SUBMISSION TO THE
Standing Committee on the Environment and Energy Inquiry into Modernising Australia’s Electricity Grid

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ATSE SUBMISSION TO THE INQUIRY INTO MODERNISING AUSTRALIA’S ELECTRICITY GRID

Australia’s energy systems need to be decarbonised as a matter of urgency. This transition will require nationally coordinated action to modernise Australia’s electricity grid.

Ensuring the security and reliability of Australia’s electricity sector while addressing Australia’s emissions reductions goals will not be without cost. However, when considering the risks and externalised costs posed by network failures and the threats of climate change, ATSE believes that the cost of not transitioning will be higher in the long run.

The existing grid is not sufficient to support this transition. Modern technology and innovative engineering solutions will help to optimise the operation of Australia’s future grid. ATSE believes that the following technologies will play important roles in maintaining the security and reliability of the modern grid as it achieves higher penetrations of variable renewable energy:

- Interconnections based on High Voltage Direct Current (HVDC) transmission systems and innovative low-cost transmission structures;
- Smart distribution networks and systems that aggregate and coordinate distributed energy resources to supply grid support services such as demand response; and
- Large scale energy storage, including pumped hydro energy storage (best suited for bulk energy storage) and grid-scale batteries (best suited for fast response applications)

To accommodate the rapid pace of technological change, governments should apply principles of technology neutrality and let different technologies and solutions compete based on their technical and economic performance.

ATSE supports the work being undertaken by the Independent Review into the Future Security of the NEM and recommend governments commit to its recommendations. Australia will need ongoing independent expert guidance and leadership to support the energy sector’s transition in the years ahead.

Key Recommendations

Australian governments must work together to establish a national framework to drive efficient investment in Australia’s electricity grid to support its ongoing reliability and security while achieving Australia’s emission reduction targets.

Australia needs an independent expert body to develop a long-term strategic plan for the transition of the electricity sector, and to provide guidance to optimise the transition and address whole-of-system integration challenges at a national level.

The Australian Academy of Technology and Engineering (ATSE) advocates for a future in which technological sciences, engineering and innovation contribute significantly to Australia’s social, economic and environmental wellbeing. The Academy is empowered in its mission by some 800 Fellows drawn from industry, academia, research institutes and government, who represent the brightest and the best in technological sciences and engineering in Australia. The Academy provides robust, independent and trusted evidence-based advice on technological issues of national importance. ATSE fosters national and international collaboration and encourages technology transfer for economic, social and environmental benefit.
Detailed Responses to the Discussion Paper’s Questions

How are the objectives of security, reliability, sustainability, and affordability interrelated? What should be the highest priority objectives of a modern grid in Australia?

Ensuring the reliability and security of the grid while transitioning to a low emissions economy should be the primary objective of Australia’s grid at this time. This transition will not be without cost. However when considering the costs imposed by power outages and the costs of externalities such as greenhouse gas and pollutant emissions\(^1\), ATSE believes that the cost of not transitioning would be far greater. Achieving the objectives of security, reliability and sustainability, without increased electricity costs is unlikely. Strategic and sustained political leadership will be required to achieve this transition, by encouraging the investment required to deliver ongoing reliability and ensuring that increased costs are equitably shared.

What are appropriate standards for the security and reliability of the electricity system?

AEMO's Future Power System Security program exists to identify challenges and opportunities to maintaining the NEM's security and reliability over the short and long term. The existing reliability standard is reviewed regularly. However, it is a planning standard rather than an enforced regulatory or performance standard.

What are the costs associated with an ‘outdated’ grid?

If energy supply is not secure and reliable, customers can face severe consequences. The power outage in September 2016 in South Australia resulted in significant losses for a number of businesses, including an estimated $10 million for the Arrium Whyalla steelworks and over $100 million for BHP Billiton’s Olympic Dam operation.\(^2\)\(^3\) Power outages also pose health risks especially when associated with extreme weather events. These can include “increased deaths from accidental and natural causes, increased cases of foodborne diarrheal illness from consuming food spoiled by lack of refrigeration, and increased rates of hospitalization”.\(^4\) The elderly, the very young, and individuals with pre-existing health conditions or disabilities are especially vulnerable to health impacts from an outage.

The primary cost associated with an outdated grid is the risk of stranded assets due to early retirement of generation equipment or network overbuilds. Research by the International Energy Agency (IEA)\(^5\) has also suggested that a well-managed transition is the key to enabling high penetrations of variable renewable energy at least cost, and that total system costs can triple if the transformation is poorly managed.

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It is undeniable that retail electricity prices have increased dramatically in recent years (see Figure 1), although there are differing conclusions as to why this has occurred. There is a general consensus that the market is not operating efficiently. ATSE welcomes the recently announced Australian Competition and Consumer Commission inquiry into the supply of retail electricity and the competitiveness of retail electricity prices.

Figure 1 - Average Retail prices in the NEM States (1999-2017)

What might be the role of new technologies in improving system security, reliability, sustainability, and affordability? What is the potential for new technologies to alter the inter-relationships between these objectives?

Modern technologies can support a stable transition to a decarbonised energy system and ensure the grid’s effective operation once the transition is complete. The potential contribution of some key technologies is discussed below.

System strength is a measure of the stability of a power system. Stronger power systems exhibit better voltage control in response to system disturbances and are less susceptible to voltage instability or collapse. Higher penetrations of large-scale wind and solar (power electronic converter connected generation) have a negative effect on system strength and it is essential to compensate for this effect. Research by Prof Simon Bartlett AM FTSE suggests that system weakening is the fundamental cause of the 2016 SA blackout. As the transition to a renewable energy based system continues, the need to ensure the strength of the grid will extend to other areas.


Modern technologies are available to strengthen the grid. Key technology options include High Voltage Direct Current (HVDC) - Voltage-Source Converter (VSC) interconnections, and static synchronous compensators (STATCOMs). HVDC-VSC interconnections offer a number of benefits over High Voltage Alternating Current (HVAC) interconnections including controllability and lower losses over long distances. They feature extremely fast response capabilities and can be used to black-start failed power systems. These are characteristics that will be required for the NEM with greater penetration of renewable energy. Technologies such as super-capacitors and battery storage are able to provide support services to the grid (e.g. fast frequency response and dynamic reactive voltage support to keep the power system operating within its limits) and they perform even better as part of an HVDC-VSC interconnection. Europe and China are already using these technologies. It is essential that Australia invests in technologies that will be able to address the future challenges of high renewable energy penetrations in the grid, and not in technologies that may quickly become obsolete.

Other technologies including energy storage technologies (battery and pumped hydro storage), demand management, and synthetic inertia, may also play an important role in supporting grid reliability and security. These technologies require rigorous evaluation to determine their ability to support Australia’s electricity goals. Careful consideration must also be given to the grid’s ability to support these services by connecting the locations or systems which can supply certain services to locations that require the services (e.g. connecting an area where suitable geography for a pumped system exists to an area that requires wholesale energy arbitrage for energy reliability).

As Australia’s electricity system evolves, the creation of smart distribution networks will be critical for beneficial integration of distributed energy resources and technologies, such as rooftop solar photovoltaic (PV) systems and battery storage, electric vehicles, home energy management systems, smart appliances, peer-to-peer trading, embedded networks and micro-grids. Smart integration of these technologies can benefit all objectives of a modern grid through demand response, efficient use of energy and increased utilisation of rooftop PV. There will need to be significant improvements in the monitoring and management of low and medium voltage distribution systems. To support this, the University of Queensland is currently working with Energy Networks Australia (ENA) and ARENA to develop and trial an algorithm that can be applied to vast unbalanced distribution networks with sparse metering.

Well-designed systems based on distributed energy resources can reduce the security risks posed by single failures in infrastructure (e.g. microgrids that can operate independently of the main grid during a blackout). To do this they require appropriate aggregation and orchestration to ensure that they ultimately deliver the necessary security. The September blackout in South Australia – in which disturbances in the transmission network led to a major outage – also highlights the risk of centralised infrastructure. A modern grid must be able to support a mix of centralised and distributed energy resources.

It should be noted that ENA and CSIRO are developing a Network Transformation Roadmap that targets grid modernisation measures that will create positive outcomes across multiple grid objectives.9

Reducing demand (especially peak demand) through energy efficiency and demand response is one of the few actions that can support all four of these objectives. New technologies and efforts to improve energy productivity (value provided per unit of energy) should play a lead role in Australia’s efforts to decarbonise its economy. ATSE’s action statement on energy productivity10 stresses the

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importance of energy efficiency as one of the most cost-effective measures to improving security, reliability, and sustainability of the electricity system.

How can the grid better accommodate the rapid pace of technological change, including an increasing level of variable electricity generation?

Clear objectives and the application of principles of technology-neutrality are essential to accommodate the rapid pace technological change. Australia needs to develop long-term energy strategies and policies supported by independent evidence-based advice. There is a delicate balance in encouraging investment in new technologies, while avoiding investments in network infrastructure that may become quickly obsolete or much cheaper in the years ahead. It is essential to consider the short and long term goals of Australia’s electricity grid in order to drive strategic investment that will support achievement of these goals.

The energy transition is creating an investment challenge due to the changing balance between capital and operating expenditure (driven by renewable energy systems that utilise inherently free energy sources, but impose system integration costs on the grid). This poses a challenge for maintaining and rewarding efficient investment in the electricity sector.

What possibilities are there for alternative pricing models (for example, cost-reflective pricing) to better reflect the true cost of services provided by a modern grid?

The price of power should reflect the costs and risks accepted by the various suppliers and the customer. Markets need to be designed to be fair and equitable and to incentivise efficient and positive outcomes. The end goal is for customer interaction to be harmonised with the availability of generation and the capacity of the network. Energy consumption should be affordable but reduction or shifting of peak energy consumption should be beneficial to the customer. Previous attempts to introduce cost-reflective pricing have not been successful. ATSE notes the efforts of other organisations to investigate different pricing models (e.g. the Victorian Essential Services Commission inquiry into the true value of distributed generation\textsuperscript{11}, the CSIRO and ENA Network Transformation Roadmap\textsuperscript{12}, and CSIRO’s research on consumer responses to cost reflective tariffs\textsuperscript{13}).

What opportunities are there to improve governance and regulation in the grid?

Many of the issues regarding governance and regulation are likely to be addressed by the Independent Review into the Security of the NEM. ATSE’s submission to the Independent Review recommends the establishment of an independent body of experts to provide advice and guidance to optimise the transition of the NEM and address whole-of-system integration challenges at a national level. Such a body should be equipped to provide strategic advice on generation, transmission, distribution and demand issues to support the efficient transition to a low carbon electricity sector. To support evidence-based governance and regulation of the sector transparent access to relevant data collected by energy businesses should be afforded to governments, regulators, market operators, and researchers.

The governance structure of AER, AEMC and AEMO will require clearer lines of responsibility and authority to accommodate the rapid changes occurring in networks. ATSE supports AEMO’s recent


decision to extend the planning horizon for its National Transmission Network Development Plan beyond a 20 year horizon. AER’s Regulatory Investment Test – Transmission should also consider long term horizons when analysing the benefits of new transmission infrastructure. A long term national strategy for the transition of Australia’s energy system is essential to support this. The interests of individual states and transmission businesses can conflict with achievement of national benefits. It is essential that transmission planning is primarily focused on supporting the nation to achieve its long term electricity objectives. The rules and regulations associated with the present grid are often complex. Governance and regulatory structures should be simplified wherever it is beneficial to do so.

The privatisation of much of Australia’s electricity networks has fragmented responsibility for their operation. Balancing future investments, ensuring security and reliability of supply, and addressing climate change creates significant challenges for the economic regulation of networks. The objectives of achieving security, reliability, affordability, and sustainability can conflict with the need to ensure private rates of return and maintain investment in the sector. This may have led to recent actions by state governments proposing to re-enter the electricity market as generators or providers of services (e.g. South Australia’s announcement of a state owned gas peaking plant and a grid scale battery system).

What opportunities are there for consumers to benefit from the modernisation of the grid? How can we ensure that these benefits are able to be shared equitably by all consumers? What sort of community attitudes or concerns will need to be addressed in order to successfully modernise the electricity grid?

The grid exists to serve electricity to consumers. Consumers will benefit from efficient modernisation that supports the community’s needs for secure, reliable and sustainable energy at an acceptable cost. ATSE commends the ENA/CSIRO Electricity Network Transformation Roadmap for identifying customer choice and control, and fairness and incentives as key objectives to address in a modern grid. It is important to minimise cross subsidies and ensure equitable sharing of benefits from grid modernisation. Energy consumers and prosumers (active consumers who both produce and consume electricity) will benefit from grid modernisation efforts that ensure the reliability and security of the electricity sector, enhance their freedom of choice and flexibility, reward beneficial behaviours such as demand response, and maintain its affordability.

It is important grid modernisation efforts consider the desires, values, and concerns of the community. Presently, community attitudes towards the power system and its governance are negative because of rising prices, and perceptions of reduced security and slow progress on emissions reduction goals that need to be addressed. Furthermore, the backlash to the mandatory implementation of smart meters in Victoria provides a key example of the problems that can occur when there is a limited social license for changes. Smart meters have proven challenging, unpopular, and costly to implement, and are also likely to be superseded by ICT-connected distributed energy management systems.

What options are there for addressing geographical barriers to achieving a truly national grid?

Achieving a national grid could be an appropriate long term goal for Australia, however this would be an expensive proposition and a compelling business case for such a project has not been made. Modern transmission technologies including HVDC transmission cables and innovative lower-cost transmission towers (e.g. chainette guyed structures) offer the potential to achieve a truly national

grid or even international grid. Strategically designed interconnections could potentially unlock renewable energy resources in remote regions of Australia. In the long term, it is expected that the existing electricity system based on HVAC transmission and synchronous generation will evolve into a HVDC based power system. This is currently being investigated at the conceptual level. The development of an HVDC circuit breaker will be a fundamental enabler of this transition.

ATSE’s submission to the Independent Review of the Future Security of the NEM recommended a detailed investigation by AEMO into the business case for a Queensland-to-South Australia HVDC interconnector that traverses a strategic route through central Australia. This interconnection would connect the NEM network around SA – VIC – NSW – QLD – SA and strengthen the grid. It would also enable development of some of Australia’s best renewables and low-emission resources along the route.

Research by ATSE Fellows, Prof Simon Bartlett and Prof Andrew Blakers, suggests that a combination of HVDC transmission interconnectors and pumped hydro storage would currently provide the lowest cost option for improved grid security & reliability under high renewable energy penetrations. Increased interconnection between existing NEM states and other areas supports the integration of higher penetrations of renewable energy into the grid. Well-designed interconnections can greatly reduce the amount of storage required for energy balancing.16 This occurs as the temporally and spatially diverse sources of renewable generation and demand tend to smooth out over very large areas, making the grid less susceptible to local variations. A well-designed grid would also support the utilisation of Australia’s most efficient fossil fuel based generation as older/less efficient coal fired stations close.

Strategic grid modernisation could theoretically underpin a new export industry for Australia: generating renewable energy for export into Indonesia and Asia through an international HVDC connection.17 18 However, the business case for such an interconnection is subject to some debate.19

What are the key similarities and differences between the electricity system in Australia and those of other countries?

The National Electricity Market features long and relatively weak interconnections between states. Western Australia and the Northern Territory are not connected to the NEM and Australia has no interconnections with neighbouring countries. Australia is one of the most developed countries in this situation. As such, there is a strong case for Australia to assist countries with similar geographic challenges to make the transition. In terms of generation potential, it should be noted that Australia has world-class renewable energy (including solar, wind and tidal) resources. Australia also has excellent uranium resources but nuclear energy is prohibited in legislation.

How does Australia compare with other countries in the rate of adoption of variable electricity generation and other new technologies?

Australia has been in the forefront of adopting new technologies for many years. There has been high penetration of rooftop PV. The rapid current (and predicted) growth in domestic energy storage, leads many to believe that Australia will be a test bed for distributed energy resources and the smart

18 Taggart, S., James, G., Dong, Z., & Russell, C. (2017). The Future of Renewables Linked by a Transnational Asian Grid. Proceedings of the IEEE, 100(2), 348-359. doi:http://dx.doi.org/10.1109/JPROC.2011.2159089
systems that can control and coordinate them (e.g. Reposit, GreenSync, Evergen, dEX\textsuperscript{20}). This presents a potential opportunity for Australia to export the knowledge, expertise and systems developed to solve these problems to support countries that face these problems in the future.

How does Australia compare with other countries in progress towards electricity grid modernisation? What are examples of best-practice governance and regulation in other countries?

As the transition is under way and the number of economies similar to Australia is limited there is not enough evidence to answer this definitively. As noted above, the upcoming Report from the Independent Review into the Future Security of the NEM is expected to provide further insight into this issue.