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

Submission to the Draft 2020 Integrated System Plan Consultation

Prepared by:
Mr. Felipe Arraño-Vargas,
Dr. Harith Wickramasinghe,
and Dr. Georgios Konstantinou

The Real-time Digital Simulations Laboratory at UNSW Sydney (RTS@UNSW) welcomes the opportunity to make a submission to the Australian Energy Market Operator's (AEMO) *Draft 2020 Integrated System Plan* document, the Draft 2020 ISP. We also support AEMO's initiatives to request feedback and improve stakeholder engagement.

RTS@UNSW is supportive of the different approaches taken in the Draft 2020 ISP to provide an actionable roadmap to guide Australia's energy transition. Moreover, we consider that development options and actions are appropriate for Australia's future National Electricity Market (NEM).

RTS@UNSW would like to provide comments and recommendations that can be used by AEMO in future ISPs. Please feel free to contact us if there are any questions or if you wish to discuss any matter with respect to this submission via e-mail (f.arranovargas@unsw.edu.au).

1. ISP methodologies

1.1. Network augmentation methodologies

The Draft 2020 ISP recommends various projects to provide additional capacity, balance resources and unlock potential renewable energy zones (REZs). In particular, high-voltage alternating current (HVAC) and high-voltage direct current (HVDC) transmission systems are considered when selecting the technology for new developments. In the Draft 2020 ISP, costs of AC/DC converters are one of the main factors that drive the selection of technology. Since these costs are high, HVAC option is generally preferred. However, proper attribution of value may be given to additional functionalities that can be provided by HVDC technologies not currently explicitly considered in Draft 2020 ISP documents.

We suggest that the following factors should be considered in future ISPs when assessing which technology to select:

1) **Ancillary services provided by HVDC.** HVDC transmission systems, and especially voltage-source modular multilevel converters (VSC/MMC [1]), provide greater flexibility and/or functionality as they can operate under low short-circuit ratios, provide independent active and reactive power control, "firewall" AC systems from disturbances, and provide power quality functions (frequency stabilisation, black-start capability, artificial fast frequency response, among others) [2, 3, 4, 5].

2) **HVDC as multiterminal networks and DC grids.** In the 2020 ISP Draft, VNI West, QNI Upgrade and Marinus link projects are the only ones that explicitly consider HVDC technology as an option. Moreover, HVDC has been only considered as a point-to-point connection or as an interface of two systems (back-to-back configuration). The assumption that these alternatives are the only possible configurations for HVDC might limit the potential that DC systems can provide to the NEM. Multiterminal networks and DC grids are alternative approaches to increase transmission capacity as well as to integrate REZs. Furthermore, multiterminal networks and DC grids may be staged by commissioning point-to-point or back-to-back systems, providing more flexibility to Transmission Network Service Providers (TNSPs) and giving more confidence to investors.
   Recent developments have shown the feasibility and proper operation of high-voltage and high-capacity DC grids. The Zhangbei HVDC grid (a four-terminal grid with a DC voltage level of $\pm$500 kV and a total converter capacity of 9000 MW [6]) has enabled the integration of remote and large scale renewable sources while ensuring stable and reliable supply to the extensive metropolitan area of Beijing. The grid, designed by State Grid Corporation of China, allows the integration of remote wind, solar and hydro energy ensuring the optimization of power flow by handling the intermittency of variable sources [7]. A similar solution, at a smaller scale/capacity, can be developed in the NEM to allow the integration of remote REZs.

3) **Medium-voltage DC (MVDC) grids.** As the aims of the 2020 ISP Draft are to provide pathways for the next 20 years, it is also beneficial to identify and allow for future consideration of upcoming trends that are at earlier stages of research[1]. One key technology is MVDC (ranging from $\pm$ 1.5 to $\pm$ 100 kV) systems driven by developments in semiconductor technologies and ongoing system research that can enable/unlock additional functionalities at a smaller scale compared to HVDC systems [8]. This technology can allow for DC-based distribution and subtransmission systems at a local level.

It is worth noting that VSC-based HVDC and MVDC developments can also be considered as embedded power flow controllers when assessing new alternative network technologies [9]. As a consequence, VSC-based HVDC and MVDC may be a more economical and beneficial solution that address more than one need.

1.2. Renewable energy zone methodologies

The Draft 2020 ISP considers a sound range of requirements when selecting REZs, to further assess related transmission investments, we recommend to also examine different network and technology alternatives. Rather than a point-to-point interconnection/upgrade, specific buses within a REZ (or REZs) can be used as collector points to then inject power to the NEM or to concentrated demand areas. HVDC and MVDC grids can be designed as collector systems, simplifying network integration and easing the operation and controllability of it, and thus, providing a more robust, secure and reliable service to consumers.

[1]The development of MMC for HVDC applications has resulted in a rapid growth of VSC-HVDC systems. These developments, from demonstration projects to fully commercialised ones, have taken place in less than a decade. The complete timeline of projects can be found in the following link: https://hvdc.shinyapps.io/scatterplot/

2. Access to models

To further increase the transparency for both the process and outcomes of future ISPs, we encourage AEMO to continue making available the detailed long-term PLEXOS model. AEMO should also consider to release short-term models and provide them at consultation stages as these can help to carry out specific related ISP studies. By making these models available, as well as detailed electromagnetic transients (EMT) ones of the NEM, further and more comprehensive analysis can be made by stakeholders (e.g. NEM planning, system strength and inertia assessments, and modelling and integration of renewables and HVDC systems [10, 11, 12]).

3. 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 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.

4. Acknowledgment

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