify the most viable ones (in terms of resource quality, cost-effective developments, low environmental impact, among others).

On the transmission planning process

Transmission system expansion is required to provide access to new REZs. However, its development may require several more years when comparing with a generation project, such as a solar or wind power plant. Furthermore, transmission investments can be considered as both a natural monopoly and an irreversible investment, therefore a joint approach is needed to reach the scope of the particular REZ development.

When the viable REZ options are identified, transmission alternatives must be formulated. Feasible approaches should consider factors such as the type of technology, overhead or underground transmission, voltage level and transmission capacity [6]. As stated in the submission to the ISP consultation [7], High-Voltage Direct Current (HVDC) transmission technology is a credible solution for transmission planning, in particular to increase renewable energy penetration in the transmission network. Moreover, it was also highlighted that a more holistic cost-benefit approach will allow to incorporate this kind of technology when taking into account its additional benefits [8].

One of the main advantages of DC technology over AC is the greater flexibility and/or functionality. In particular, Voltage-Source Modular Multilevel Converters (VSC/MMC, [9]) HVDC transmission is capable of:

- Providing dynamic reactive power for voltage regulation independently at each terminal.
- Quickly adjusting real and reactive power flow in response to system contingencies.
- "Firewalling" one AC system so that disturbances do not spread to an adjacent system.
- Operating under low short-circuit ratios (suited to weaker grids, such as connection of offshore/onshore renewables or systems with high penetration of asynchronous generation).
- Providing a variety of power quality support functions such as *i)* frequency stabilisation, *ii)* artificial fast frequency response, *iii)* power oscillation damping, and *iv)* black-start capabilities.

HVDC transmission and multi-terminal HVDC networks should be considered with REZs development in order to handle the intermittency and to ensure secure and reliable supply with required quality of service. Intrinsic variation in wind and solar generation may be balanced by other renewable sources such as hydro or geothermal, which also can be located far away from load centres and connected through HVDC links. Today, more than 51 GW of renewables are connected through HVDC links worldwide. Less costly solutions, such as those based on current-source converters (CSC-HVDC) may also be considered in certain cases.

On the regulatory framework

In considering REZ development combined with HVDC transmission, the latter should be considered as a regulated monopoly networks asset – preferably centrally managed – instead of a market asset or a merchant interconnector. The additional benefits of HVDC, apart from long distance flexible power transmission capability, are key considerations that justify its necessity for transmission planning particularly with REZs integration. Therefore, the enhanced role at a planning entity across the whole system (e.g. AEMO) should help to overcome the challenge in developing REZs together with associated transmission projects.

The geographic distribution of several REZs defined in the ISP suggests that further interconnectors between states (not directly linked to a REZ development) as well as interstate links for REZ development, not in the form of state interconnectors (e.g a REZ in NSW connected to the VIC network) will be necessary. This requirement demonstrates the need for a lead entity capable of ensuring the development of REZs and its corresponding transmission expansion. Incentive-based regulation may further facilitate grid expansion and a centralized planning approach will help reduce investment as well as consumer risk (who are the ones paying via Transmission Network Services Providers (TNSPs) under the current framework).

About the Real-time Digital Simulations Laboratory at UNSW Sydney

The Real-time Digital Simulations Laboratory at UNSW Sydney (RTS@UNSW) offers extensive real-time digital simulation capabilities in the areas of power systems, power system protection, HVDC transmission, renewable energy systems, power electronics, microgrids, etc. Real-time digital simulation (RTS) offers an accurate, reliable and cost-effective method to simulate, verify and experiment with multiple technologies, functions, operations and control from individual components to small and large-scale power systems. Detailed information on the capabilities and hardware infrastructure can be found at https://research.unsw.edu.au/projects/real-time-digital-simulation-rts-laboratory-unsw-sydney.

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