

SPECIAL REPORT

A S P I

The challenge of energy resilience in Australia

Strategic options for continuity of supply

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August 2017

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Australian Prime Minister Malcolm Turnbull delivers the introductory remarks to the Council of Australian Governments (COAG) meeting in Hobart on 9 June 2017. Chief Scientist Alan Finkel presented the Final Report of the Independent Review into the Future Security of the National Electricity Market at the meeting. © AAP / Rob Blakers

INTRODUCTION

The foreword to the 2015 Energy White Paper proclaims:

Australia is a growing energy superpower. Our energy sector underpins our economy, secures our standard of living and drives our international competitiveness. It also underwrites our stature in the global economy.¹

Steps to realising this superpower status might not be an easy path to pursue following last year's 28 September storm in South Australia, which triggered a state-wide blackout.

In a press statement following the 'black system' event, the Prime Minister was unequivocally clear that 'energy security should always be the key priority.'² Given the aspirational statement from the Energy White Paper that a viable supply of energy 'underwrites our stature in the global economy' and the Prime Minister's comments about the vital importance of a secure energy supply, one might ask whether we're in a position—yet—to carry the mantle of a growing (resilient) energy superpower.

Other disruptions to electricity supply that may indicate variable resilience include the 2015–16 Tasmanian energy crisis, which was precipitated by a combination of damage to the Basslink submarine cable connecting Tasmania with the mainland electricity grid, and the el Niño fuelled drought, which reduced the availability of hydroelectric power. Arguably, the loss of access to these power sources could have been foreseeable, and contingency plans could have been made before the events occurred. The National Electricity Market Review by the Chief Scientist Dr Alan Finkel delivers a blueprint for domestic electricity but there is more to energy security than electricity alone.

As part of the most recent Australian Government review of Australia's oil refining capability, in 2013, the major oil refining companies—Shell, Caltex, BP and Exxon Mobil—argued that Australia's oil refineries were at a competitive disadvantage in the region, and subsequently domestic refineries were closed.³ The oil refinery sector and the Australian Government agreed that a market-based approach was the best way to meet Australia's liquid fuel needs.⁴

The National Roads and Motorists' Association questioned our sole reliance on the market to meet fuel demand in 2014, asking 'whether a significant supply disruption to our shipping lanes or trade routes—which could take the form of a natural disaster, accident, commercial failure, act of terror or war—could quickly imperil Australia's capacity to provide necessary fuel'.⁵ This is a legitimate question of supply-chain resilience, as vulnerabilities in essential maritime supply chains, if unaddressed, may be sources of significant concern for our liquid fuel security.

However, opportunities from technological innovation, which pervades all aspects of the energy value chain, promise a bright future for Australia as a major supplier of energy. In this environment of volatility and change, the continuity of our energy supply will require adaption to disruption and continuing regulatory reform. It's not enough to rely on traditional supply-chain management in existing markets as the only lever of energy security.

Ensuring continuity of domestic supply means that Australia must adapt to global variations in demand with minimal disruption. When there's a shock, the energy system must be able to provide defined levels of supply in a systematic manner while action is taken to address the supply shortfall.

Consideration of these issues is not new. In 2007, ASPI published *Power plays: energy and Australia's security*, which argued that the energy 'shock' that was extant at that time was substantially different from those that had occurred in earlier decades (as in 1973–74). The report found that Australia was in the enviable position of being dependent on imports for less than a quarter of the energy it consumes, which has led to an understandable tendency for Australian governments and society to be more sanguine about energy security than many of the other countries of the Asia–Pacific.⁶

However, *Power plays* specifically cautioned against discounting the importance of wider contexts of energy security, which include competition for energy sources and market dominance, threats to supply infrastructure, accidents and the impact of natural disasters.

Since that time, the status quo has generally prevailed in Australia but with some of the problems predicted in the 2007 report now upon us. These combined with the recent findings from the review of the National Electricity Market (NEM) form an important demarcation between the old and the new. The future side of this line-in-the-sand, following the Finkel Review, emphasises a backdrop of technological and market disruption along with degrees of geopolitical uncertainty.

Australians can no longer afford to be complacent about future energy availability. As an economy, we need to pursue the means to actively discover vulnerability, ensure continuity of supply and ultimately enhance resilience.

The intent of this report is not to rake through the findings the Chief Scientist's review but to examine approaches to ensuring Australia's energy sources are resilient. It therefore does not address the 'Market' per se but concentrates on policy contexts critical to making informed decisions about continuity of energy supply.

The first section of this report discusses Australia's energy continuity needs from a complex system-of-systems perspective and details several systemic vulnerabilities that contribute to potential gaps in the resilience of our energy supply. It suggests that a new resilience-based approach to thinking about continuity of energy supply will support Australian interests and economy in the future and be better than piecemeal reform.

The second part of the report provides options for addressing the surety of energy supply, reforming energy supply through the electricity grid, addressing evolving transport energy demand, and future-proofing our communities. Steps to fulfilling these strategic options are examined in several recommendations addressing whole-of-government and whole-of-nation gaps in energy policy.

PART 1

Does current Australian Government policy provide for energy resiliency?

The Australian Government is responsible for preparing the nation for unexpected energy shocks. For several decades, energy policy has consistently reinforced a robust, market-based approach across a suite of energy types. This approach has generally served Australia well.

The 2015 Energy White Paper provided a detailed overview of Australia's energy requirements and how energy markets function to meet domestic requirements, but included very little discussion of global factors that could counter the Australian view. The market analysis of gas, electricity and transport fuels markets was well accepted, but policy considerations were focused on productivity and economic investment, rather than on providing strategic options to respond to future challenges.

The failure of the White Paper to proactively engage with climate policy was widely criticised, particularly when Australia's fossil fuel production and use contributes almost three-quarters of Australian greenhouse gas emissions.⁷ Since the release of the 2015 White Paper, Australia has committed to a 2030 target of a 26% to 28% reduction in national emissions (relative to 2005) in accordance with the 21st Conference of the Parties (COP21) to the UN Framework Convention on Climate Change. The Paris Agreement negotiated at COP21 was ratified by Australia in 2016.⁸

An alignment of both energy and climate policy is needed to achieve the sustainable environmental and economic outcomes that underpin the attenuation of global average temperatures agreed in COP21. Interestingly, the Department of the Environment and Energy was formed on 19 July 2016, bringing climate and energy policy closer together through a machinery-of-government change.

The often complex relationship between energy policy and national security was well detailed in the 2007 ASPI report and remains particularly relevant. The 2015 Energy White Paper, however, was issued without the completion of a contemporaneous National Energy Security Assessment (NESA). The most recent NESA was undertaken in 2011, and the next NESA is due in 2017, well after the publication of the White Paper. This is a concerning delinking of policy from up-to-date security assessment.

The 2011 NESA concluded that our electricity sector faced significant challenges—most notably reliability of supply and price pressures associated with the implementation of climate change and renewable energy policies—as well as 'the upgrading and refurbishment of ageing network infrastructure in the face of rising demand'. However, the assessment found that market reforms and mechanisms associated with the Australian Government's Clean Energy Future package would assist in facilitating a flexible market response to these challenges.⁹

A key message in the 2011 NESA was that:

Australia's overall level of energy security has remained largely consistent with the assessment undertaken in 2009, and that Australia's energy security situation is meeting Australia's economic and social needs, albeit with

some emerging market and policy uncertainties that could have implications for maintaining our current level of energy security.¹⁰

If the 2017 NESA doesn't reflect marked change from previous iterations, it will fail to prepare Australia for ongoing challenges expected in the global energy system.

Considering the public failures of the NEM in 2016, it's alarming that fundamental flaws in the market had been identified in the 2011 NESA without a definitive plan to address those vulnerabilities. Therefore, it may be no surprise that the South Australian 'black system' event occurred or that there was such limited preparation for the closure of the Hazelwood Power Station in Victoria in March 2017. These disturbances in the NEM in late 2016 prompted the Minister for the Environment and Energy, Josh Frydenberg, to instruct the Chief Scientist, Dr Alan Finkel, to develop an independent national blueprint to ensure energy security as we transition to a lower emissions future.¹¹

Interestingly, the 2016 Defence White Paper acknowledged the strategic influences of energy flows and energy security on national defence in much more depth than any previous White Paper. While energy has never been a key driver of the development of Australian defence policy, there have been subtle shifts since 1976 on the importance of energy security in maintaining our defence posture. The Defence White Paper also raised the requirement for a resilience-based approach to fuel security. To date, energy policy proponents have been relatively silent in linking the issue of energy supply with national security, and the next NESA must be consistent with the Defence White Paper aspirations or there's a potential for divergent and confused energy security policy.¹²

Resilient infrastructure policy is the domain of the Attorney-General's Department and is embodied in the Australian Government's Critical Infrastructure Resilience Strategy. The aim of the strategy is the continued operation of critical infrastructure in the face of disturbances in an all-hazards context. Functional and reliable critical infrastructure supports Australia's national defence and national security and underpins our economic prosperity and social wellbeing.¹³

An important element of the Critical Infrastructure Resilience Strategy is government and industry collaboration and the sharing of information on the challenges faced by a range of industries in the sustainment of essential services. This joined-up approach is epitomised by the Trusted Information Sharing Network (TISN), which is an ongoing collaboration between industry and government agencies to share information on threats and vulnerabilities and to define appropriate measures to mitigate risk and enhance resilience.

One of the TISN focuses is its Energy Sector Group. Nested within that focus is an Oil and Gas Security Forum, which examines the resilience of the Australian oil and gas industry. The Department of Industry provides the secretariat for the Energy Sector Group and the Oil and Gas Security Forum subgroup.

Both the NESA process and TISN activities address issues related to energy supply-chain security and possible disturbances to supply. An important consideration is that, by government direction, upstream energy security concerns are generally addressed through non-regulatory means.

The National Strategy for Disaster Resilience was adopted by the Council of Australian Governments (COAG) in February 2011. The strategy, administered by the Attorney-General's Department, provides strategic intent on disaster management for federal, state, territory and local governments, businesses, community leaders and the not-for-profit sector. It emphasises a collective responsibility for resilience and recognises that a national, coordinated and cooperative effort is needed to enhance Australia's capacity to withstand and recover from emergencies and disasters.¹⁴

However, the national strategy doesn't emphasise the importance of energy in providing a basic level of human security, even though energy and wider infrastructure considerations are foremost in disaster recovery and resilience. A major challenge to creating an energy-resilient Australia is in bringing these disparate policy pieces together so that the vision of a prosperous future doesn't ring hollow.

The fragile nature of energy systems

Access to energy is a core enabler of growth in modern economies. This centrality makes the provision of energy services an important national and global security consideration and critical to achieving viable and sustainable societies across the world. Yet the global energy system is complex and increasingly fragile. Oil prices have recently risen after two years in the doldrums but remain sluggish.¹⁵ Volatility in oil prices generates uncertainty, and uncertainty inhibits or confuses investors and means that global forces affecting energy can't be taken for granted.¹⁶

Shocks to supply and demand within the global oil system that are unforeseen by the conventional wisdom of the industry are not new. In 1973, the shock of the oil crisis highlighted the volatility of oil supplies and prices in a geopolitically fragile world (see box).

The 1973 oil crisis

With the 1973 Arab–Israeli conflict as a backdrop, members of the Organization of the Petroleum Exporting Countries increased oil prices by 70%. Oil producers had started what was to be a five-month embargo on selling oil to the US and other countries deemed to be supportive of Israel. Those decisions made oil supply a political weapon, leading to the global price of oil rising and supply tightening. These effects manifested at a time when many nations experienced inflation, growth stagnated and recessions occurred.

By the mid-1970s, in addition to the disruption of oil supplies, many advanced economies found themselves simultaneously experiencing economic stagnation and monetary inflation. These twin effects, which became known as stagflation, were startling to economists, as the dominant macroeconomic conceptualisation of the time considered that stagnation and inflation were mutually exclusive.

Some key response measures included introducing oil rationing and distribution control, diversifying the sources of oil supply, especially away from Middle East, and diversifying the energy mix by replacing oil with natural gas, nuclear power and renewable sources.¹⁷

Forty years on from the 1970s oil crises, the relevance and applicability of the measures put in place then are worthy of reevaluation against new and emerging circumstances. The Middle East continues to be a geopolitical hotspot. While the Organization of the Petroleum Exporting Countries isn't as powerful as it was in the 1970s, its members still control approximately 80% of the world's proven crude oil reserves.¹⁸ The 'oil business', with its peculiar mix of market forces and geopolitical interconnections, has the potential to break open old wounds from the oil crisis four decades ago.

But oil is no longer the singular geopolitically sensitive energy resource it once was, and global energy governance structures now struggle to keep pace with technological change, disrupted markets and a complex, ever-increasing array of commercial interests. Each energy generation source, such as gas, coal, renewables or nuclear power, brings with it different technological dependencies, market issues and distribution networks, as well as governance and regulatory requirements.

This is starkly obvious in the case of the global liquefied natural gas (LNG) market, as it needs to change rapidly to cope with a threefold increase in supply projected to be available within the next three years.

At least \$130 billion of global investment in LNG targets Australian reserves. With this level of interest, Australia may be destined to become the world's largest LNG producer within the next few years, possibly as early as 2018.¹⁹ One aim of this expanded investment in global LNG is to reduce uncertainty of supply and the variability in the price of oil and to provide degrees of certainty to the future of the gas industry.

Australia will require both commercial and technical agility not only to address our own prosperity but to balance international and regional expectations of us as a leader in the LNG market (see box).

The Australian LNG security and leadership challenge

The Asian LNG trading hub, which includes Australia, may soon equal those in America and Europe. China, through its energy policies and stated objective to reduce coal-fired electricity generation, will influence this gas trade. As countries in Asia become more dominant in the new global gas market, the sea lanes that connect these regions are increasingly important. The US has been the principal guarantor of security for these routes since 1945, but there's no guarantee that it will remain unchallenged. Any change in the Indo-Pacific sea lanes could have significant implications for Australia as we strive to deliver the expected LNG supply to this growing market.²⁰

On 26 May 2014, Papua New Guinea became a player in the global LNG market with the first shipment of gas from ExxonMobil PNG Limited's US\$19 billion LNG project to the Tokyo Electric Power Company. As a resource-rich nation, Papua New Guinea will deliver natural gas to meet the growing demand of Asian markets over the long term. It's in Australia's national interest to see an independent and prosperous Papua New Guinea participating in regional growth.²¹

A dominating characteristic of participation in the global energy system is the ongoing management of uncertainty and volatility. The 1970s oil crises triggered changes to economic, political and governance systems that provided surety for a robust, market-based system, which has continued to fuel economic growth. However, if the promised expansion of prosperity and growth is to continue, sustainable energy markets must avoid repeating past mistakes, so thinking about how to embed resilience into practices and policy in the energy industry is an important step.

A resilience-based approach

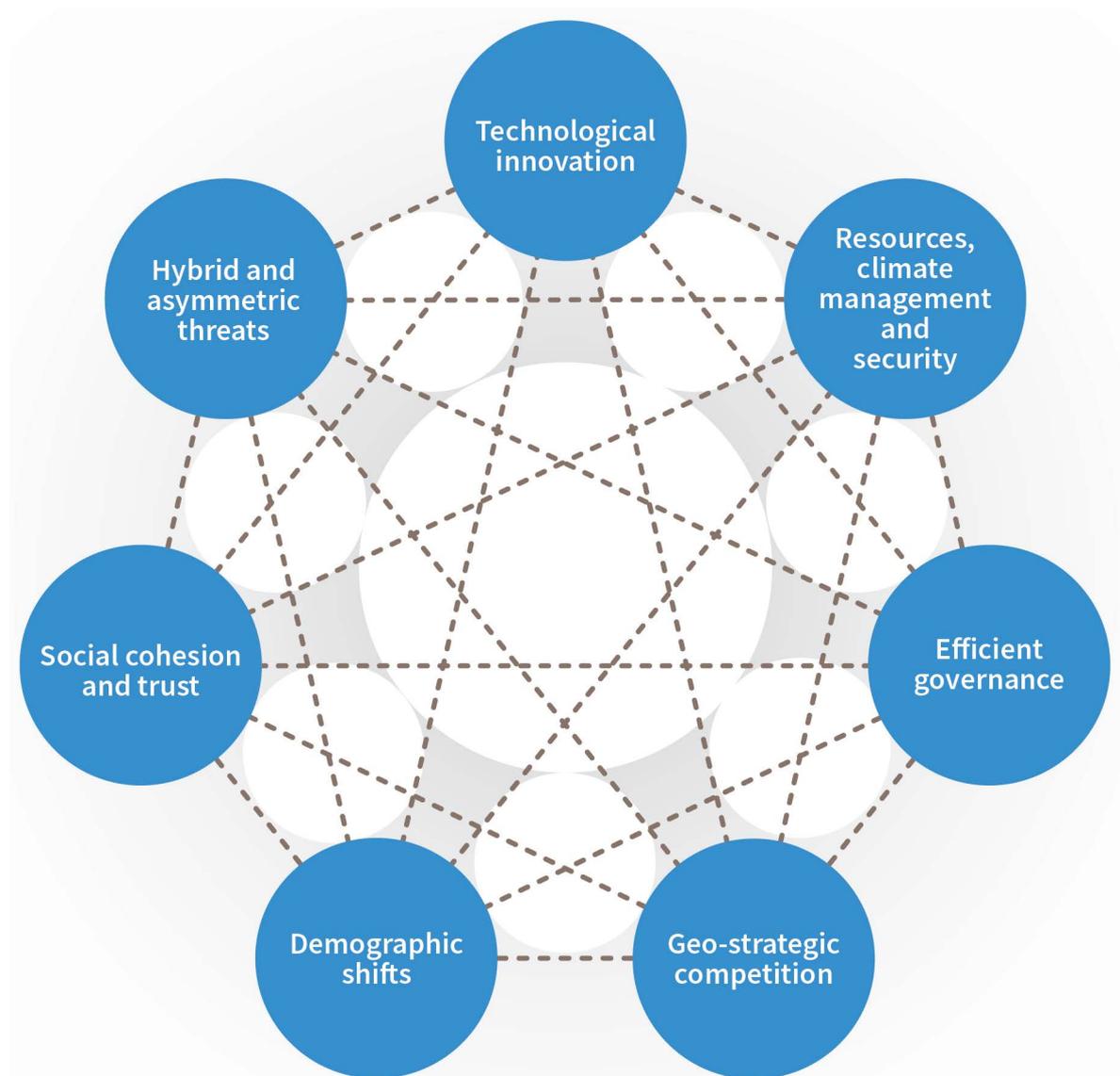
A resilience-based approach to energy continuity ultimately entails strategic choices about how to sustain supply and reduce the potential for the disruption of supply chains along which energy products are imported and energy is generated in Australia. Enhanced resilience for energy systems isn't an ephemeral concept but a pragmatic goal that requires comprehensive understanding and appreciation of the challenges of managing complex technical systems and of the nature and sources of disturbances that can and are likely to occur.

From a whole-of-economy perspective, this would mean the alignment of policy, practices and decision-making across the public and private sectors to ensure the geographically wide stability of energy supply. If this stable system of supply is affected by disturbances and significant losses occur, there must be a planned capability to regain and sustain optimal capacities for energy production and use.

A comprehensive analysis of vulnerability within and outside Australia's energy ecosystem is a critical factor enabling the achievement of energy resilience at the national level. The 'ecosystem' construct encompasses the interdependencies of modern systems of infrastructure and includes energy from generation, transmission and usage components. Also important is the realisation that certain high-value energy resources enter this ecosystem via global supply chains.

Assessing the continuity needs of complex supply chains isn't a simple undertaking and requires analyses of vulnerabilities in all aspects of each relevant supply chain. The World Economic Forum has defined a framework showing vulnerability factors considered pertinent to interconnected energy systems, and by extension to the global energy marketplace (Figure 1).

Figure 1: Vulnerability factors for interconnected energy systems



Source: A Kaspersen, I de Sola, *The global risks report 2015*, World Economic Forum. The model has been adapted by the authors to describe energy risks rather than global risks.

Describing the vulnerability factors as an interconnected system in which relationships are one-to-many and varied in complexity is fundamental to understanding systemic uncertainties in energy systems. To fail to address the factors in this ecosystem is to encourage unintended consequences and, at worst, catastrophic failure.

The relevance of these systemic vulnerability factors for Australia's energy future is detailed as follows:

- Technological innovation.** Technology offers innovative and disruptive influences not yet envisaged. Innovation in the energy sector will continue to improve, driven by the need for both generators and consumers to address the ongoing trilemma of security of supply, affordability and environmental outcomes. It will drastically change the electricity grid. Some recent advances include low-emissions electricity generation technologies, distributed energy resources such as digital metering, rooftop solar photovoltaic systems, battery storage systems and electric vehicles. It's been predicted that innovations in data collection and analytics ('Big Data') will have a disruptive effect on the electricity sector by facilitating the integration of unprecedented levels of renewable generation. Future innovations could come in many other forms.²²

- **Resources, climate management and security.** The combined effect of climate change and resource scarcity stand to play a big part in geopolitics and shape the international energy landscape over the coming years. Weather-related disruptions to the national energy market, as seen recently, are unlikely to be rare events into the future. Australia can't afford an energy sector tied to narrow generation choices and cumbersome technology, which provide limited choices for adaptability.

The National Climate Resilience and Adaptation Strategy sets out how Australia is managing exposures to a variable and changing climate. The strategy suggests that some impacts from climate change are now unavoidable, but that the costs of adaptation might be reduced by early and effective action to reduce greenhouse gas emissions.²³ Recognising climate change as a threat and closely linking it with energy strategies will minimise exposure to risk and be likely to create new economic opportunities.

Australia needs a much broader context for understanding energy security than is currently used by most policymakers. The existing one is too narrowly focused on economic harm arising from a loss of supply and gives insufficient attention to the fact that energy security is a multidimensional concept intertwined with issues across the social, political, economic and environmental spectrums.

- **Efficient governance.** Networks such as supply chains require levels of governance that match the complexity of those systems. Components of governance include trade transactions, dispatch, arrival, maritime sections and in-port elements. Supply chains that are overgoverned are likely to be expensive and uncompetitive, while too little governance may lead to fragility and reduced levels of control. Sound managerial oversight requires a balance between the two extremes.
- **Geostrategic competition.** In the energy domain, geostrategic competition for market share is multifaceted. Nation-states and multinational corporations often act together in an expression of national energy security strategies. New, emerging uncertainties are posing ever greater threats to the energy sector, affecting both the physical structures and the capital returns needed to steer the energy system to a more sustainable future.

Without a solid understanding of the nature of these future factors and the appropriate adaptation of infrastructure design and of financing mechanisms, it's possible that an investment impasse could threaten to cripple global energy systems.

Since 2000, Australia has enhanced its efforts in energy diplomacy to advance its national interest. Energy diplomacy recognises that, due to the interdependencies of global energy markets, cooperation on energy issues is generally attractive at the multilateral and bilateral levels. For supplier nations, such as Australia, supplying energy resources generates strategic and trade benefits.

- **Demographic shifts.** As Australia's population grows and our economy expands, our dependence on electricity will increase. Future energy policy will need to address long-term population growth, greater urbanisation and growing expectations of materially comfortable lifestyles. Like other developed countries, we'll have an ageing population with greater health needs. With those changes comes an ever-increasing demand for energy in all forms, and governing these developments will pose a significant challenge for future Australian governments.
- **Social cohesion and trust.** In Australia, as in most modern economies, access to secure and affordable energy is a basic expectation of society. Affordability and continuity of supply have often been issues central to public debate and political dialogue. Prime Minister Turnbull made that clear in laying out his agenda for energy policy in 2016, when he stated that 'families and businesses need reliable and affordable power.'²⁴ Blackouts during extreme weather are widely considered to be the result of poor contingency management by energy businesses and governments. This has been clearly demonstrated by the public response to the South Australian 'black system' event and subsequent blackouts.

The UK Energy Research Partnership provides an example of what needs to be done to address failed community engagement on energy issues. The partnership made a call for a strategic narrative accessible to affected end-users in its *Report on public engagement* in May 2014. However, while the public largely supported transformation in energy policy, trust in the UK Government and energy industry was low.²⁵

- **Hybrid and asymmetric threats.** Energy infrastructure is heavily dependent on cyber control systems, which are mainly SCADA (supervisory control and data acquisition) and PLC (programmable logic controller) systems using network connectivity through wireless, internet, dark fibre, microwave, satellite or priority local area networks. The widespread use of these systems, many of which use legacy technology, has heightened the energy sector's dependence on computer and information systems to monitor consumption and to drive the production, transformation, transmission and distribution of supply.

While these systems have reduced operating costs, increased reliability and enhanced transparency, opportunities to exploit weaknesses have increased, particularly where systems operate in open networks and across networks. These threats can manifest themselves in many ways and are limited only by the imagination of the cyberattacker. Examples are direct attacks on critical infrastructure by the remote control of decision-support software and the theft of market-sensitive information that gives advantage to competitors.

The degree to which these and similar factors are considered in medium to longer term policy assessments in Australia is important. Detailed proactive assessment of such vulnerabilities in critical energy infrastructure systems is crucial.

The trigger to reform supply in the electricity system

Although Tasmania suffered no blackouts during its energy crisis in early 2016, the state government conducted a thorough review of energy security. The review's interim report examined risk to energy supply in Tasmania and made recommendations to achieve secure and affordable power for all Tasmanians.²⁶

However, it was the loss of power in the South Australian event of 28 September 2016 that brought energy security forward as a national issue. The expected but rapid closure of Hazelwood Power Station in 2017 also emphasised to Australians the disruption occurring across the NEM. The Australian Government was compelled to act.

The Minister for the Environment and Energy, the Hon. Josh Frydenberg, announced the Independent Review into the Future Security of the National Electricity Market by the Chief Scientist on 7 October 2016 at a COAG Energy Council meeting. Dr Alan Finkel delivered the final report to the Australian Government on 9 June, in the first half of 2017.

The report contains 51 recommendations. These recommendations are grouped into seven key themes:

- Preparing for next summer
- Increased security
- A reliable and low emissions future
- More efficient gas markets
- Improved system planning
- Rewarding consumers
- Stronger governance.²⁷

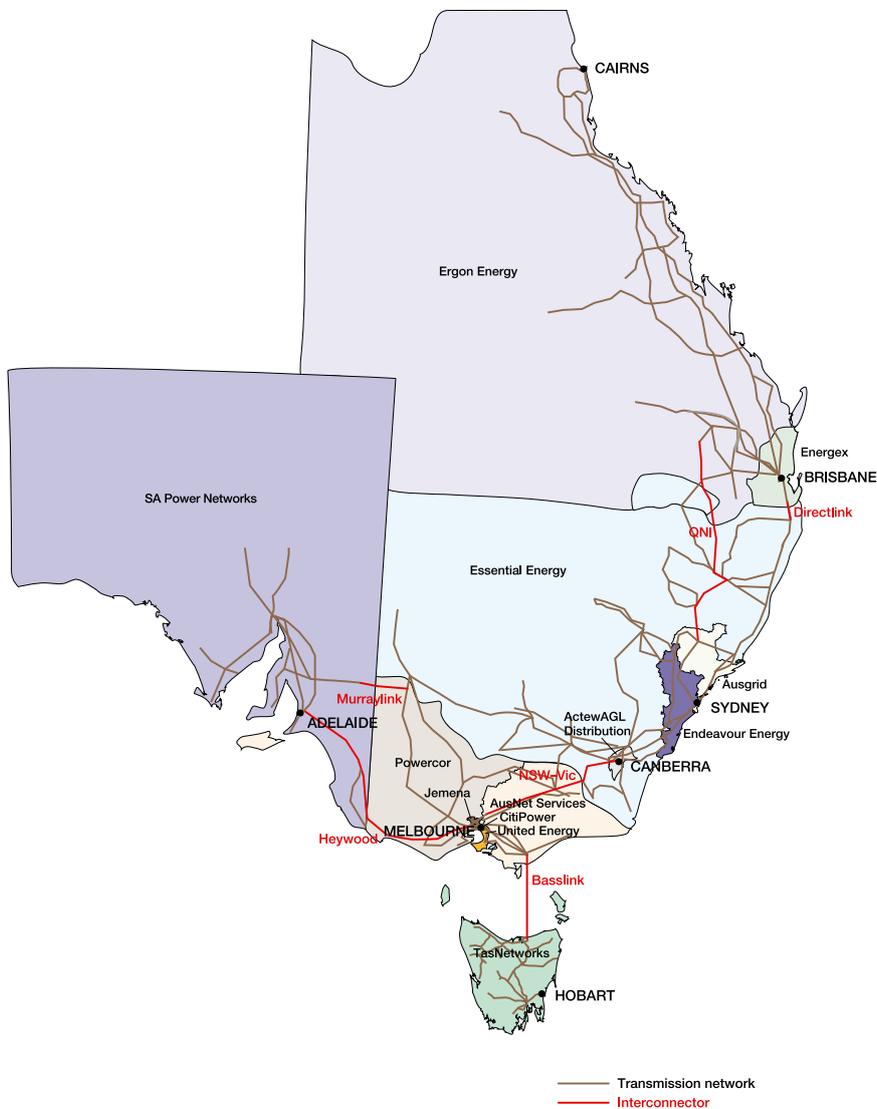
Building a resilience framework that addresses reform in the electricity system supports these key themes and, more importantly, addresses the interconnected nature of the themes makes considerable sense.

While a focus has been on reviewing the national market for electricity, an important aspect is that the market is embodied by the electricity grid as a critical connection and means for distributed energy generation. The grid is the mechanism for security of supply in our built environment.

Some reference to the form and governance of the NEM is warranted here.

The NEM has well-defined distribution networks along the eastern and southern coasts. Figure 2 shows the linear, elongated nature of the NEM; the grid, which spans our eastern and southern states, reflects Australia's demographic spread.

Figure 2: The National Electricity Market



Source: Australian Energy Regulator, *State of the energy market*, Figure 3.1, May 2017. Reproduced with permission.

Australia's electricity system involves four kinds of businesses, which operate in different markets:

- *Generation businesses* own power stations, which produce electricity.
- *Transmission businesses* own the high-voltage 'poles and wires' that carry electricity across large distances to local markets.
- *Distribution companies* carry power across low-voltage networks to businesses and homes.
- *Electricity retailers* manage customers' electricity accounts and are responsible for buying enough power from generators to supply homes and businesses.²⁸

Transmission and distribution companies are known as 'network' businesses.

The Australian Energy Market Operator (AEMO) oversees the NEM. Generators sell electricity through the market, which matches supply to demand instantaneously. From the generators' offers, the market determines the combination of generation to meet demand in the most cost-efficient way. The AEMO then issues dispatch instructions to the generators.²⁹

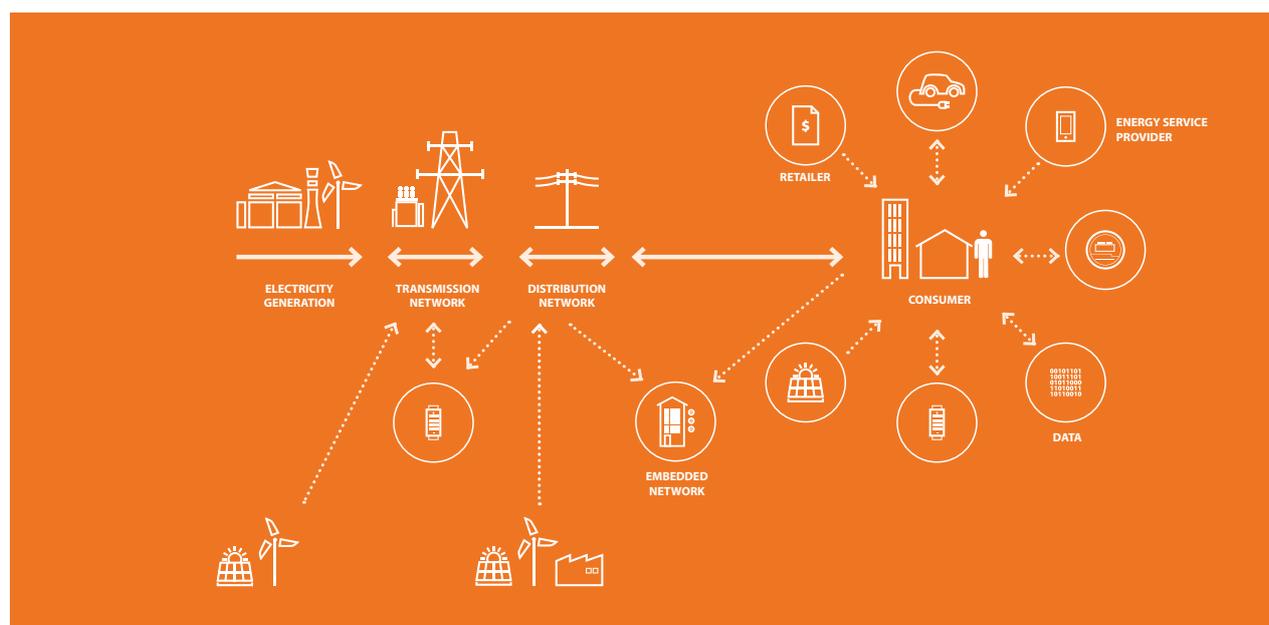
The role of the Australian Energy Market Commission (AEMC) is to make and amend the National Electricity Rules that underpin the NEM.³⁰ The Australian Energy Regulator (AER) regulates the energy markets and networks under the NEM legislation and rules.³¹

COAG established the Energy Council in December 2013 to provide a forum for collaboration on developing an integrated and coherent national energy policy.³²

The Chief Scientist's preliminary and final reports reviewing the NEM contains a comprehensive assessment of consumer demands, technological possibilities and market responses. It details the changing nature of electricity generation, storage and use (Figure 3). This changing electricity market demands reform, but from an energy resiliency perspective the necessary NEM reform is part of a wider suite of options.³³

The NEM review considers technology disruption to be a large part of market reform. Importantly, market competition and governance reform are considered equal partners with technological change. What is critically important is the change in the relationship between the grid and the consumer.

Figure 3: The changing electricity market



Source: Introductory webpage of the *Independent Review into the Future Security of the National Electricity Market* © Department of the Environment and Energy, 2017, [online](#).

An obvious point from the initial findings is that consumers are no longer at the endpoint of a single electricity supply chain. Technology and market reforms mean the consumer now, for the first time, has choice about the type of storage and distribution method in the grid.

Furthermore, traditional assumptions about the design and operation of electricity supply chains have been disrupted by innovation. There's a need to think deeply about choices that enhance the resilience of the industry and of supply for both private and public consumers.

While the recommendations of the Chief Scientist's final report are yet to be fully considered by government they, and supporting arguments, have generated rigorous debate. Notwithstanding the ongoing considerations by industry participants and government a number of actions central to national energy resilience need to be considered.

PART 2

Strategic options for ensuring a resilient energy supply

Achieving energy resilience will require change not only by the energy sector but by all sectors of the Australian society and economy, and that change must be planned to take effect over years and decades. Strategic options provide for risk mitigation against external shocks, both financial and physical, but importantly provide for transitions to alternative energy sources, technologies and processes.

Several strategic outcomes are needed to address Australian energy resilience and thus energy-proof our communities into the future.

Simply put, there's a real need to address future supply and demand at the community level. Segmented reform that addresses only electricity supply or demand, or addresses both separately, would merely make Australia less resilient. While the implementation of findings from the Finkel Review might result in a systematic 'grand strategy' approach to meet national energy security goals such a position would seem to be some way off. In the interim the following options should be considered.

Build the smart grid of the future

The 2016 Australian Infrastructure Plan reports that Australia's electricity generation sector is still among the most carbon-intensive of those of all major economies, producing higher emissions per unit of electricity than the US or China.³⁴ Black and brown coal contribute about 61% of our total electricity generation. In addition, many of our coal-fired plants were constructed over 40 years ago, limiting the capacity for cost-effective improvements to their efficiency.

The Australian Infrastructure Plan calls for future electricity generation technologies to support a lower emissions economy. Coal-fired plants currently provide consistent, reliable electricity to the grid at relatively low economic cost. Decisions on how this baseload electricity generation is to be replaced over coming decades will have a significant impact on the growth and development of renewable and other forms of energy generation. It will also have a considerable impact on Australian sustainability and productivity over the long term.³⁵

The current electricity grid's overreliance on ageing 20th century technology based on centralised power generation and interconnected distribution architecture creates systemic vulnerabilities. Larger cities get their power primarily from large clustered electric power producers now located away from the urban centres. Electricity is then transmitted over long distances, across vulnerable high-voltage infrastructure. The grid is well managed by network businesses, but has little flexibility and many preventable points of failure that can result in the loss of large segments of the distribution system. This was clearly demonstrated in the South Australian 'black system' event in September 2016.

Existing technologies, such as microgrids, in concert with proven distributed electrical generation systems fuelled by renewable energy sources, can become a feature of the new 'smart' grid. Microgrids are small-scale versions of traditional power grids. They add degrees of flexibility by drawing energy from clean sources, such as wind

and solar power, as well as from conventional technology. They can be connected to larger electric grids but also work independently.

Evolving systems that will use distributed electrical generation plants, such as commercial-scale hydrogen engines, fuel cells and small modular nuclear reactors, also offer unexplored advantages. Smart-grid technologies and emerging energy storage systems can potentially increase electrical generation and distribution resilience.

The concept of localised power generation isn't new in Australia. Before World War II, most utility grids were self-contained, using power plants located close to the markets they supplied. It wasn't until the middle of the 20th century that utility grids became today's sprawling networks in which central power generation facilities distribute power to homes and businesses hundreds of kilometres away. In the past 10 years, the modern microgrid has emerged as an alternative to a localised utility.

The microgrid's ability to work independently from the larger utility grid, known as 'islanding,' makes it attractive to many essential services providers. Islanding is in many ways a more sophisticated version of backup generation, maintaining power during outages. However, the unrealised potential of microgrids lies in their role as part of the future smart grid.

For example, the University of California San Diego campus microgrid provided valuable energy to San Diego Gas & Electric's system during wildfires in 2007. The utility asked for assistance in keeping the grid up when fires had destroyed key infrastructure. In response, the university's curtailed load on the microgrid provided a critical 7 megawatts of power to the main grid. This was a game-changer in grid management: rather than remaining 'separated', the microgrid was a partner to the utility.³⁶

The Australian Government's 2015 *White Paper on developing northern Australia* expressed a vision to 'unlock the great potential and opportunities of the north'.³⁷ To achieve that vision, investment must be made in infrastructure and energy. Infrastructure Australia concludes that there's a need for continued government assistance to support electricity supply in remote communities where generation can't be provided on a commercial basis.³⁸ Unfortunately, there seems to be very little consideration of resilient design in the planning supporting the energy needs of the 'envisioned' northern Australia.

In February 2017, the Minister for Resources and Northern Australia called for the building of a coal-fired power station in the north to meet baseload energy needs.³⁹ Putting aside arguments about the economic viability of a coal-fired power station, the construction of 20th century grid technology around a power station in a sparsely populated region doesn't seem economically or physically feasible. Opening the market to smart-grid technologies, including microgrids and potentially small modular nuclear reactors supporting remote large-scale mines, could be a flexible application of the smart-grid concept into the future.

If the grid of the future becomes a reality, electricity will be produced closer to consumers, from a wide variety of sources, and shared or stored until needed. This new production paradigm will be driven by technological advances, demand for increased service flexibility and more secure, lower cost power, and a growing public demand for cleaner energy sources.

Achieving low-cost power will demand continuous rigorous assessments of the cost and benefits of wider competition in an evolving grid. Australians enjoyed the benefits of relatively low electricity and gas prices for many decades, without any significant price shocks. Competition policy reform brought significant benefits to the energy sector in productivity gains. This relative energy price stability underpinned the international competitiveness of many of our industries, which traded off other higher costs, such as labour costs, while striving to be productive and efficient.⁴⁰ Fundamental to the NEM review is the need to address the evolving macroeconomics of energy (see box).

The changing energy economics landscape

The widespread deregulation of the Australian energy market in the 1990s was led by the Hilmer Review, which emphasised the need to allow market forces to rebalance supply and demand through price signals. Markets are not static but are constantly evolving, and there's ongoing reciprocal influence between them and their supporting institutions and customers.

In March 2017, the Grattan Institute published *Price shock: is the retail electricity market failing consumers?*. The report noted that competition has delivered lower costs in the wholesale/generation sector, where purchases are specialised, but that competition in electricity retailing hasn't delivered lower prices for consumers or customer service innovation. Indeed, the Grattan Institute found that the failure to deliver the lowest prices was most significant in Victoria, which had the most retailers and the longest experience of deregulation.⁴¹

This story is being repeated in the gas industry, albeit driven by different factors. The market prices for gas are escalating on the east coast in response to a huge demand for locally sourced gas for LNG production and export, driving up the value of new gas and hoovering up existing low cost of production gas. This led to the Australian Government intervening in the gas market on 27 April with the aim of ensuring that households and businesses will get adequate gas supplies at reasonable prices.⁴² Upstream oil and gas producers criticised this action, arguing that gas reservation policies impair local gas supply and affordability, rather than improve it.

One of the greatest challenges for traditional energy economics is the unexpected change in the market caused by the take-up of renewable energy. Renewable energy generation and energy storage costs have defied continual conservative estimates and fallen remarkably. During the past two decades, the efficiency of commercial solar panels (the percentage of solar energy converted into electricity) has risen to 20%, while panels have achieved as much as 44% efficiency in laboratory tests. In addition, the cost of solar cells has already dropped from nearly \$8 per watt of capacity in 1990 to less than 50 cents in 2016. Similarly, large reductions have occurred in the cost of lithium ion batteries and related systems for storing energy. It's expected that further cost reductions will come from economies of scale in hugely increased production by China and others, plus savings through 'learning by doing'. Advances in technology will keep prices falling after scale economies have been exhausted.⁴³

Throughout the electricity grid, traditional energy systems are being digitised by the increasing penetration of conventional and emerging information and communication technologies. This means that there are new opportunities to analyse and understand energy supply and demand from generator to consumer. Analytic capabilities within computer clusters will help gauge the intermittency of renewable energy and introduce quantitative metrics to measure and assess the benefit of different energy options. This will require data architectures that enable analyses of systems across the social and energy informatics domains—thus improving the ability to make informed choices on energy trade-offs.

Australia needs a modernised and reliable electricity grid. Moving away from large singular nodes of generation with comprehensive networks will also better protect communities against disruptions from cyber threats and natural disasters. Planning processes, models and design approaches should be modified now to consider distributed generation and distribution applications, with an emphasis on the cost benefits of energy storage solutions and smart-grid technologies.

Recommendation 1: Through the COAG Energy Council, integrate and improve federal, state and local government planning processes, models and procurement processes to foster greater cost-effective choice in the adoption of new technologies, microgrids and more diverse energy generation options.

Identify existing and future vulnerabilities

Extreme weather events are a threat to the traditional electricity grids in Australia and the high-voltage transmission lines that support them. In response to the 2009 bushfires, the Victorian Government established the Powerline Bushfire Safety Taskforce to address the risk of bushfires being ignited by faulty power lines. In December 2011, the state government accepted a package of recommendations from the taskforce that is expected to cost about \$750 million over 10 years.⁴⁴

In addition to natural hazards, sophisticated cyberattacks with physical impacts are now a major threat to the electrical grid. Because digital control systems can be vulnerable to remote attacks, physical proximity is no longer needed to inflict damage on infrastructure. In December 2015, the NSW Department of Industry's IT security systems detected a marked increase in virus/security activity during attempts to affect systems at the Division of Resources and Energy office in Maitland. While the attack was detected, the extent of the data compromise remains unknown.⁴⁵ All commercial and industry networks are open to computer-based attack and have varying degrees of cyber protection.

Concern about cyber threats is further complicated by potential foreign ownership of Australian network electricity businesses. In April 2016, the Senate Economics References Committee reported on the foreign investment review framework. That inquiry was prompted primarily by the Northern Territory Government's decision to grant a 99-year lease over sections of the Port of Darwin to the Landbridge Group and the potential lease of major sections of the electricity transmission grid (TransGrid) by the NSW Government to a consortium that included State Grid Corp of China. TransGrid was subsequently leased to an Australian-led consortium.

Evidence provided to the committee argued that 'infrastructure' shouldn't be thought of as only physical assets, but also production systems and control networks. This includes such areas as maritime ports and airports, communications systems, power generation, distribution and transmission, hospitals and medical facilities, critical industrial capabilities used to support the Australian Defence Force, and essential government infrastructure.⁴⁶

The Senate Economics References Committee recognised that regulating foreign investment is a complex and constantly changing policy area that will continue to challenge Australian governments seeking to secure the benefits of such investments without jeopardising Australia's long-term strategic interests. Therefore, the foreign investment review arrangements were deemed in need of strengthening to support assessments while also ensuring that they can continue to be responsive to new and emerging challenges.⁴⁷ A key question about foreign investment in energy networks is the effectiveness of governance and maintenance arrangements implemented after a sale or leasing agreement.

On 18 August 2016, the lease of 50.4% of Ausgrid, the NSW electricity distribution network, to foreign interests was formally blocked by the Australian Treasurer on the grounds of national security. The Treasurer stated that:

... during the review process national security issues were identified in critical power and communications services that Ausgrid provides to businesses and governments ... no suitable mitigations have been identified that would, for the proposed transaction structure, appropriately address the identified risk.⁴⁸

Recommendation 2: Develop a formal national approach overseen by the new Critical Infrastructure Centre to strengthen the security and resilience of the electricity grid. Use a whole-of-government approach at all levels and across all agencies to examine relevant threats and manage the current misalignment of stovepiped policy.

Address Australia's evolving transport energy demands

Policies to address our evolving demand for transport energy will need to consider Australia's liquid fuel supplies, possible geopolitical challenges to supply chains and the potential for technological disruptions to demand.

Liquid fuels

Just as the domestic electricity grid is critical to the resilience of our built environment, liquid fuels are fundamental to ensuring the resilience of our national logistics supply chains. Australia's transport industry is almost wholly dependent on oil. In the near and medium term, there are no alternatives to the fossil-based liquid fuels used for transport. Consequently, liquid fuel supply poses an enduring risk to Australia's economic resilience, national security, food security and social stability.

The key mitigation strategies, which are all lessons from the 1970s oil crises, are to have strong liquid-fuel supply chains, hold emergency oil stocks, have a domestic refinery capability, and maintain an emergency fuel distribution system for times of shortage. Australia undertakes these actions to various degrees, but it's questionable whether current practices can achieve liquid fuel security.

Geopolitical challenges to liquid fuel supply chains

Significant geopolitical challenges affect the security of liquid fuel supply chains. For example, conflicts and disasters in oil producing and refining countries could disrupt supply.

Another issue is that national oil companies, such as Petro China and Saudi Aramco, are beginning to dominate the production and refining of oil at the expense of private oil companies. As the name suggests, national oil companies have strong strategic and political links to their governments. Almost 80% of the world's proven and probable reserves of conventional and unconventional oil are controlled by national oil companies or their host governments.

China's net crude oil imports continue to grow and could reach 8 million barrels per day by 2025, with the greatest volume coming from the Arabian Gulf. Australia's persistent faith in global supply-chain stability could be sorely tested in the future if national oil companies make decisions based on security interests rather than commercial interests.

While infrastructure enhancements, continued diversity in sourcing and the management of imported petroleum product supply chains will attenuate the effect of unexpected geopolitical tensions, a future continuity strategy must ultimately address the security of Australia's petroleum supply lines. Even though the US is rapidly reducing its dependence on Middle Eastern oil, Australia, along with Japan and South Korea, remains highly dependent on the security of sea lanes for energy imports (and other commercial trade).

While it's unlikely that the US will significantly reduce its provision of sea-lane security in the Indo-Pacific region, instances of limited conflict or increased competition may have some effect on the reliability of the sea lanes. Given the shared national dependence on the energy trade, there's a common interest in maintaining basic freedom of maritime navigation in those areas.

However, shared interest doesn't equate to consensus on how best to cooperate to achieve this outcome. There are significant and ongoing questions about whose responsibility it is to secure sea lanes, and who should bear the costs of guaranteeing their security.⁴⁹

Technological disruption in transport energy demand

Given the potential vulnerability of liquid fuel supply chains, changing transport energy demand is a reasonable strategy to promote medium-term energy resilience. Freight movement could be shifted from road to rail, although that requires infrastructure investment and government commitment to changing practices in the freight industry. Enhancing the technology used in public transport may also reduce demand by reducing the number of vehicles on roads and the requirement for conventional fuels.

Electric vehicles drawing energy from a mature grid, including hybrid electric, plug-in hybrid and all-electric options, have an advantage over vehicles using liquid fuels. A major benefit of electric vehicles will come from shifting energy consumption from liquid fuels to electricity; a secondary potential benefit will come from reduced peak electricity demand.

When connected to charging stations during a peak-demand period, electric vehicles could have their batteries drawn down to help provide power to the network. This could reduce the need for network businesses to expand the electricity network to cope with high-demand periods.

Hydrogen is an alternative fuel that can be produced from domestic resources. Clean, economical and safe production and distribution of hydrogen for use in fuel-cell electric vehicles is now a proven technology. Fuel-cell electric vehicles are beginning to enter the consumer market in localised areas domestically and around the world.

On 30 August 2016, the Australian Capital Territory Government announced a landmark project that includes Australia's first-ever commercial order for hydrogen-powered cars. Hyundai Motor Company Australia will provide 20 next-generation hydrogen fuel-cell electric vehicles to the government in 2018 as a part of the Renewable Transport Fuels Test Berth in Canberra. Servicing and maintenance are included in the package.⁵⁰

Autonomous (driverless) cars are already legal in several states of the US and are now being trialled in Australia. By employing several technologies, the driverless car will completely reshape the design of vehicles. In time, there will be fewer requirements for many safety features because artificial intelligence will reduce accidents, resulting in a lighter and smaller vehicle that uses less fuel. In combination, electric and autonomous vehicles will completely disrupt the transport energy value chain.

The overall impact of these changes will be to reduce the reliance of land-based vehicles on petroleum products and shift further energy demand to the electricity grid. However, aircraft and ships will rely on petroleum fuel for several decades yet.

The Prime Minister has publicly supported innovation in energy policy by promoting the pursuit of 'affordable, reliable, energy security' and taking an innovative approach.⁵¹ Australia should maximise returns on technological investment and its resource advantages.

The energy sector, which is a national good employing a skilled and educated workforce and generating innovative products and services, should invest in its own reliability rather than simply being at the end of a global supply chain. Australia has comparative advantages in zero- and low-emissions technologies. Supporting efforts to enhance and sustain collaboration between research and industry groups can help promote Australian industry (see box).

The transition from the current transport energy profile to a different one will involve changes to the existing pattern of production, transformation, transport and use across all sectors of the economy, against a backdrop of evolving social and environmental demands. It will require changes to the fleet of current vehicles and infrastructure. This means that achieving energy resilience must be seen in terms of decades rather than years and linked with long-term industry- and community-based strategies.

Recommendation 3: As part of the 2017 COAG Energy Council agenda, specifically plan to address the nation's response to disruptive innovation and enhanced choices for meeting the energy needs of the transport industry. This planning schema should address affordability, long-term stability, demand management and incentives.

The RASER Project led by Renewable Hydrogen

The RASER (Renewable Hydrogen, Siemens and Hyundai) Project looks to exploit the characteristics of anhydrous ammonia (NH₃) as the 'other' hydrogen and showcases all the advantages of hydrogen as a fuel. Importantly, NH₃ provides proven, practical, low-cost storage and delivery of hydrogen, overcoming the main barrier to the hydrogen economy. NH₃ can be produced from any primary source (wind, solar, biomass, coal, nuclear, hydro, ocean thermal and so on).

Upstream (production) investments into renewable energy storage and grid stability have driven investment in electrolyser technology, which makes the hydrogen available from NH₃. RASER makes use of an innovative electrolysis system that uses wind and solar energy to produce hydrogen with zero carbon emissions.

Key downstream (consumption) technology investment advantages are:

- fuel cells (50%+ efficient) approaching \$100/kW and forecast to fall to \$60/kW
- hydrogen cars, buses and heavy transport on the market
- hydrogen fuel station rollout well underway.

The project addresses the full ecosystem. The Davos World Economic Forum in January 2017 confirmed industry commitment to renewable hydrogen as a core part of the global economy. RASER creates a complete value chain in Australia and takes advantage of a low-carbon 'super-convergence' of energy, transport, industry and agriculture.

Australia has a high dependency on imported liquid fuels—a condition we share with Japan, Korea and other Pacific neighbours—so partnering with those energy-intensive markets provides economies of scale and gives Australia's 'stranded' solar and wind assets of immense domestic, export and strategic value.⁵²

Senate Inquiry into Transport Energy Resilience and Sustainability

In 2015, the Senate Rural and Regional Affairs and Transport References Committee conducted an inquiry into Australia's transport energy resilience and sustainability. The committee made three recommendations:

- That the Australian Government undertake a comprehensive whole-of-government risk assessment of Australia's fuel supply, emphasising assumptions of availability and consequences of significant loss or reduction in supply. The assessment should consider the vulnerabilities in Australia's fuel supply to possible disruptions resulting from military action, acts of terrorism, natural disasters, industrial accidents and financial and other structural dislocation. Any other external or domestic circumstance that could interfere with Australia's fuel supply should also be considered.
- That the Australian Government require all fuel supply companies to confidentially report their fuel stocks to the Department of Industry and Science on a monthly basis.
- That the Australian Government develop and publish a comprehensive Transport Energy Plan directed to achieving a secure, affordable and sustainable transport energy supply. The plan should be developed following a public consultation process. Where appropriate, the plan should set targets for the secure supply of Australia's transport energy.⁵³

These three recommendations support resilience by addressing systemic issues of geostrategic competition, hybrid threats and resource security. The Australian Government responded in 2016, accepting the first two recommendations, with caveats, but didn't accept the final recommendation, arguing that the market and the upcoming NESA will address the identified shortfall in policy.

This report has noted the inadequate way the market responded to vulnerabilities in the electricity sector identified in the 2011 NESAs. The government's failure to accept Recommendation 3 reinforces an incomplete approach to a critical aspect of the Australian economy.

Recommendation 4: Reconsider the government's non-acceptance of Recommendation 3 of the Senate Rural and Regional Affairs and Transport References Committee's inquiry into Australia's transport energy resilience and sustainability.

Ensure compliance with the International Energy Agency's 90-day stockholding obligation

Since 2012, Australia has been noncompliant with its obligation under the 90-day liquid-fuel stockholding policy of the International Energy Agency (IEA). On 31 May 2016, Australia provided a plan to meet compliance requirements to the IEA's governing board. The plan contains both immediate actions and a forward work program to enable full compliance to be achieved by 2026. The government has allocated \$23.8 million to the first phase of returning to compliance.⁵⁴

It's encouraging that the Australian Government is acting to remedy the IEA noncompliance and that the arguments presented by the petroleum industry that IEA compliance wasn't necessary have now been dismissed. The stockholding policy is a sound practice; however, it will take until 2026 to reach compliance, and the remediation measures are not fully funded.

Recommendation 5: As a matter of urgency, act to address noncompliance with the IEA agreement to maintain reserve supplies of liquid fuels sufficient to meet demand for at least 90 days.

Energy-proof our communities

One of the fundamental energy vulnerabilities in modern Australia is based in demography. With close to 90% of Australians living in cities, supplying energy in those cities is critical to our future resilience. Recent developments targeting city resilience have helped to bridge a policy gap between disaster risk reduction and climate change adaptation. Such approaches move away from traditional disaster risk management, which has often been founded on assessments that relate to specific natural hazards. Instead, the newer approaches accept the possibility that a wide range of disruptive events—both stresses and shocks—may occur but are not necessarily predictable.

Resilience at the city level results in part from a sustained provision of services in the face of multiple hazards and cascading disruptions, rather than from preventing or mitigating the loss of assets due to specific events.⁵⁵ The robustness of essential service networks in cities becomes particularly important during severe environmental events. Energy networks underpin the operation of sufficient, safe and reliable city-wide water and sanitation systems.

Electricity power lines are regularly damaged by storms and repaired as rapidly as possible, but an efficient and effective response is only part of delivering resilience. Energy systems designed with redundancy can accommodate surges in demand or disruption to supply networks. Engineering design and construction must deliver functional infrastructure that's robust and won't fail catastrophically when design thresholds are exceeded.

New approaches to engineering standards and guidelines may be useful. Standards normally change only after the accumulation of a significant body of evidence on inefficiencies or when the change is forced by catastrophic failure. While this means that sound practices aren't changed until modern techniques are proven and tested, the length of the process and its complex governance mean change can be very slow.

Out-of-date design and maintenance practices leading to infrastructure failure in extreme weather can reflect very poorly on governments, the engineering profession and builders. While impact-resistant infrastructure was built in the past, today's system complexity (and the projected mix of technology in future electrical grids) and the

increased incidence of extreme weather require a shift towards having energy infrastructure operating under a ‘graceful degradation’ schema.

Graceful degradation requires a systematic understanding of failure modes and effects that can make the design of energy systems more secure and more reliable and can contribute to the quicker restoration of services in case of disruptions.

In time, new design considerations can be implemented in the energy system and associated urban infrastructure, but the non-retrospective nature of most regulation leads to a significant range of compliance across the city. Given that existing properties with ageing electrical infrastructure form 90% of the building stock at any time,⁵⁶ a greater focus on how existing buildings can be made more resilient is needed.

A significant burden for local government is the need to manage infrastructure assets for continuity, insurability and long-term value.

Energy-proofing means providing for future economic prosperity. At some time, Australia must integrate the demands of carbon reduction into energy economic models. The principal problem is that carbon pollution isn’t priced correctly in Australia and, given the toxic nature of the political debate on carbon reduction, there’s no confidence that it will be any time soon. Addressing the effects of climate change is a complex topic, and there’s no single crude brushstroke solution. Considering a price on carbon dioxide should be part of the mix, as should factoring in the possibility of non-carbon or low-carbon energy technologies that may emerge through time.

The need for economic future-proofing is widely recognised. In his preliminary report, the Chief Scientist pointed to the work of the COAG Energy Council, the AEMC and the AEMO, which have called for:

- an emissions intensity scheme in which an emissions intensity baseline is established for the generation sector
- an extended Large-scale Renewable Energy Target
- the regulated closure of fossil-fuelled power stations.⁵⁷

The political reaction was swift, as the Prime Minister quickly ruled out the introduction of an emissions intensity scheme for the electricity sector.⁵⁸ However, this only serves to ‘kick the can down the road’, as a price on carbon is a key part in climate change solutions that will ultimately help energy-proof our communities.

Establish responsibility for energy resilience in the face of disasters

The 2008 ASPI report *Taking a punch: building a more resilient Australia* noted that, with higher rates of private ownership of infrastructure, an important question is ‘Who manages resilience?’⁵⁹ Large-scale foreign ownership of network businesses, as discussed above, complicates this question, but the many complex public–private and mixed ownership arrangements found across all communities also make it difficult to understand where responsibility for the stability and continuity of an energy system lies.

Energy infrastructure may be maintained with outsourced service industry support, albeit with variable contractual responsibility. While such arrangements might support efficient daily operational requirements, managers may not fully comprehend the level and nature of extant risk within infrastructure components. Addressing the potential for ‘outsourced’ vulnerability is critical to promoting energy resilience.

Adequate and dependable supplies of transport fuels are essential to the provision of essential services at the local and state levels. During disasters, federal intervention to assure energy supplies is supported under the *Liquid Fuel Emergency Act 1984*, which gives the Australian Government the authority to prepare for and manage a national liquid fuel emergency. The Act aims ‘to minimise the total impact on the community ... minimising economic dislocation’. In practice, it provides a level of economic insurance to industries with a heavy reliance on liquid fuel.⁶⁰

The Act enables the activation of the National Oil Supplies Emergency Management Committee to assist in implementing plans. Existing plans or options available to the committee aren't publicly available, as they contain sensitive information and are event driven, but the goal is the recovery of supply to communities and urban areas as soon as practically possible following a disturbance.

Australia's heavy dependence on liquid fuel imports means that any unexpected shocks to the system will test the nation's resilience, both collectively and individually. Public consultation before a disruption would achieve some public trust and cohesion when the system is put to the test.

Recommendation 6: Reinvigorate the National Strategy for Disaster Resilience to include support for wide consultation with stakeholders (communities and local and state governments) on electricity and transport fuel demands.

Securing the livability and sustainability of our communities will require coordination across all three levels of government—an aim that's unfortunately fraught with inaction in Australia. The goals of reduced carbon emissions, better transport solutions and improved local environmental outcomes will be delivered only if energy infrastructure is continually developed in consultation with the community.

CONCLUSIONS AND RECOMMENDATIONS

The global energy system is under stress from volatile oil prices, the challenge of climate change, geopolitical unrest and economic uncertainty. Now isn't the time to pretend that a business-as-usual approach in the Australian energy sector is a viable strategy that provides support for national energy resilience.

Currently, Australian energy policy tends to be stovepiped and sector-specific, which doesn't map well to the complexity inherent in energy infrastructure systems. A major cause of this failure to adequately and fully address energy has been decades of policy focused on economic benefit and assured supply, with a lesser emphasis on other drivers of change.

Developing energy resilience strategies is essential after a long period during which energy supply has been seen through singular lenses focused on differing energy types with discrete global supply chains and disparate, separately managed, vulnerabilities.

The energy sector faces interconnected vulnerabilities: technological innovation; resource management and security; climate change; geostrategic competition; demographic shifts; efficient governance; social cohesion and trust; and hybrid and asymmetric threats. In formulating policy, it is critical that the Australian Government consider the complex interdependencies of these vulnerabilities. Continued planning in isolation will ensure that Australia will face ongoing and increasingly chronic insecurity from failed energy policy.

To secure a prosperous and secure future for all Australians, we must expedite reform of supply in the electricity system to allow for collaborative planning that can assure the future energy-proofing of our communities.

This report makes six recommendations to the Australian Government:

- Through the COAG Energy Council, integrate and improve federal, state and local government planning processes, models and procurement processes to foster greater cost-effective choice in the adoption of new technologies, microgrids and more diverse energy generation options.
- Develop a formal national approach oversights by the new Critical Infrastructure Centre to strengthen the security and resilience of the electricity grid. Use a whole-of-government approach at all levels and across all agencies to examine relevant threats and manage the current misalignment of stovepiped policy.
- As part of the 2017 COAG Energy Council agenda, specifically plan to address the nation's response to disruptive innovation and enhanced choices for meeting the energy needs of the transport industry. This planning schema should address affordability, long-term stability, demand management and incentives.
- Reconsider the government's non-acceptance of Recommendation 3 of the Senate Rural and Regional Affairs and Transport References Committee's inquiry into Australia's transport energy resilience and sustainability.
- As a matter of urgency, act to address noncompliance with the IEA agreement to maintain reserve supplies of liquid fuels sufficient to meet demand for at least 90 days.

- Reinvigorate the National Strategy for Disaster Resilience to include support for wide consultation with stakeholders (communities and local and state governments) on electricity and transport fuel demands.

The means and vision exist to build a national electricity grid that's more resilient and at the same time more agile and adaptable to changing circumstances, be they linked to natural hazards, geopolitical change, market fluctuations or technological advances. The challenge of achieving resilient energy supply must also consider the needs of our future communities, economic stability and, ultimately, our national interest.

NOTES

- 1 Department of Industry and Science, *Energy White Paper 2015*, 2015, 'Foreword by Minister'.
- 2 Malcolm Turnbull, 'Doorstop—Launceston City deal MOU signing', transcript, 29 September 16, [online](#).
- 3 These closures include Port Stanvac (SA), closed in 2009; Clyde (NSW), refinery converted by to a fuel import terminal in 2013; Kurnell (NSW), refinery converted to a fuel import terminal in 2014; Bulwar Island (Qld), closed in 2015.
- 4 House of Representatives Standing Committee on Economics, *Report on Australia's oil refinery industry*, January 2013, paragraphs 2.3–2.4.
- 5 J Blackburn, *Benchmarking Australia's transport energy policies*, NRMA Motoring & Services, December 2014, 2.
- 6 M Wesley, *Power plays: energy and Australia's security*, ASPI, Canberra, 2007, 2, [online](#).
- 7 Energy Change Institute, *ECI Energy White Paper forum*, Australian National University, 28 April 2015, summary, [online](#).
- 8 UN Framework Convention on Climate Change, *Paris Agreement—status of ratification*, [online](#).
- 9 Department of Resources, Energy and Tourism, *National Energy Security Assessment*, 'Key messages', 2011.
- 10 Department of Resources, Energy and Tourism, *National Energy Security Assessment*, 'Key messages'.
- 11 Matt Chambers, 'National energy security panel appointed', *The Australian*, 24 October 2016, [online](#).
- 12 Department of Defence, *Defence White Paper 2016*, 2016, [online](#).
- 13 Australian Government, *Critical Infrastructure Resilience Strategy*, 2010.
- 14 Council of Australian Governments, *National Strategy for Disaster Resilience: building our nation's resilience to disasters*, 2011.
- 15 'Something has to give in oil markets', OilPrice.com, 17 February 2017, [online](#).
- 16 Institute for Energy Studies, *Does oil price volatility matter?*, University of Oxford, [online](#).
- 17 International Energy Agency, *Oil supply emergency response of IEA countries*, 'Summary', 2007.
- 18 Organization of the Petroleum Exporting Countries, *Annual statistical bulletin 2016*, [online](#).
- 19 Department of Industry and Science, *Energy White Paper 2015*.
- 20 Energy Studies Institute, *The future of sea lane security between the Middle East and Southeast Asia*, meeting summary, 23–24 June 2015, National University of Singapore.
- 21 P Barker, *Can LNG continue to fuel Papua New Guinea's economic growth?*, Australia – Papua New Guinea Network, 25 February 2015, [online](#).
- 22 Ian Finkel, *Independent Review into the Future Security of the National Electricity Market: preliminary report*. Department of the Environment and Energy, 16 December 2016, [online](#).
- 23 Department of the Environment, *National Climate Resilience and Adaptation Strategy*, December 2015.
- 24 Malcolm Turnbull, 'Address to the National Press Club', 1 February 2017, [online](#).

- 25 UK Energy Research Partnership, *Report on public engagement*, 'Summary', 2014.
- 26 Tasmanian Government, *Tasmanian Energy Security Taskforce: interim report*, December 2016, [online](#).
- 27 Finkel, *Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future*, 9 June 2017, Recommendations, 21–28, [online](#).
- 28 Australian Energy Regulator (AER), *Our role*, [online](#).
- 29 Australia Electricity Market Operator, *About AEMO*, [online](#).
- 30 Australian Electricity Market Commission, *National Electricity Market*, [online](#).
- 31 AER, *Our role*.
- 32 COAG Energy Council, *Our role*, [online](#).
- 33 Finkel, *Independent Review into the Future Security of the National Electricity Market: preliminary report*.
- 34 Infrastructure Australia, *Australian Infrastructure Plan: priorities and reforms for our nation's future*, January 2016, [online](#).
- 35 Infrastructure Australia, *Australian Infrastructure Plan: priorities and reforms for our nation's future*.
- 36 Smart Cities Council, *Case study: University of California San Diego microgrid*, 2012, [online](#).
- 37 Australian Government, *Our north, our future: White Paper on developing Northern Australia*, [online](#).
- 38 Matt Canavan, 'Interview on ABC AM program', transcript, 3 February 2017, [online](#).
- 39 Infrastructure Australia, *Australian infrastructure audit 2015*, Recommendation 67.
- 40 J Snow, *The economic impact of high energy prices in Australia*, 'Executive summary', policy paper 6 2014, Energy Policy Institute, February 2014.
- 41 T Wood, D Blowers, *Price shock: is the retail electricity market failing consumers?*, 'Executive summary', Grattan Institute, March 2017, [online](#).
- 42 Malcolm Turnbull, 'Doorstop with the Minister for Industry, Innovation and Science, Senator the Hon Arthur Sinodinos and the Minister for Resources and Northern Australia, Senator the Hon Matt Canavan', transcript, 27 April 2017, [online](#).
- 43 Engineers Australia, *The future of Australian electricity generation 2017*, 'Renewable technologies', March 2017, 29.
- 44 Department of Economic Development, *Powerline Bushfire Safety Program*, Victorian Government, [online](#).
- 45 Department of Industry, Resources and Energy, *Statement on recent reports of a cyber attack on DRE's Maitland office*, NSW Government, 3 February 16, [online](#).
- 46 Senate Economics References Committee, *Final report: Foreign Investment Review Framework*, 8 April 2016, [online](#).
- 47 Senate Economics References Committee, *Final report: Foreign Investment Review Framework*.
- 48 Scott Morrison, 'Foreign investment applications for the 99-year lease of Ausgrid', media statement, 11 August 2016, [online](#).
- 49 Energy Studies Institute, *The future of sea lane security between the Middle East and Southeast Asia*.
- 50 Hyundai Motor Company Australia Ltd, 'Hyundai secures order for 20 next-generation hydrogen fuel cell vehicles in Australia', media statement, 30 August 2016, [online](#).
- 51 Malcolm Turnbull, 'Remarks at Energy Committee of Cabinet', media release, 21 February 2017, [online](#).
- 52 Presentation to the authors by Project RASER (Renewable Hydrogen, Siemens and Hyundai) team, 14 February 2017.
- 53 Senate Standing Committee of Rural and Regional Affairs and Transport, *Australia's transport energy resilience and sustainability*, 25 June 2015, [online](#).
- 54 Australian Government response to the Senate Rural and Regional Affairs and Transport References Committee report *Australia's transport energy resilience and sustainability*, November 2016.

- 55 Ove Arup & Partners International Limited, *City Resilience Framework*, April 2014.
- 56 Melbourne Energy Institute, Beyond Zero Emissions, The University of Melbourne, *Zero Carbon Australia: Buildings Plan*, 2013, 'Non-residential modelling', 211–212, [online](#).
- 57 Finkel, *Independent Review into the Future Security of the National Electricity Market: preliminary report*.
- 58 Malcolm Turnbull, 'Transcript: Doorstop, Sydney', media release, 7 December 2016, [online](#).
- 59 A Bergin, D Templeman, *Taking a punch: building a more resilient Australia*, Strategic Insights 39, ASPI, Canberra, 2008, [online](#).
- 60 *Liquid Fuel Emergency Act 1984* (Cwlth), Part I, section 6.

ACRONYMS AND ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
COAG	Council of Australian Governments
COP21	21st Conference of the Parties to the UN Framework Convention on Climate Change
IEA	International Energy Agency
LNG	liquefied natural gas
NEM	National Electricity Market
NESA	National Energy Security Assessment
NSW	New South Wales
OPEC	Organization of the Petroleum Exporting Countries
TISN	Trusted Information Sharing Network
UN	United Nations

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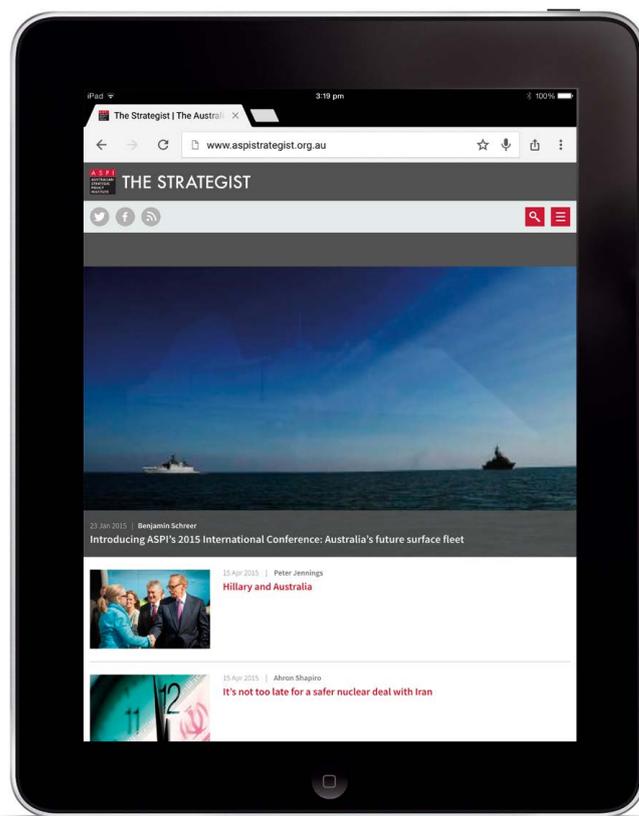


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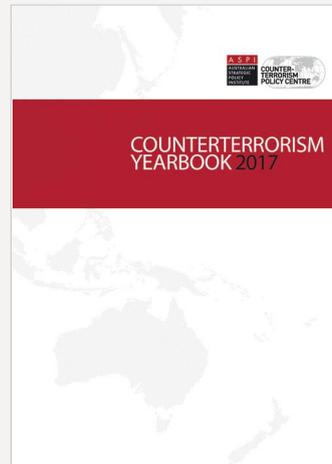
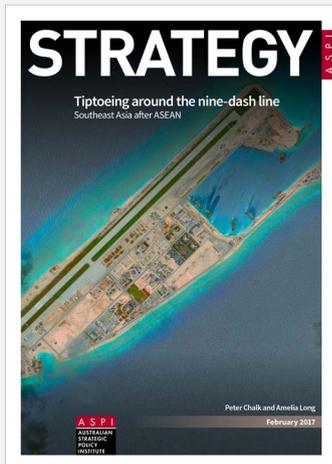
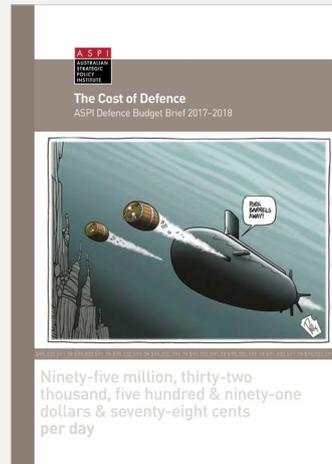
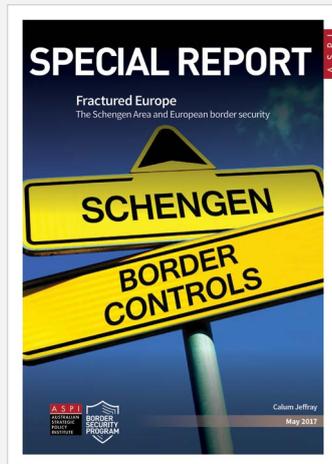


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