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Senator Mathias Cormann
Chair, Senate Select Committee on Fuel and Energy
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SENATE SELECT COMMITTEE ON FUEL AND ENERGY – INFORMATION REQUEST

Dear Senator

The Energy Networks Association (ENA) welcomes the opportunity to provide further information to the Senate Select Committee on Fuel and Energy for its investigation into fuel and energy security.

The Energy Networks Association (ENA) is the peak national body for Australia's energy networks which provide the vital link between gas and electricity producers and consumers. ENA represents gas distribution and electricity network businesses on economic, technical and safety regulation and national energy policy issues.

ENA has consulted with its members and would like to offer the following comments to the Committee for its consideration.

Question 1: Can the ENA advise the committee of the relative merits of transmitting electricity via Direct Current (DC) and via Alternating Current (AC), at High Voltage (HV)?

ENA members have indicated that when HVDC technology is employed, it is done so within the constraints of the incumbent AC power system. HVDC is employed as a single element requiring AC/DC conversion at each end. In general, high voltage DC transmission becomes economic for transfer of high volumes of electrical energy, point to point, over large distances or where a significant length of cable is required.

Because of the high cost of the AC/DC conversion, HVDC transmission has limited economic applications, for example:

- High voltage cable links where AC technology is not feasible even for modest lengths (Basslink is an example);
- Very long transmission links where the high cost of AC/DC conversion equipment can be offset by the relatively lower cost of the DC overhead transmission line;
- Some special cases where precise power control is required such as non-regulated links (Murraylink is an example).

Notwithstanding the above applications of HVDC, there are a number of distinct disadvantages of HVDC including the technical and cost imposition of making added connections to the link, as well as the possibility of lower reliability of HVDC compared with AC transmission due to the significantly increased number of components required. There are significant technical difficulties and large costs associated with establishing an additional off-take along a DC transmission circuit. An off-take along an AC transmission line is much easier technically and can be achieved at a relatively modest cost.

AC transmission systems must operate in synchronism – that is to say that each generator connected to the AC system must be generating electricity "in phase". The ends of DC transmission lines are not required to be in synchronism, which has advantages for geographically large distances. Generally, each end of the DC link will need a synchronous source for frequency control, such as a generator or a synchronous compensator, however some relatively new DC technologies may have overcome this requirement.

Question 2: What are the issues associated with the conversion of electricity from AC to DC and vice versa? Are there any implications regarding conversion which may arise if electricity was transmitted via HVDC? What would be the implications for the way electricity is delivered to end consumers?

Electricity grids in Australia (and indeed elsewhere in the world) are generally AC (alternating current) systems. That is to say, energy is generated as AC, transmitted and distributed as AC and is consumed in industry, business and homes as AC. While the distribution networks are designed, constructed and maintained for AC, there are an increasing volume of appliances and equipment that use DC, at Low Voltage (LV). Although the standard end consumer LV connection to the distribution network must receive their electricity supply as AC, due to the existing distribution network design, the customer's installation could be AC or DC depending upon their choice or needs. The mechanism used for transmission (AC or DC) is not relevant to the physical delivery of electricity to end consumers but would be relevant to the network costs associated with end consumer electricity charges.

There is a significant loss of energy associated with the conversion of electricity from AC to DC and vice versa – generally of the order of up to 1.5% of power transferred at each end, depending on the HVDC technology employed. This loss is taken into account in the economic comparison of AC and DC transmission for any given circumstance. It is also worth noting that AC/DC converter equipment is relatively expensive and induces significant harmonic currents into the grid, which in turn require filters.

Question 3: Can the ENA provide the committee with a comparative assessment of the energy efficiency, cost effectiveness, and emissions of HVDC transmission and HVAC transmission?

As previously mentioned, ENA members have stated that HVDC transmission generally becomes cost effective for transfer of high volumes of electrical energy, point to point, over fairly large distances or where a significant length of cable is required. There is a substantial loss of energy associated with the conversion of electricity from AC to DC and vice versa – generally in the order of up to 1.5% of the power transferred at each end, depending on the HVDC technology employed.

Both AC and HVDC transmission links result in resistive losses as electrical power is transmitted over metallic conductors (wires). HVDC transmission also incurs resistive losses within the AC/DC conversion equipment at each end. There is no simple comparison as to whether AC or HVDC has lower losses. With both technologies, losses can be reduced by increasing the transmission voltage or by increasing the conductor size, i.e. by making increased investments to reduce losses.

Question 4: In Australia, the Basslink cable transmits electricity via HVDC. What has been learnt from this deployment? How does it compare with AC transmission in Australia?

As ENA understands it, the Basslink was deployed as HVDC due to the length of the undersea cable required. It is not technically possible to transmit electricity over this distance of cable using HVAC transmission. This connection was facilitated by the Tasmanian Government and ENA does not wish to comment on the economics of this deployment.

Question 5: In the ENA's view, can HVDC transmission provide energy efficiency savings? In what way?

Whether or not HVDC can provide energy savings depends on the circumstances in which it is proposed to be used. ENA notes that the Australian electricity network is almost exclusively AC transmission with many take off points. In these circumstances and taking into account the energy losses associated with the conversion from AC to DC and vice versa, DC is unlikely to be competitive in most of the decisions for additional transmission. ENA also notes that for specific applications involving significant cable distances or large overhead distances Transmission Network Service Providers (TNSPs) will evaluate all technically feasible options, including the potential use of HVDC.

Question 6: If HVDC transmission is implemented in Australia on a large scale, will this make it more feasible to connect the Western Australian grid with the grid on the east coast?

ENA members had stated that given the very vast distances involved in connecting the two sides of Australia and the relatively small system sizes in terms of maximum demand and energy use, it is unlikely that such a connection would be economic. The use of DC transmission elsewhere would not change the feasibility or economics of such a connection.

It should also be noted that if DC transmission were to be used on such a link, it would not be possible to have many take off points along the link to supply remote communities.

Question 7: In the ENA's view, how can Australia best improve the energy efficiency of its transmission grid? What role should the government take in this regard?

Some ENA members have indicated that the construction of a higher voltage interconnected grid between TNSP's may increase energy efficiency. Increased interconnectedness would assist in providing improved security and reliability of supply as well as market benefits in certain instances.

Question 8: If Australia moved to a decentralised transmission grid due to increasingly distributed generation, will this affect which form of electricity transmission is the most efficient for use in Australia?

Due to the diverse construction of the distribution and transmission electricity network across Australia, including the varying topography, it is difficult to provide a clear position on the most efficient grid for Australia. However, ENA members have stated that generally distributed generation would be better suited to a HVAC network rather than HVDC.

ENA members have indicated that small to medium distributed generation (1MW – 10MW) is generally easily accommodated and managed within the distribution network on a 11kV, 22kV or 33kV distribution feeder, however larger sized units will require higher voltage networks (sub transmission – 33kV, 66kV or 132kV).

It has been suggested that to effectively manage distributed generation, network businesses must take into account the size, customer base (centralised load/demand) and the location of source to the demand. It is likely that the greater benefits for decentralised transmission would be in the urban / city areas where demand is concentrated and micro-small/medium generation (solar, CHP, gas turbine, micro/small wind turbines etc.) may prove to be beneficial. However some higher density distribution networks would require adaption to accommodate increased grid connected distributed generation, due to current technical and safety limitations.

Question 9: In the ENA's view, would the implementation of a HVDC transmission system contribute to the security of Australia's energy supply?

ENA believes that it is difficult to determine whether the implementation of a HVDC transmission system would contribute to the security of Australia's energy supply. However, there have been suggestions from ENA members that the more interconnected a grid, the more inherently secure it becomes.

Question 10: Are the current policy settings conducive to the implementation of a HVDC transmission system in Australia? If not, how can this best be addressed?

The current policy settings for investment in transmission are based on delivering economic outcomes. As such they require evaluation of all feasible options and implementation of the option which delivers the lowest cost mechanism to meet the relevant market outcomes. Regulatory rules in the National Electricity Market (NEM) provide for inclusion of the cost of losses in the economic assessment used for investment, which ensures that loss reduction is factored into the overall economic optimisation. It is this mechanism which determines the overall most favourable technology solution. Including the cost of losses themselves and the additional costs of reducing losses in determining the most economic solution is commonly applied, rather than dictating the solution or technology.

Investment in transmission assets generally occurs for introduction of new assets to meet market growth and improve market economics or for the replacement of end of life assets. Due to transmission assets having a lifespan ranging from 15 to 50 years or more, changes to the investment criteria may take a very long time to impact on the existing stock of assets.

Question 11: In your submission to the committee, you noted that increased connection of renewable energy sources into transmission and distribution networks reduces reliability. Can you please elaborate on how the integration of renewable energy sources affects transmission infrastructure, and whether there are any implications for management of the grid? How can such issues be addressed?

Government policies, such as premium feed in tariffs, are seeking to increase the uptake of embedded generation, particularly generation from renewable energy sources. As higher penetration levels of embedded generation appear, energy flow will increasingly become two way flow on electrical networks that were historically built for one way flow to consumers. Much of the technology deployed in the distribution network is relatively old, therefore this change to two way energy flows will impact metering, protection equipment, IT systems and network operations. Given that the uptake and locational effect of embedded generation is unpredictable, the exact impacts on the network are difficult to predict.

It should be noted that there is an incentive regime on distributors to manage reliability and network performance measures such as minutes-off supply. Distributors have an obligation to connect all connection requests on fair and reasonable terms. There is no such penalty regime on customers with co-generation or residential customers with photovoltaic cells (PV). Therefore the distributor cannot rely on the generation in its planning process to deliver the same service levels that the network provides, unless a network support agreement is in place which guarantees a certain level of performance.

Connections for large co-generation are handled as projects within the network operations, with separate negotiated connection agreements. Connection of photovoltaic (PV) cells on residential premises in aggregate may generate the same impact on the networks; however the level of control the distributor might have over the connection and electrical work is far less. Generally connection approval for small installations is assumed to be automatic if the customer's installation complies with the distributor's connection guidelines.

In addition, the technical standards for connection for various types of embedded generation (other than PV) are still immature and need to be developed to ensure that these issues are minimised. ENA members have indicated that the major issues at the moment relate more to compliance of customer generation installations with the distributor's connection guidelines, rather than a lack of connection standards.

It is also to be noted that with the proliferation of distributed renewable energy generation (typically intermittent in nature) there will be many challenges in managing the voltage and load variations in the networks due to changing weather conditions and uncontrolled availability. The management of energy flows across Australia will require major refinements as the percentage of renewable generation sources increases and locations and sizes become more dispersed.

The development of energy storage and accurate meteorology forecasting data will be a major component in managing this distributed generation. The concept of distributed generation will also bring challenges with redesigning and adapting the auxiliary systems and protection/voltage regulation, along with new safety, security and reliability issues to overcome.

As the Smart Grids develop, islanding and microgrids will become part of the normal system configuration. Controlling the quality of supply from these sources will become a major part of the system management.

Question 12: There has been some public comment regarding the potential of smart grids in addressing issues relating to intermittent energy sources. Would the implementation of smart grid technology assist the development and useability of renewable energy sources? If so, can you explain to the committee how these technologies can work together?

ENA members have indicated that presently there is very little monitoring of low voltage networks. However, the rollout of smart meters will provide thousands of low voltage distribution network information points. This level of information from smart meters, or other information points on the network, will provide information on things such as voltage variations and energy flows.

The deployment of segments of smart grid technology, namely the two way monitoring and control, will provide both extensive historic and near real-time network visibility and control. This will assist in the management and enablement of renewable generation by providing network operators with data to reconfigure networks in near real-time as required. This combined with advanced energy storage technologies and sophisticated meteorology forecasting data, will provide the tools to efficiently manage the distributed generation and load/generation levelling.

Question 13: The committee has received evidence that an increase in the percentage of renewable energy in Australia's energy mix will significantly increase the price of electricity. What are your views on this?

ENA members have stated that distributors do not yet have a full understanding of the complexity involved in managing a two way flow network with large volumes of distributed, intermittent generation.

If forecast embedded generation uptake cannot be relied upon, distributors still need to build the network to cater for peak capacity, in any location, in order to ensure energy is able to be supplied to customers despite the weather conditions.

The ability to transition the old technology from a one way flow electrical network to a two way flow electrical network will incur additional costs in the form of protection equipment, electrical network IT systems and network management and operational practices as they are upgraded.

These factors may lead to some cost increases from a distributor viewpoint, in addition to the replacement of much of the aged infrastructure installed over the last half a century. However, it remains to be seen whether embedded generation will reduce the overall wholesale market and hedge costs, as well as the CPRS costs, to result in a lower bill to customers overall.

Question 14: There has been some public comment regarding the potential of smart grids in addressing issues related to peak demand. Can you elaborate on this for the committee?

One of the main limitations of the existing electricity production and delivery processes is that consumers are passive participants, with limited accessible information to demonstrate energy usage and costs, little or no choice about energy source and only receiving a bill weeks after using the electricity. The wide uptake of domestic and commercial air conditioning has led to peak demands coincident with high temperature days and therefore lasting for only small proportions of the year. The lack of any real-time pricing or load control at times of peak demand have led to much larger growth rates of peak demand over growth in annual energy.

There will need to be a greater dependence on the need for consumers to fundamentally change the way that energy is used to enable peak demands to be managed into the future. Smart Grid is a way of potentially achieving this. A main objective of the smart network is to enable consumer choice, and as increasing awareness of climate change and the financial impacts of rising electricity prices take effect; consumers are beginning to show a willingness to become participants in the energy market and to make choices about their energy use.

The key means by which peak demand can be reduced is by:

- providing consumers with information about the amount and cost of the energy they are using and enabling them to make choices before they buy;
- facilitating local, renewable generation and providing better ability to deal with the intermittency of large-scale renewable generation such as wind, wave and solar;
- careful facilitation of the uptake of electric and hybrid vehicles as a means of providing distributed storage;
- encouraging energy efficiency and conservation; and
- deploying sensors and smart grid applications that enable more efficient use of existing assets such as condition monitoring, dynamic ratings, power factor correction and grid automation.

Question 15: In the ENA's view, can the implementation of smart grid technology contribute to improved energy efficiency? How would this work?

The means by which the energy industry will deliver a smart network is to add an 'intelligence' layer to the core transmission and distribution systems. This intelligence will enable secure, reliable and cost effective two-way energy and information flows to and from consumers and devices on the network, and will be supported by enabling solutions.

A secure communication network is essential for a smart grid to flourish. Smart grid technology offers the opportunity to switch and control the power flows on the distribution network in real time in order to assist in reducing network losses and in turn, increase efficiency. This type of operational management of the network has not been done before and there a number of issues that have to be taken into account (such as impacts on power quality) for this to be implemented effectively. A significant amount of communication, sensing and automation infrastructure would need to be deployed, coupled with intelligent local systems and centralised back-end systems to get such a network optimisation scheme to work.

Deployment of smart grid technologies within the home such as in-home displays and portals will enable customers to monitor and manage their energy usage and will facilitate greater energy efficiency measures by the customer.

The implementation of smart grid monitoring and control devices will allow real time and historic data to be used to manage the operational and planning applications with maximum efficiency. ENA members have stated that current practice involves the use of minimal data sets and often theoretically calculated figures where real data is not available, often based on a single phase reading, to determine the operational and planning requirements. The availability of an extensive array of real time accurate data, provided by the deployment of smart grid devices, will allow these functions to base all determinations on accurate, three phase data, maximise operational efficiency and operational/capital expenditure.

Question 16: In the ENA's view, what role should government play in the implementation of smart grids in Australia?

Provision of research and development or grant funding for smart grid demonstrations or trials is an important way to facilitate implementation of smart grids in Australia. The Australian Government's National Energy Efficiency Initiative and in particular the *Smart Grid, Smart City* trial, is an effective way to achieve this and will be very valuable for the sector.

Assistance by Government with regulatory and standards changes would also assist. In respect of cost recovery, the existing regulatory framework may prove to be inadequate and inflexible because of the five-yearly cycle of regulatory reviews and the long lead times involved in educating and appraising regulators of the changed infrastructure requirements. ENA therefore firmly believes that more flexible and innovative mechanisms should be put in place.

To optimise investment in emerging smart network technologies, there are three areas in which the regulatory framework needs to be examined:

- facilitating research and development expenditure;
- provide incentives for advancing smart grids; and
- ensuring the full value of investments in smart grid technologies is maximised.

A challenge to smart network implementations across Australia is that the current 'ex-ante' regulatory framework does not adequately accommodate change and the adoption of new technologies in a timely fashion. The regulatory framework needs to be modified in a way that supports the implementation of smart network solutions across five-year regulatory periods. It is in the interests of the network industry—and ultimately the national interest—that policies should be amended to encourage businesses to optimise their investment in this area. ENA also believes that in order to gain the maximum benefit from the investment of smart network infrastructure and technologies, it is essential that cost reflective pricing to consumers is implemented.

Any investment to stimulate the initial development of smart networks should be directed towards funding the areas that to date are not enabled as part of the current regulatory framework. This may include areas that involve multiple industry participants such as the development of electric vehicles.

Another issue which ENA believes is important for the government to consider is the standardising of smart grid technologies, information and data formats. The national coordination of the deployment of these technologies would see the deployment of a cohesive smart grid much sooner and would assist in ensuring inter-operability between systems. An example is the approach by the different states to smart meter deployment, coordination at a national level including a controlled and monitored trial and learning program would see a much more efficient and consistent deployment.

Question 17: The committee has heard some evidence noting the benefits of distributed generation. What are the ENA's views on this?

ENA members have indicated that there may be several benefits resulting from distributed generation. A potential benefit may be reduced network losses due to the generation source being located nearer to the load source, thus reducing transmission and some distribution losses and allowing the network to be operated more efficiently.

There may also be some security of supply benefits as the reliance on a few large generators and a transmission network is reduced. There is also the potential that capital investment in networks could be deferred if the embedded generation can reduce the demand on network assets and can be relied upon to maintain reliability levels.

However, a key problem with intermittent generation sources is that they are not always continuously available and energy storage technology is still in its infancy. The existing electricity networks were designed for bulk generation and transporting energy to loads, with distributed generation there will be a number of challenges to overcome in re-designing and adapting the network for this concept.

Question 18: Are there any issues regarding regulation or taxation that the ENA would like to raise with the committee?

Please refer to the answer provided to question 16.

I have also attached for your information, a copy of the *ENA Smart Networks Position Paper* which is a high level document aimed at generating discussion on the development and implementation of smart networks (smart grids). ENA is also currently developing a Smart Networks Roadmap and would be happy to provide you with a copy in due course.

Should you wish to discuss the issues raised in our submission please contact me on (

Yours sincerely

Andrew Blyth
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