Towards Australia's Energy Future

The Enabling Role of Smart Grids

Disclaimer

SGA Contacts for More Information

Secretariat: admin@smartgridaustralia.com.au
President: president@smartgridaustralia.com.au
CEO: ceo@smartgridaustralia.com.au
Website: smartgridaustralia.com.au

Cover Image: adapted from a photo by Phillip Parr (September 2006)

Executive Summary

We all have a vital interest in ensuring the success of Australia's energy future and a transition to a low carbon economy. What is at stake is not only economic development but also social and environmental well-being for our communities and for future generations of Australians.

Australians require energy to sustain their changing lifestyles. Our economy is predicated on affordable and reliable energy. We also have a global responsibility to meet our sustainability targets. All Australians are concerned about the rising cost of energy but this belies a number of key industry issues which are driving price rises.

As a consequence the industry is faced with a number of challenges:

- maintenance of ageing infrastructure;
- integration of next generation technologies and renewable energy sources;
- recovery of the cost of past long term investment; and
- establishment of a market structure that supports competitive consumer choice.

Whilst we recognise that these represent imperatives for change, they also represent opportunities to not only modernise energy networks but to also deliver new products and services to meet the unique needs and wants of all Australians.

Exactly how the future will unfold and the pace of change is unknown but the broad direction is clear. The installation of renewables will increase, homes will get smarter, energy efficiency is becoming important and there will be a growing uptake of electric vehicles (EVs).

Change enabled by Information and Communication Technology (ICT) is familiar to many Australians and indeed to the industry. However, it has yet to reach its full potential in what it can deliver across energy networks. Further, without industry collaboration and proactive government leadership the transformation may take many decades to complete.

The real question is why we need to make a fundamental change now?

Australian consumers expect their lifestyles to be sustainable and affordable. In addition, industry would like to avoid short term overly-reactive decisions and appropriately manage the risk and uncertainty associated with long term investments. From a network perspective, the future demands modernisation of Australia's electricity networks, transforming them to become so called "Smart Grids". This will enable a transition from passive to active consumer and empowered participant who can contribute to minimising future long term price rises.

This paper argues that, due to the far reaching benefits on offer, there is justification to accelerate the modernisation and automation of the electricity grid and to promote competitive consumer engagement. There are, however, impediments to the transition and this paper makes recommendations to overcome them.

The necessary and inter-related actions required to achieve an optimum outcome for Australia are:

1. Work towards a common direction for all government policies and initiatives, forming a cohesive view recognising that the Smart Grid is the foundation for unlocking Australia's energy future.
2. Develop a framework that creates incentives for industry innovation to encourage breakthroughs in consumer engagement.
3. Review institutional arrangements to identify barriers that need to be dismantled to provide the most appropriate incentives for investment in modern technologies.
4. Promote broad collaboration to progress the above recommendations, recognising that the active participation of many stakeholders is needed to deliver these benefits.
5. Review and update education and training programs to reflect the more pervasive role that ICT will play in the electricity sector of the future.

Australia's energy future is in our hands. SGA looks forward to playing its part in realising the benefits of the changes that lie ahead.

---oOo---

Table of Contents

---oOo---

1. Introduction

Australians have all come to expect change that provides consumers with greater choice and greater control, and change that improves the operational efficiencies of the nation's industries. It is evident everywhere, in transport, in telecommunications, in the way people live, learn, work and play.

One of the sectors experiencing significant impetus for change is the energy sector, but it will also be one of the more difficult environments in which to achieve progress. Australia is moving through a period of major reinvestment, shifting away from traditional energy sources and responding to increased consumer awareness and demands. At the same time as it is making these changes, it must ensure sufficient energy capacity and reliability to underpin a 21st century economy. There will be many challenges, not the least of which will be the industry's need to engage closely with consumers and the community to develop effective solutions on this journey of change.

In recent years, the modernisation of the electricity sector has been identified on the critical path to transitioning Australia to a low carbon economy. Any significant penetration of distributed renewables, solar and wind farms, distributed storage, EV charging, will require a modernised grid. Failing to do this effectively will create a bottleneck to advancing Australia's energy future.

There are numerous examples of how technology change has enabled the transformation of established industries – resulting in the creation of new products, services, business models and business opportunities. It can be seen in the Finance and Banking sector, with intelligent automation in the Manufacturing sector, and particularly in the Communications sector. These transformations are reshaping Australia's society and its future.

The next twenty-five years for the electricity industry will also see a major transformation in the way we generate electricity, the way it is distributed and, most importantly, the way it is managed and used by commercial and residential consumers. As in other sectors, the impact of technological change on the electricity industry will be disruptive and far-reaching. In order to fully realise the benefits of this change, the electricity industry will need to become actively involved and engage with the broader industry, consumers and the community.

At this early stage, it is impossible to accurately predict all of the innovations that will occur. Nevertheless, broad directions and some of the initial steps that are needed can be identified, including the development of a national energy strategy that clearly articulates the participation required from a diverse range of stakeholders.

This paper discusses:

- the importance of a sustainable energy future;
- the drivers of change in the industry;
- opportunities arising from the transformation;
- significant trends and their impact on the grid;
- the imperative of moving quickly; and
- concludes with a list of recommendations.

---oOo---

2. An affordable, sustainable energy future is vital to Australia

2.1 Sustainability

The world is facing unprecedented energy challenges. Australia and other countries traditionally base economic success on access to cheap and reliable energy, and availability of secure, reliable and competitively priced energy supplies is crucial to the continuing economic development of Australia.

Australia has been fortunate to have ready and relatively cheap access to plentiful supplies of energy up until now. However the environment in which the sector operates is changing and stakeholder expectations are evolving. As a result, significant change is needed to ensure that Australia's energy future is sustainable.

The Australian government has set a goal of having 20% of the country's energy needs sourced from renewable supplies by 2020[i] – less than a decade from now. To this end, a range of policies have been introduced to encourage reductions in energy consumption and the adoption of cleaner energy sources. This includes hot water system replacements, more stringent building codes, insulation and solar programs, the Renewable Energy Target (RET) scheme and the recently introduced price on carbon[ii].

Despite the relative abundance of clean energy resources, only 5% of Australia's primary energy is currently generated from renewable sources[iii]. The options that are available range from geothermal and bio-fuels to wind, wave and solar. However, there is a large amount of development work required before these sources will be able to support a major proportion of Australia's needs. The development lead times required to change the supply paradigm are long and action is needed urgently to plan and implement the transition to a more sustainable future.

Of the 95% of energy that is generated from fossil fuels, electricity accounts for 43% and road transport for 18%[iv]. This heavy dependence on traditional fossil fuels continues in an era when the long-term viability of such fuels is being questioned and there is a general acceptance of the need to find alternatives.

The current supply paradigm needs to change as the adoption of renewable fuel sources increases. Related elements that exacerbate the need for change include the growing electrification of industry processes, the expected trend towards more road transport being powered by electricity, and the introduction of more storage of electricity to bridge gaps between time of generation and time of consumption.

To assist in meeting sustainability objectives, tomorrow's electricity network needs to be much more intelligent, utilising sophisticated information, communication, sensing and control systems to cope with a more dynamic and diverse operating environment.

2.2 Affordability

Electricity costs are estimated to have increased across Australia between 20-33% in the last three years and are forecast to further increase by about 29% by 2014[v]. The concern over increasing prices for energy in Australia has become a significant public issue, and these concerns are likely to continue as additional infrastructure is required to meet the demands of a society that depends on energy for its well-being.

There are numerous factors underpinning electricity price increases. They include:

- ageing network assets requiring replacement;
- network augmentation investments required for new small-scale generation;
- network investment associated with increasing peak demand which is growing faster than energy demand;
- mandated increases in network security, safety and reliability standards in NSW, Queensland and Victoria – for example, Victoria's new bushfire safety standards;
- rising cost of debt;
- rising costs of copper, steel and aluminium driven by the commodity boom;
- the price on carbon.

Network costs typically account for 40 to 50% of an electricity bill, and replacing ageing electricity network assets have been estimated to account for over 40% of network investment in NSW[vi].

Network companies and generators must build infrastructure to meet peak demand which is largely driven by increasing penetration of home appliances such as air conditioning units[vii]. In a submission to the Prime Minister's Task Group on Energy Efficiency, Ergon Energy estimated that around $500 million of network investment exists to support peak demand that occurs just 3.3% of the time (in aggregate, equivalent to approximately 12 days per annum[viii]). Clearly, peak demand leads to poor asset utilisation, and it is therefore appropriate to question whether traditional solutions focused on building more capacity are adequate to meet future needs.

It is expected that costs will rise regardless, but the extent to which they rise can be mitigated by innovation that exploits our ability to mobilise local and global intelligence to pioneer solutions that facilitate a 'smart' evolution of Australia's energy delivery systems. New solutions will range from technological advances to new business models and skills, many of which will provide jobs and new business opportunities to support the more efficient delivery of electricity supply demands by customers.

Residential electricity consumers significantly influence our economy and are the strongest political constituency. Therefore it is imperative that significant effort is invested in bringing the community on the transformation journey. Without this understanding and alignment, the consumer will lack the interest and motivation to support this market-based transition and may potentially obstruct smart grid progress.

Keeping the cost of energy affordable to individuals and businesses in Australia translates into some very clear goals for the electricity supply industry. Every opportunity must be seized to reduce losses, improve operational efficiency and optimise asset utilisation – without compromising power quality and reliability. One of the keys to achieving this lies in modernising the grid by exploiting information and communications technology.

2.3 Timing

The issues of sustainability and affordability pose very real challenges for the electricity sector. A key question to address is *"How much more expensive will the change be if Australia defers action until it no longer has a choice?"*

It is likely that costs will continue to increase to meet rising energy and peak demand growth whether or not Australia embraces smart grids. However it is critical to accept the challenge to develop a smarter and more efficient electricity sector as soon as possible.

---oOo---

3. Shaping the future – industry drivers

Change is being driven not only by external influences, but also by emerging trends within the sector that impact on the energy supply chain.

3.1 Managing distributed energy resources

Modernising the grid will be integral to managing the complexity and allowing real-time control of distributed energy resources. Technology advances in control and communications within the grid are needed to balance supply and demand within the grid, thereby ensuring stable operation. Improved information about the network status underpins effective management of infrastructure to ensure safe and reliable supply to consumers and the rapid identification of loss of supply for proactive remedial action. An additional benefit is more accurate information for better network planning to ensure reliable electricity supply and optimised network investments.

For managing fluctuations in renewable energy and coping with peak demand, grid-scale storage batteries are potentially the most promising albeit disruptive technology. The advent of economic battery storage may also give rise to new business models. Batteries may be located at the generation source, within the grid, at a community or at an individual site level to address different aspects of energy management. The eventual scenario will be shaped by technological advances, or possibly the evolution of secondary markets from partially exhausted electric vehicle batteries. Significant battery markets may not eventuate for up to 20 years; in the meantime, a smart grid approach to management of intermittent generation will be necessary to ensure a stable and reliable electricity grid.

3.2 Investment models in a changing world

One of the most difficult aspects of incentivising the transformation is ensuring that parties making an investment capture the benefits or are appropriately remunerated for the risks to which they are exposed. It may be argued that current regulatory structures do not adequately address the necessary incentives, economic returns and value allocation for all stakeholders – especially when it comes to Smart Grid investments.

Another significant challenge in advancing the development of smart grids is the time delay between upfront investment and benefits realisation. This is comparable to, for example, the slow return on investment of energy efficiency solutions, such as insulation and double glazing. Investments such as the current implementation of smart meters in Victoria will take a period of years before all benefits are fully realised. Timeframes could extend even further if these devices are not utilised to implement appropriate tariffs to motivate consumer behaviour to reduce peak demand and improve energy efficiency.

Many of the social and economic benefits of Smart Grids are national, extending beyond the operators to the wider community. As such, they are typically not reflected on the balance sheets of the individual energy companies involved and nor can they be easily factored into their business cases for investment. Governments, who have primary responsibility for driving the national interest, need to develop outcomes-oriented policies rather than trying to pick technology winners. These policies should be aimed at stimulating investing in smart technologies that unlock the overall societal benefits of a modernised grid.

Investment in smart metering, for example, is a potential enabler for a range of smart grid outcomes provided that requirements are specified with a view to future capabilities. There is the potential to forgo significant benefits if the focus is only on metering objectives without recognising the additional benefits that can be delivered through more 'feature rich' meter specifications. Understanding how consumers want to interact with their service providers (for example, being able to actively control energy use via smart phone applications), and how this could be facilitated through appropriate meter functionality is important for ensuring consumer engagement and raising awareness of future possibilities.

3.3 Rethinking market structure

The first step in empowering a consumer to become an active participant in the market is to provide accurate and timely information – contrast this with the current practice of issuing a three-monthly bill in arrears.

In addition, a single tariff provides little scope to drive a range of improved outcomes. Accordingly more targeted dynamic tariffs will be required to encourage more energy conscious consumer behaviour and thus allow infrastructure investment costs to be rationalised.

An effective approach involves cost-reflective pricing to target consumers who contribute to increasing peak demand coupled with energy management tools and systems to help these consumers better manage their energy consumption. Safety-net protection for consumers with special needs or hardship should of course be an integral part of any new system.

3.4 Information & Communications Technology (ICT) Impact

Whether or not the full potential of Smart Grids is embraced, ICT is playing a growing role in the electricity industry. Supervisor Control and Data Acquisition (SCADA) systems and central information management are becoming more sophisticated, many grid hardware elements are now available with data interfaces, and digital technology is commonly replacing older analog equipment. The change extends into the user domain with growing adoption of technology such as computer-based building energy management systems. These provide opportunities to manage consumer information within the premises and regulate demand in response to price signals.

In combination, ICT is having a far-reaching impact on the skill requirements of the industry and on the approaches to both traditional and new challenges.

Some networks are already making advances in developing automated systems to minimise the number of consumers impacted and duration of outages. Other intelligent applications are being developed such as weather prediction models. These rely on a wide range of information including both network sources and Bureau of Meteorology data to anticipate problems and schedule work crews to minimise outages.

A smart grid implementation takes this trend to its logical conclusion with the introduction of potentially millions of new intelligent end-points into the network. There will be major new challenges in:

- capturing relevant information;
- deploying capable 2-way real-time communications fabrics;
- processing, managing and storing this information – whether locally or centrally;
- operating associated real-time systems;
- maintaining and upgrading technology platforms; and
- ensuring appropriate security and privacy.

One of the more powerful options for managing the large volumes of data involved will be to distribute processing of the data, thus limiting the amount of data that has to be transported back to a central location and enabling a faster response to changing local circumstances. A modern IP-based communications fabric can support distributed processing in the data communications platform itself, allowing local data processing. Intelligence at the edge of the network can also be applied to requirements such as translating legacy protocols.

---oOo---

4. Golden opportunities – seizing the future

4.1 Modernising the grid

The Smart Grid represents the modernisation of today's grid and is central to Australia's energy future.

The Smart Grid enables:

- real-time management of electricity supply-demand across a complex ecosystem of centralised and distributed generation and storage including fluctuations of renewable energy sources;
- machine-machine communications between smart grid and smart devices from smart appliances to smart building management systems to smart EV chargers in both commercial and residential sectors; and
- asset monitoring and increased operational efficiency across the electricity grid itself including automated outage management.

4.2 Broad-reaching benefits of a smarter grid

The US Department of Energy suggests that the deployment of Smart Grid technologies is expected to create improvements in six key value areas[ix]: reliability, economics, efficiency, environment, safety and security. Figure 1 shows how these value areas build on particular components of a Smart Grid implementation. The 'many-to-many' relationships illustrate the synergy of smart grid solutions, an effect that must be considered when the scope of the smart grid is planned to ensure the benefits are optimised.

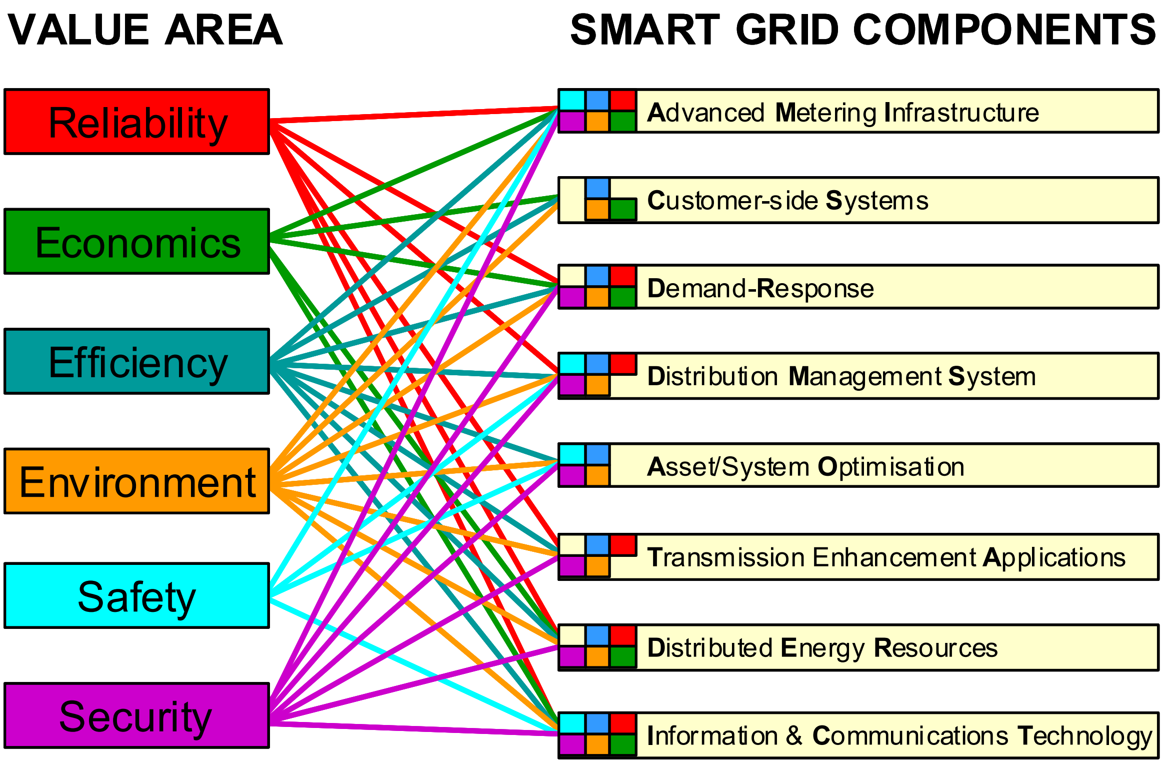

Figure 1 – Key Value Area Relationships

The benefits of a Smart Grid implementation encompass communal benefits as well as benefits to individual stakeholders in the energy value chain.

At this point in time, significant investment is required to upgrade Australia's ageing electricity network[x]. This represents an opportunity to direct this investment into modernising Australia's networks given that traditional solutions are unlikely to be adequate to meet emerging new requirements. Deploying grid-side 'foundation' technologies will also clear the way for the development of consumer products and services in the future and attaining the associated benefits outlined below.

Much of the progress on the consumer front will only start to unfold when other critical fundamentals are in place – such as the introduction of time-of-use tariffs, the evolution of smart appliances and energy management systems, the emergence of new services and service providers. In addition, once the basic functionality and infrastructure is in place, benefits from services and capabilities that cannot today be envisaged are inevitable.

Stakeholders (utilities, residential and business consumers, vendors, society) can look forward to the following benefits of a smart grid:

(a) **Minimising long-term price rises** – through improved operating and market efficiencies, reduced supply cost resulting from peak reductions, consumer engagement, and deferral of future capital projects. It should be noted that up-front investment is required to modernise the current grid, and some price rises are unavoidable. However, Smart Grids will help to keep those prices to a minimum over the long term.

(b) **Consumer empowerment** – through detailed and timely information to enable effective purchasing and behavioural choices. Near real-time information that shows which appliances use energy, and when, will enable consumers to take action in managing their costs, consumption and appliance selections.

(c) **Improve safety** – for both consumers and employees by reducing injuries and loss of life from grid-related incidents. Improved monitoring and decision support systems will quickly identify and manage hazards, reducing exposure to health and safety issues.

(d) **Reduce environmental impacts** – by reliably and economically integrating high penetration levels of renewable resources as well as reducing system losses and conserving energy. Smart Grids will incorporate energy storage and demand-response and thereby increase the capability of the electricity network to balance intermittent renewable supply with consumer demand patterns, contributing to the reduction of carbon emissions and other pollutants.

(e) **Improve efficiency** – by reducing the cost to produce and deliver electricity, through the use of grid information, to improve operational and maintenance processes and by enabling more effective capital investments through better load forecasting. Additional savings will be achievable by consumers when they can utilise smart tools to understand their usage and take action to use renewable energy sources and more efficient appliances, or improve building design.

(f) **Improve reliability** – by reducing the probability and consequences of loss of supply through outage identification down to the level of individual consumers, self healing networks, improved power quality and real-time condition monitoring of grid devices. More reliable supply for commercial and industrial consumers contributes to benefits within the economy generally as well as for the employees and customers of those organisations.

(g) **Improve resilience** – through increased utilisation of a diverse range of energy resources, coordinated effectively to achieve supply and demand balancing. Integrated information and communication technologies, sensors and control devices will help grid operators better understand the state of the grid following a major event, enabling them to more rapidly and effectively respond to restore grid operations. Failure of a major generator or transmission line could be supplemented by distributed generation and storage assets incorporated into a smart grid in a localised area.

(h) **Improve energy security** – by increasing the integration of renewables and reducing dependence on imported fuels through the electrification of transportation and other amenable industrial and commercial processes. Electric vehicles, representing a manageable load and energy store, can facilitate the integration of intermittent renewable generation into the grid and have the potential to feed excess stored energy back into the grid during periods of high demand.

(i) **Improve asset utilisation** – by effectively balancing supply and demand using real time system data, operating equipment within design tolerances, deploying augmentation more selectively, and streamlining maintenance programs. Real-time monitoring of grid devices facilitates more targeted and efficient grid-maintenance programs (resulting in fewer equipment failures, safer operations and lower overall maintenance costs) and extends the life of system assets.

(j) **Economic benefit** – through a reliable and more cost efficient grid, creating new jobs, products, services, and markets which will help Australia to remain globally competitive. New generation and storage devices, including electric vehicles, will encourage the development of new products and services for consumers as well as for the utility industry in areas such as demand response.

Grid modernisation has come onto the agenda of every electricity utility, driven by specific tangible benefits that they stand to realise in particular areas of their business. Nevertheless, capturing the full spectrum of benefits requires a holistic approach that is broadly supported by all stakeholders, including consumers.

In this regard, the level of awareness and support amongst consumers is generally low, and there is an understandable reaction against any investment which may be perceived simply as adding to cost increases. More work is required to develop convincing smart grid value propositions and to communicate the benefits to all stakeholders in order to encourage the removal of barriers and effectively progress the development of a smart grid.

---oOo---

5. Broad directions are clear despite uncertainty on specifics and timeframes

5.1 Demand trends

Driven by a rising population and a growing number of electric appliances in the home (many capable of high energy consumption), the total demand for electricity over the past decade has increased by 19%[xi].

The overall situation masks two different underlying trends:

- the growth in average demand per household has slowed and even shows a slight decline in the past two years; some caution needs to be exercised in interpreting this as it has generally been a benign weather period; other factors include the adoption of electricity saving measures (better use of solar hot-water heating, insulation etc) and the uptake of distributed photovoltaic arrays; electricity price rises and the downturn in global economic conditions may also be contributing factors, so any reduction due to these may not necessary be an enduring one;
- peak demand – typically occurring 3.3% of the time (in aggregate, equivalent to approximately 12 days per annum) continues to rise; without the ability to moderate peak demand, both generation and distribution businesses need to continue upgrading their infrastructure to cope with peaks if reliable supply is to be maintained; clearly this represents poor utilisation of assets.

The combination of stable (or falling) average demand and rising peak demand presents a dual driver for price increases. Rising peak demand adds to the requirement for further infrastructure investment, but that investment needs to be recovered over a small number of kWh (kilo-watt hours) supplied.

5.2 Renewable energy sources

The pressures to embrace new sources of energy are growing.

At a macro level:

- Australia has embraced renewable energy targets as part of its effort to evolve towards a cleaner and more sustainable energy future; this is contributing to the deployment of large-scale renewable generation plants (wind, solar);
- The price on carbon creates commercial incentives to replace fossil fuels (which produce high carbon emissions) with fuels that have a lower impact on greenhouse gases (such as solar, wind, gas and potentially nuclear).

At a household and business level, Australia's adoption of rooftop photovoltaic (PV) arrays has been nothing short of spectacular[xii]. Early uptake was driven by attractive government support schemes and lucrative feed-in tariffs. Whilst these have been substantially scaled back or withdrawn, ongoing increases in electricity prices coupled with falling capital costs as the global market for PV technology achieves new economies of scale may see growth continue into the future. Installed domestic capacity has risen from approximately 10 MW in 2007 to 1,450 MW by the end of February 2012[xiii], and AEMO predicts continuing growth over the coming decades.

5.3 Continuing electrification

Fifty years ago computers were large and expensive equipment used only by the biggest organisations. The advent of the microprocessor saw enthusiastic uptake of desktop computers throughout the community – and cheap microprocessors are now embedded into much of the technology that is used in every day life – from vehicles to almost every electric appliance.

Coupled with low-cost electric motors, much of our modern lifestyle is increasingly supported by equipment that relies on electricity for its operation. In some areas – such as air-conditioning – the wave of uptake has been dramatic. In other areas, the process is more subtle but nonetheless pervasive. In addition to adding to overall demand, increasingly sophisticated and sensitive equipment requires consistent power quality to prevent damage.

The trend towards intelligence and electrification is also evident in industry. Computers and robotic technologies are increasingly used in automated assembly lines and process control systems.

Consumers will continue to embrace the best of what new technology can deliver. It may not always be easy to predict exactly what the next big 'wave' will be or when it will peak, but history demonstrates that the waves will continue to roll in.

5.4 Smarter buildings

One of the trends that can be anticipated is the application of new technologies to more effective energy management in buildings, driven by rising electricity prices and other emerging constraints on energy use.

Trials have shown that despite incentives being offered to encourage more energy-efficient practices, changes in human behaviour are often short-lived. In contrast, the choice of an energy-smart appliance at purchase time can allow a set of energy-efficiency rules to be automated, obviating the need for manual intervention under normal circumstances. Many appliances already have the inbuilt intelligence to make quite sophisticated operational 'decisions', and extending this to deliver increased energy efficiency is a logical next step.

Building codes are increasingly requiring more energy efficient practices, and this is also proving attractive to prospective occupants as a demonstration of their environmental commitment. As part of this trend, Building Energy Management Systems (BEMS) are now a common feature in many modern buildings. These deliver benefits by coordinating and managing energy use across multiple controllable elements in a building. In this approach, intelligence is centralised in the BEMS and control is asserted over individual appliances – as such, individual appliances only need sufficient communications and intelligence to respond to external requests to power on/off or to adjust operating levels.

Whatever the approach, maximum optimisation demands real-time knowledge of the electricity supply environment – whether in the form of a current supply cost or potentially more sophisticated parameters (such as the state of the grid, or the current mix of energy sources).

5.5 Electric vehicles

The electric vehicle (EV) represents one of the more major disruptive technologies that is looming – and the magnitude of demand that a large fleet could generate is very substantial. A typical EV charger could draw around 3.6 kW – significant in the context of traditional planning provision of the order of 3 kW per household. If even a modest number of electric vehicles were to start drawing at this rate in a local area on arrival home from work, the existing evening peak in that area (when PV generation has typically ended for the day) would be dramatically exacerbated.

With appropriate technology however, the potential exists to intelligently schedule such recharging demands so that they are staggered through the night.

The potential goes even further with Vehicle-to-Grid (V2G) models, where at times of critical peak demand, the grid could potentially draw energy back out of vehicles (under consumer-defined rules) to alleviate the peak load.

Management of EV charging will be critical in ensuring that the grid remains stable and to avoid incurring significant augmentation costs to cope with higher peak demand periods.

It should be noted that to achieve a worthwhile reduction in greenhouse emissions from the road transport sector, the use of renewable generation needs to be maximised.

5.6 Impact of trends on the grid

In combination, the trends outlined in this section pose huge challenges for those responsible for maintaining Australia's electricity supply.

Challenges include:

- dependence on fossil fuels may be alleviated by the increasing use of large-scale renewables, but their intermittent nature presents unique challenges;
- the demand from individual consumers is becoming less predictable due to the growing use of electric devices (some that draw heavily on the network);
- energy flows are becoming more complex due to the impact of distributed generation sources; and
- consumers react negatively to any threats to the capacity, reliability and quality of supply and to price increases well in excess of inflation rates.

For most consumers, the grid will remain the backbone infrastructure for supplying their electricity needs. However, many will seek to build a higher level of self-sufficiency in order to moderate the impact of price rises. However, the cost of catering for abnormal peaks in individual use and the wastage of energy that cannot be stored or consumed means even the most independent users will typically want to remain connected to the grid. The structure of the grid may change over time, but its central role in Australia's energy future will not.

For network operators, maintaining the balance between supply and demand is becoming a much more difficult and dynamic challenge. Two key requirements emerge:

(a) Budgeting on stable, average per-consumer demand levels has to be replaced by improved monitoring to give real-time visibility of energy flows within the grid.

(b) As imbalances emerge, improved real-time control mechanisms are needed to better manage controllable loads and to route energy to where it is needed.

Implementing Smart Grids addresses these requirements by:

- deploying sensing and control deep into the network;
- increasing both central and distributed computer-based intelligence; and
- by establishing a ubiquitous real-time communications fabric that can meet emerging new requirements.

Whilst it is essential to maintain a "big picture" focus, one element of the Smart Grid which needs to be more effectively explained is the smart meter. It introduces a framework to support time-of-day pricing, allows manual meter readings to be automated and provides some additional operational capabilities. The first of these is their most critical function, since dynamic pricing will be the catalyst that drives much progress on other fronts (such as the development of smart appliances). Other possibilities for the future include extending existing load control arrangements to devices beyond hot water systems based on consumer agreement.

Based on lessons gained from early deployments, it is clear that an investment needs to be made in communicating and promoting the benefits of smart meters (for both consumers and utilities) in order to maximise public acceptance.

---oOo---

6. Overcoming barriers to progress

In the sections following, a number of challenges facing the effective and timely development of smart grids are discussed. These need to be addressed if progress is to be expedited, and the time to act is now!

6.1 Collaboration

A significant challenge facing the deployment of smart grid technologies across energy networks is encouraging and nurturing effective collaboration between all the interested parties: distributors and retailers, consumers, the wider business community (including vendors) and government. Collaboration encompasses developing trusted partnerships with shared responsibility, focused on delivering effective and efficient progress that is in the best interests of all stakeholders.

All players must be able to see the challenges and work cohesively to focus on the changes needed to deliver agreed objectives. The parties must avoid duplication, work strategically and be flexible enough to respond quickly to changing circumstances.

Within the electricity sector, collaboration between these stakeholders is showing signs of moving in the right direction. Energy retailers and distributors are working together through a range of forums, some facilitated by government, others by industry. Key industry issues being discussed include smart metering, the changing energy environment and cost and other pressures impacting consumers.

SGA believes that these collaborations will gain considerable value by a broadening of focus. Wider engagement between the parties around new network technologies and how they can deliver efficient and reliable electricity to consumers will drive benefits for all stakeholders. More work is needed to ensure that collaborative efforts become the norm rather than incidental.

To some extent, Australia is in the fortunate position of having a foundation for national collaboration across the major political parties. They are broadly supportive of the need for technology upgrades in electricity networks to address the challenges of climate change, energy efficiency, reliability, safety and rising network costs. The major parties also have similar goals in terms of carbon reduction targets (albeit with different approaches to delivering progress) and these will drive efforts towards increased sustainability and energy efficiency.

To date, many of the policies affecting the electricity industry have been focused on individual issues – sometimes with unintended consequences. If instead a holistic approach was taken, the end result would be more effective and coherent government leadership. Smart Grids would also form a natural core that functioned as the "glue" between elements in the energy supply chain.

6.2 Technology maturity

Many of the Smart Grid technologies are relatively new and either have not yet been used in energy networks at scale, or represent a significant step-change in capability. Distributors are testing a number of these technologies to understand how they can fit together in the Australian environment – including in the "Smart Grid Smart City" project. What needs further quantification is how the benefits of these technologies can be leveraged across the network at scale, and which parties will specifically gain the benefits.

Managing the different investment horizons and the various technologies within electricity networks can be challenging. The industry tends to make large investments in capital intensive network projects that are designed to operate robustly over extended periods of time in a range of environmental conditions. This can mean that making changes is not easy and often depends on difficult modifications to legacy systems. In contrast, information and communications technologies have a comparatively short investment cycle, with changes and upgrades occurring more frequently.

In areas of rapidly emerging technology, including Smart Grid specific and consumer-driven areas, progress sometimes pre-dates industry-agreed standards. Change can also occur at a pace that outstrips the ability of the network to adapt. The result can be unnecessary complexity, stranded investment, threats to network reliability and frustration for consumers as well as vendors.

As in other areas, Australia needs to strike a judicious balance between pioneering new standards to fill gaps and embracing appropriate international standards as they are developed. Standards are the key to ensuring easy integration, interoperability and open environments in which many suppliers can compete, thereby lowering costs.

6.3 Market participation

It is anticipated that Smart Grid technologies, coupled with open market policies that encourage competition where appropriate, will stimulate the market and attract new participants to develop and offer innovative products and services across the electricity value chain. To facilitate new entrants bringing breakthrough innovations, the 'playing field' needs to be level so they can compete equally with established participants.

New players could include:

- aggregators, bringing together sources of supply and controllable load from a large number of small consumers, and using buying power to obtain the best outcome for those consumers based on optimising their response in the competitive electricity market; the introduction of dynamic pricing (where price actively responds to demand and supply conditions) is a key requirement for facilitating opportunities of this nature;
- integrators, who specialise in bringing together disparate technology elements, business models and processes to create a coherent solution of higher value;
- energy auditors and service providers, who advise clients on opportunities to improve energy efficiency; and
- technology and product businesses, who spot opportunities in the market and devise a solution to fill the gap.

Smart Grid technologies will create the environment in which new players will be able to actively participate in the energy market. There will be a greater level of network and other information available, so they will be able to analyse the market and develop business models to meet niche opportunities.

The challenge will be creating the regulatory environment that enables all players to operate in a more open and dynamic market.

6.4 Regulation

Australians and the Australian economy rely on an affordable energy supply.

In the case of electricity, an affordable supply has been achieved by large power stations delivering their output through transmission and distribution networks. These networks are natural monopolies because they require significant investment in long term infrastructure that would simply not be economic to duplicate in any given geographic area. In other words, competition alone would not ensure that consumers received a reliable electricity supply at lowest cost.

Accordingly networks have been regulated, earning a lower but more certain return than many other investments in the economy. This balances low costs for consumers and investor confidence, ensuring that necessary economic network investment is made.

These regulatory arrangements have until recently created certainty for the market. This has been beneficial to investors, even when other sectors are operating in difficult economic conditions. However, rapidly rising energy prices are prompting consumers to question the effectiveness of existing regulatory arrangements and the need for further network investment (which has been a significant factor in price increases). In addition, the proliferation of alternative generation sources, reductions in demand due to energy efficiency measures and the advent of new technologies have the potential to fundamentally change traditional investment paradigms.

As regulated monopolies, network businesses do not operate in open competitive markets with their typically strong incentives for innovation. In open markets, competition considerations would drive the adoption of new technologies such as Smart Grids. In turn, Smart Grids also have the potential to lay the foundation for further innovation and change.

In addition, regulated businesses operating in a low-risk regulated environment are not encouraged to innovate and take risks through the introduction of new technologies. This culture further inhibits the pace of network modernisation.

In the absence of strong market forces, SGA believes that changes in the regulatory framework are needed to ensure timely modernisation of Australia's electricity networks with Smart Grid technologies. The mechanisms used must both remove barriers to Smart Grid investment and actively create incentives to encourage their more widespread deployment. In addition to reviewing the regulatory framework, consideration could be given to grant schemes or other such incentives.

6.5 Business transformation

Deploying smart grid technologies will underpin business transformation through a range of effects.

These include:

- help the electricity industry play its part in moving to a low carbon economy;
- assist in limiting the rising costs of electricity over the long term; and
- provide the catalyst for a significant change in the way electricity run their businesses.

To achieve the maximum benefits from these changes, it will be necessary for network businesses to develop new operational processes and procedures, in some cases with a profound impact on existing practices. In the new environment:

- information and communications technologies will play an increasing role in managing networks;
- as new technologies are infused into the grid, the need for new management strategies and skills to integrate and operate these technologies will intensify;
- additional real-time information from many new sources will create opportunities for businesses to streamline their operations and improve performance for the benefit of consumers;
- the sharing of appropriate information between different businesses in the end-to-end value chain will facilitate greater integration and contribute to improved efficiency; for example, with greater information available about consumer responses to pricing, distributors will be able to work more collaboratively with retailers towards developing better products and services to meet consumers needs and wants.

A plethora of new business models and services will emerge in association with the new technologies. The energy industry has traditionally been a relatively stable industry that has not faced radical upheaval at scale. This is about to change with the industry and the various stakeholders (distribution businesses, retailers, consumers and the emerging entrants) all having to cope with change at a pace they are not used to.

6.6 New skill requirements

One of the challenges that the electricity industry routinely faces is recruiting personnel to fill positions as staff move or retire. The changing nature of skill requirements will exacerbate this challenge.

Introducing next-generation technology requires experienced engineers and specialists who can manage the impact on existing systems and propose solutions that facilitate both the integration and operation of the new environment. For example, building analytical systems that can predict change and automatically respond requires skills that are only just being developed. These new skills will need to be coupled with the knowledge and experience of those who have engineered and operated the transmission and distribution networks that have served Australia so well to this point in time.

As other sectors in the economy, such as transport and water management, also undergo modernisation, the electricity sector will need to compete to attract skilled resources. This will add to the contention for skills that already exists with the ICT sector.

The changes in skills needed to support the electricity industry in the future are not widely understood at present, and urgent planning is needed to ensure that tertiary institutions can offer appropriate courses and produce sufficient graduates to meet industry requirements.

---oOo---

7. Recommendations

7.1 Clear vision

Recommendation: ***Work towards a common direction for all government policies and initiatives, forming a single cohesive view recognising that the Smart Grid is the foundation for unlocking Australia's energy future***.

Although many policy initiatives have been devised to support the transition to Australia's energy future, it is important that they be structured in a cohesive manner to reduce the risk of unintended outcomes. It is also important that the policy regime be stable and predictable to give investment certainty. This will allow each initiative to support and reinforce the other, thereby accelerating progress.

Government policies, regulations and programs include but are not limited to:

- Mandatory Renewable Energy Targets;
- the price on carbon;
- Advanced Metering Infrastructure (AMI) programs;
- energy efficiency targets;
- incentives for installing solar hot water systems and photovoltaic arrays;
- feed-in tariffs for renewable energy;
- various industry development incentives and programs;
- the Smart Grid Smart City initiative; and
- regulatory methodologies for determining electricity rates.

Changes in one area commonly have side-effects in other areas. By way of example, the promotion of rooftop solar systems through incentives and attractive feed-in tariffs has fuelled a rush of installations, and prima facie these help in the transition to more renewable source of energy. However, it has also had other far-reaching implications:

- cross-subsidisation adds to electricity prices, falling more heavily on non-participating consumers at a time when there is already great price sensitivity;
- "hot-spots" of distributed solar generation contribute to the destabilisation of grid voltages;
- the intermittent nature of solar energy means that beyond a certain penetration threshold, it becomes essential for utilities to introduce more sophisticated monitoring and control in order to maintain the balance between supply and demand;
- *dynamic* demand-response technology can also help manage the variability introduced by the intermittent nature of renewables, but it drives new communication and/or control requirements that were not apparent at the time the early AMI rollouts;
- more complex energy flows associated with solar systems creates potential occupational health and safety risks that may necessitate the revision of operational procedures and reconfiguration of protective mechanisms in the grid;
- whilst solar capacity may help to alleviate peak demand in certain circumstances, the fact that it cannot be relied upon at any point in time means that it is difficult to 'bank' any savings in generation or distribution infrastructure; and
- without either dynamic demand-response or improved storage, the forms of stand-by generation that underwrite intermittent sources of supply may negate the carbon savings from renewable sources.

Planning and implementing Australia's energy future will benefit if it is based on a 'big picture' understanding of the many inter-related elements of the electricity ecosystem, and the role of electricity supply more broadly in Australia's socio-economic fabric. In addition, it is important to recognise that smarter electricity networks will underpin many of the government's broader policy directions (addressing issues such as those outlined above) and set the foundation for smarter communities, smarter cities and a smarter country.

7.2 Framework for progress

Recommendation: ***Create a framework that provides incentives for industry innovation to encourage breakthroughs in consumer engagement***.

The era of unengaged consumers with relatively predictable demand patterns satisfied over quite stable distribution networks is passing. The future will be increasingly shaped by the demands and expectations of consumers as they embrace new technologies (electric vehicles, distributed generation, distributed storage, smart appliances etc). Their lifestyles will continue to become more dependent on electricity with increasing sensitivity to electricity costs and a growing concern over environmental sustainability.

Because of this, consumers are stirring as a force that will play a much greater role in Australia's energy future – a future where consumers are better informed, empowered to exercise more choice over their electricity options and assert more control over their electricity usage.

Australia must create an environment in which research, development and innovation in the energy sector is encouraged and nurtured so that the full potential for engaging consumers in new and positive ways can be unlocked. This will require a framework in which experimentation and testing is supported and where occasional failures are viewed as a stepping stone to progress.

Whilst not underestimating all of the challenges, the present climate of change creates a golden era of opportunity. With prudent investment, Australia can pioneer new products and solutions that will find a receptive market not only locally, but in a world that is struggling to map out a sustainable energy future. Governments have a valuable part to play in supporting this through economic development policies and programs.

7.3 Dismantle the barriers

Recommendation: Review institutional arrangements to identify barriers that need to be dismantled to provide the right incentives for investment.

Right now (and as discussed in Section 6), there are many barriers to progress. Not all stakeholders are appropriately motivated to play their part in creating Australia's energy future. For example, factors that can undermine motivation include:

- a segmented industry structure, where the benefits of an investment by one party may flow largely to another party;
- inequitable cost allocation, where the cost of network upgrades needed to support just a small proportion of consumers are sometimes amortised across all consumers – or vice versa;
- prescriptive regulatory arrangements that are more focused on specific requirements than on outcomes and encouraging innovative solutions;
- a regulatory framework that is based on recovering investment through usage charges and which therefore provides little incentive for distributors and retailers to encourage energy efficiency once rates are set; and
- past investment (made in good faith with the expectation of recovery over an extended period) that risks being stranded if it has to be replaced prematurely due to the accelerating pace of technology developments.

Unless these barriers are understood and addressed, the rate of investment will be slowed and opportunities for equipping Australia with the best possible electricity supply system will suffer.

7.4 Engage the stakeholders!

Recommendation: ***Establish broad collaboration to progress the above recommendations recognising that the active participation of many stakeholders is needed to deliver these benefits.***

Insufficient consideration of the impacts of particular decisions and actions on other parties heightens the risk of unintended outcomes and surprise backlashes. It is invariably more expensive and more difficult to deal with these after the event than to anticipate and manage the relevant issues as an inherent part of any plan. This is particularly evident in the case of Government policies and programs that, by their nature, often have far-reaching impacts.

Progress will be facilitated if the differing roles of the many stakeholders in the electricity sector are recognised and their contributions harnessed in planning the way forward. This will require more attention to consultation from existing bodies, and potentially the development of new forums that can support enhanced stakeholder participation.

7.5 Skills

Recommendation: ***Review and update education and training programs to reflect the more pervasive role that ICT will play in the electricity sector of the future***.

Traditional training has concentrated on producing well-qualified electrical engineers to meet the infrastructure management needs of the sector, and specialist ICT staff have been utilised to build and maintain central support systems. However, as modern digital technology becomes more tightly integrated into network infrastructure, skill requirements are changing. Utility staff of the future will need to be as comfortable with the commissioning and operation of computer and communications technology as they are today with electrical infrastructure.

The changing nature of industry needs is not well understood, and urgent planning is needed to develop and promote new courses that will ensure a healthy supply of appropriately qualified individuals in the future.

---oOo---

8. Conclusions

Australia can have a bright energy future!

It is starting from a well-developed infrastructural base, has an abundance of natural resources and its people enjoy a reputation for their creative and pioneering character. If these strengths are exploited, Australia will secure its own energy future and build the Smart Grid foundations for strong socio-economic and environmental progress. In the course of this, it will also develop capabilities for which there is a receptive global market.

The transformation that lies ahead will not happen overnight, and the detail and timing of particular waves of progress are difficult to predict with accuracy. However, the broad direction is clear and modernising Australia's electricity infrastructure by deploying Smart Grid technologies is a vital early step.

Although expressed at a high level, the five interrelated recommendations set out in this document describe a formula for ensuring that progress occurs as rapidly and as efficiently as possible.

Smart Grid Australia looks forward to playing its part in working with all stakeholders to build a bright energy future!

---oOo---

---

[i] See http://www.climatechange.gov.au/ret.

[ii] See http://www.cleanenergyfuture.gov.au/clean-energy-future/carbon-price/.

[iii] See "Australian Energy: National and State Projections to 2019-20", ABARE, 2011.

[iv] ibid

[v] "Australian Energy Market Commission – Final Report – Possible Future Retail Electricity Price Movements", 1 July 2011 to 30 June 2014, 25 November 2011, Executive Summary, page 5.

[vi] "State of the Energy Market 2011", AER *(available at http://www.aer.gov.au/sites/www.aer.gov.au/files/State%20of%20the%20energy%20market%202011%20-%20complete%20report.pdf)*.

[vii] ABS data indicates houses with cooling increased from 49% in 2002 to 73% in 2011.

[viii] Ergon Energy's Submission to Prime Minister's Task Group on Energy Efficiency: Issues Paper *(available at http://www.climatechange.gov.au/government/submissions/pm-task-group/~/media/submissions/pm-taskforce/papers/16-ergon-energy.ashx)*

[ix] "Understanding the Benefits of the Smart Grid", DOE/NETL-2010/1413, June 18, 2010

[x] "State of the Energy Market 2011", AER, cites network investment over the current 5-year period at $35 billion for distribution networks (p.62).

[xi] "BP Statistical Review of World Energy", June 2012 – shows increase from 221.6 to 264.1 TWh between 2001 and 2011 (see http://www.bp.com/statisticalreview)

[xii] Germany is recognised as one of the world leaders in PV deployment, with a total of 24.8 GW capacity deployed in 1,090,000 installations in 2011 ("BSW-Solar", German Solar Industry Association, 2011). By way of comparison, Australia had 1.4 GW capacity deployed in 560,000 installations in 2011 ("PV in Australia 2011", Australian PV Association, May 2012). On a per capita basis, Australia's deployment at 2.5% leads Germany at 1.3% – though average installation size at 2.5 kW is substantially below that of Germany at 22.8 kW.

[xiii] "Rooftop PV Information Paper – National Electricity Forecasting – 2012", AEMO (Executive Summary, p.iii).