Secure Electricity Systems for 2030

Preamble

The Academy of Technological Sciences and Engineering held an International Workshop on '**Secure Energy Systems**', drawing together the experience, challenges and future strategies of overseas and Australian organizations involved in the development and use of electricity networks. This brief report provides a high-level summary of issues discussed and conclusions reached during the Workshop.

Introduction

In the past two decades significant changes to the structure of the generation fleet in the National Electricity Market (NEM) has occurred, initially with a large increase in the proportion of gas-fuelled generators and more recently with a rapid increase in wind generation capacity. Future scenarios for the development of capacity to meet growth in demand typically include a continuing increase in the proportion of gas and wind generation capacity.

The supply network has become a immensely complex system of suppliers, transporters, and users, all with complex and changing needs and opportunities. The need to maintain long-term viability and integrity of the supply system, in which the energy delivery systems of gas and electricity are increasingly intertwined, poses both short-term and long-term challenges necessitating parallel consideration of their development and extension.

This trend has considerable impact on the structure and operation of the networks, both transmission and distribution, that constitute Australia's electricity transportation system.

As set out below the future is characterized by a greater than previous level of uncertainty at every stage from generation through transmission to the customer load.

Drivers of Change

Network structure and operation is being impacted by a number of factors associated with both energy generation and energy utilisation.

The shift to wind (and in the future to other renewables such as solar) and gas-fuelled generation has been the result of a number of policy initiatives by governments, including renewable energy targets, reduced carbon intensity in the fuel cycle, and the shift to dependence on private equity and capital for energy investments.

This has created significant changes in the structure of the generation fleet.

Generators and generation facilities are becoming smaller in capacity, and are often located remote from the main grid, or embedded within the distribution network. These generators are creating a power system with much lower stabilizing rotational inertia than had previously been the case, with consequent impact on system stability, and have reduced capability to contribute to voltage and frequency control. The more distributed

nature of new generation facilities, particularly wind generation, results in more numerous but less strong connections to the main grid.

Wind and solar sources of energy are characterised by high variability and low predictability of output power on both short- and long-term scales, and thus are difficult to schedule effectively in the market.

Most important, the incentive to incorporate renewable energy sources into the generation mix results in multiple possible scenarios of technology and location for future generation development, which increases the complexity of transmission planning and development.

There are also significant changes occurring in the utilisation of electricity which are creating greater uncertainty in the forecasting both short-term and long-term energy demands. Energy scheduled in the market is influenced by embedded generation (such as solar panels) the extent and location of which are often not accurately known, and whose production patterns are variable and unpredictable. The impact of demand side management actions, either technical or voluntary, is changing usage patterns, as are customer usage preferences. Seasonal and temperature-dependent changes to past patterns are evident.

Changes in Demand Characteristics

Significant changes in the characteristics of the demand for energy are evident. The impact of demand management initiatives, both active and passive are having a discernable influence on patterns of consumption, with diurnal and seasonal changes in demand patterns occurring. At the same time, consumer usage preferences (for example, airconditioning) are modifying both the quantum and the pattern of energy consumption, with changing temperature-dependent characteristics evident.

Renewable energy initiatives and the integration between gas and electricity markets are leading to a more volatile energy cross-substitution activity, while evolving ‘new’ consumption such as desalination plants, coal capture and storage, and electric/hybrid vehicles, and ‘old’ resources demands such as mining, transportation and gas liquefaction, are causing greater uncertainty as to future demands and consumption patterns.

The combination of these influences is creating a significant demand and energy forecasting uncertainty. This has an impact on future energy supply scenarios and uncertain transition pathways from traditional fossil-fuelled generation of electricity to a more eclectic mix of production technologies.

Technology Issues

A broad spectrum of technical issues is evolving in the network due to the changes evident and forecast for the energy production and consumption cycle.

The unpredictable short-term volatility of energy generation by wind (and increasingly solar) poses considerable challenges for the scheduling of generation, and will require a greater understanding and management of the responsiveness of generation facilities to short-term excursions in power production. Modelling capability in the transient and dynamic range will require considerable enhancement to optimize the design and response of facility and system control systems. The impacts of this volatility on power flows will require improved capabilities in network planning and protection, and in

analyzing dynamically the consequences of this volatility for control, stability and voltage and frequency management.

The limited data visibility for embedded generation and its operating regimes will pose problems for short-term forecasting and scheduling, with possible reliability and efficiency consequences. Likewise, the evolving technologies of energy storage will poses challenges for both the system and the market.

It is evident that improved modelling capabilities in various time domains will be required. This requirement will become increasingly important as the network becomes more actively managed through increased penetration of ICT technologies in the acquisition, fusion and simulation of network data to optimize delivery and operations. With the roll-out of intelligent networks and smart grids, the network management challenge will move from the current 'silos' of transmission and distribution to a more holistic end-to-end, cross-organisational activity with data standards and exchange a fundamental requirement.

The impact of new technologies on network operation and performance must be underpinned by new concepts of system reliability, and will require new measures and techniques for modeling of network robustness and resilience.

Regulatory and Market Issues

While the current market structure has served Australia well over nearly two decades, the contemporary policy interventions have caused distortions in the market. The gross energy market does not reflect the externalities of cost impost from non-scheduled generation effectively, nor the operational impost of such generation. The increasing requirements for robust and resilient systems as a consequence of decreasing political tolerance of major outages, will require regulatory and market changes for efficient economic out comes.

The inefficiency in network development arising from sequential investment connecting small generation facilities, is of serious concern and may be addressed by arrangements such as the proposed SENE (Scale efficient network extensions) initiative which will assist in improving investment efficiency.

Investment issues

The consequence of market reforms in the electricity market in the 1980's is that investment in new energy facilities is now almost totally dependent on equity and private capital. This results in investors in facilities having to access the global financial market, in which Australian investments are placed in a competitive position with other global investment opportunities in the energy sector. While in Australian terms the requirements for investments in network and generation facilities are large, in the global context they are only a few percent of the global investment market in the energy sector. Thus Australia is not a make-or-break market for investors, and the Australian market and policy position needs to ensure that the investment climate in Australia is attractive to investors, with high levels of clarity and stability in the energy environment. This is not the case at present as returns are seen to be low relative the risks involved, uncertainty exists in respect to carbon pricing, there are none of the investment incentives that are common elsewhere and government policies are subject to frequent changes.