The University of Queensland
Australia

Global Change Institute

Meeting the challenge of change

Delivering a competitive Australian power system

Part 3: A better way to competitive power in 2035

October 2013

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Executive summary

It is important for Australia to pursue a strategy of diversity in power generation technologies and energy sources to keep options open for the future and initiate climate change mitigation measures.

This paper, the final in a three-part series examining the competitiveness of Australia's power system, seeks to identify a pragmatic strategy to transition Australia to a resilient power economy at reasonable cost and in an age of uncertainty.

Background

The resilience of a country's power economy refers to its ability to meet power requirements while withstanding supply shocks and environmental constraints. For a country's power economy to be competitive, it must be both affordable and resilient.

This series examines the competitiveness of Australia's power economy and evaluates possible strategies for securing the nation's power economy into the future. In Part 1, (published December 2011), we demonstrated that Australia's power system was not resilient, with higher electricity prices than most competing countries. Various scenarios for Australia's power future were the focus in Part 2 (published February 2013). Our analysis found that shifting to gas from coal power generation did not address this vulnerability but could instead lead to large price increases. Rather, a portfolio approach to investing in electricity generation will ensure Australia starts to build a power system that is more robust, and thus more competitive, in the years to come.

The solution

While market structures are well-suited to factoring risk into investment decisions, electricity generation in Australia faces multiple layers of uncertainty and external costs which can deflect the market from efficient outcomes. For this reason, it is important for Australia to pursue a strategy of diversity in power generation technologies and energy sources to keep options open for the future and initiate climate change mitigation measures.

The best way to achieve both resilience and cost competitiveness in Australia's power system is to develop a strategy that pursues the middle ground. In this paper, Part 3 of the series, we use the Power System Resilience Index developed in Part 1 to compare German, Chinese and Californian energy policies with Australia. We ask how effective they are in achieving greater diversity and, in this way, resilience in electricity.

We find that Feed-in-Tariffs have been largely successful at achieving diversified generation; but that shifting generation to domestic and small business consumers – what we call "democratising" generation – imposes a cost burden on consumers.

To achieve a competitive and resilient power system, Australian strategy needs to focus on:

- Increasing the diversity of its energy fleet
- Decreasing the carbon dioxide (CO_2) emissions of its energy fleet
- Increasing the security of its fleet through robust storage options
- Improving the distribution efficiency of its power system

Specific policy measures to achieve these goals should:

- **Reduce** reliance on coal-fired generation. The Renewable Energy Target (RET) and the carbon price legislation have been fairly successful in encouraging investment in alternative forms of generation, although potential changes to both of these policy levers threaten their ongoing effectiveness. Also, the current structures of the RET and carbon price do not encourage investment in energy sources other than wind and gas.
- **Regulate** that new coal-fired plant can only be licensed if it meets world class efficiency and environmental standards and is fitted with Carbon Capture and Storage (CCS).
- **Invest** in community consultation with respect to acceptance of nuclear power, and the siting studies and regulatory frameworks required to enable a future option for nuclear power generation.

- **Encourage** participation in global research and development communities where a technological option exists but is as yet too expensive or too immature to deploy. This will keep the options open while Australia benefits from the knowledge gained from the combined research efforts of a multitude of larger nations.
- **Foster** bipartisan support to fund and direct the deployment of those technologies available now to benefit from increased diversity of generation, as well as reduced carbon emissions.
- **Pursue** pragmatic actions by using small, incremental steps (which are simpler to fund and implement than large, transformative change) to work towards the strategic goal of greater power system resilience.

Based on our findings, we are making two key proposals:

Proposal 1: Funds from polluters should be used to invest directly in utility scale CO_2 abatement, diversity and resilience to reduce emissions and minimise costs to consumers

Proposal 2: Australia must invest in energy innovation for economic growth. Australia's power industry has successfully exploited its local domestic resources of coal but this has resulted in too little diversity and very high levels of CO_2 emissions. It is now timely to invest in other local resources for greater resilience.

The first key proposal requires a bipartisan approach.
We recommend overlaying an incentive mechanism, similar to the Liberal-National Coalition's proposed approach, on top of the funding mechanism that the Labor Government has implemented. In this way, both major parties will have contributed to meaningful policy formulation, supplying essential policy measures which together will help position Australia's power system to meet climate change objectives and reduce vulnerability to energy and carbon shocks.

The second proposal continues the thinking started in the Australian Government's 2008 Cutler Report, and advanced in the 2011 Clean Energy Futures package, which supports investment in Australia's ability to innovate and reap the benefits from research. Pursuing this course of action would provide Australia with a remarkable opportunity to build a detailed regional development plan structured around innovation and the development of local energy sources in every state.

1. Introduction

An increased focus on energy efficiency and uptake of rooftop photovoltaics (solar panels) has reduced growth in energy demand but the impact on load growth in the longer term is still unknown.

In the first installment of this series, "Part 1: Australia's global position", we defined and constructed a metric to compare, systematically and rationally, the efficiency, diversity and security of national power systems which we called the Power System Resilience Index. We used the Index to compare Australia's power economy with its closest competitors and in doing so found that Australian power was not cheap, resilient or competitive (Ball et al., 2011).

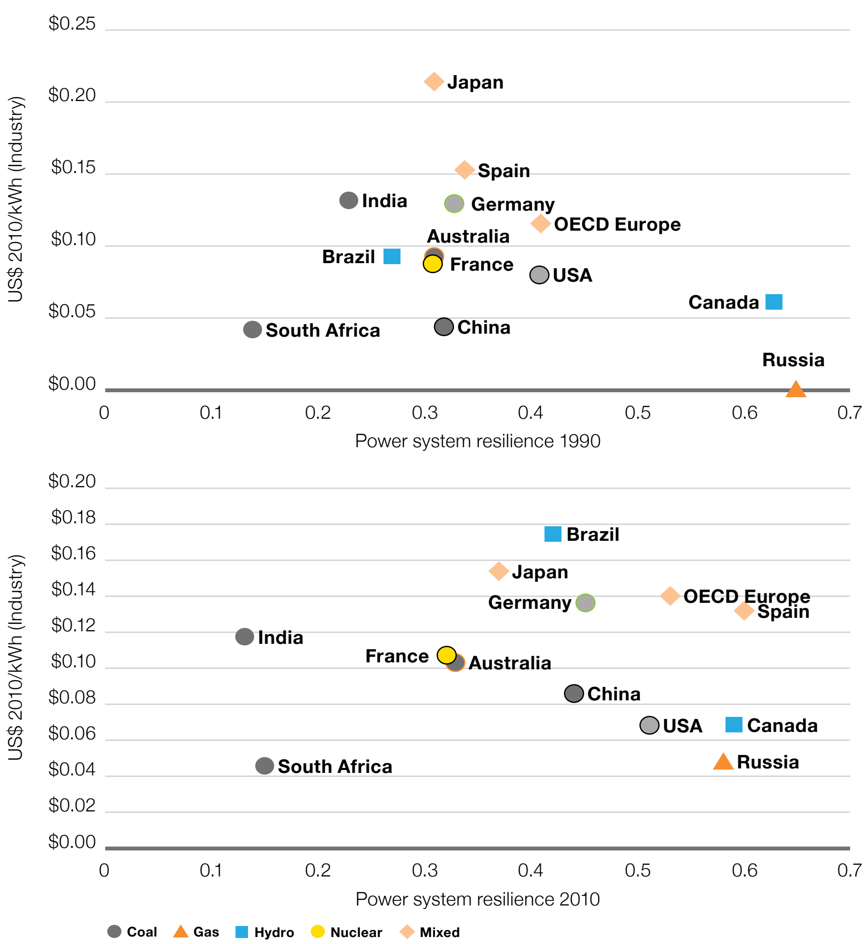
Since 1990, most other countries have improved their resilience, generally through greater diversification of energy sources. Spain, in particular, has reduced its reliance on fossil fuels, reduced emissions and increased diversity of energy sources.

However, Australia, France and South Africa remain largely reliant on power from a single source, making them vulnerable to shocks in energy supply (and carbon costs, in the cases of Australia and South Africa) which lead to higher electricity prices and thus a lack of competitiveness in attracting electricity-intensive investment.

It became clear in the second part of the series, "Part 2: The challenges, the scenarios", that shifting from coal-fired to gas-fired power was unlikely to improve resilience, cost competitiveness or gross emissions by 2035. Other key findings in Part 2 included:

- Carbon capture and storage (CCS) and nuclear investment would improve resilience and emissions reductions but longer-term global investment in research, development and deployment is needed to make the technology affordable. Even then, CCS might still not be competitive with the lowest cost renewable alternatives.
- The deployment of nuclear power relies on winning over an uncertain public after the problems experienced in Fukushima in 2011 and the likely time-consuming task of finding a suitable site for plants.
- Investing in distributed (electricity generated from many small energy sources) and renewable generation would deliver resilience, emissions reductions and an energy profile that the public is likely to support but this depends on cost, security of supply, size and location of the generation projects. In relation to security of supply, research and development is required to deliver new cost effective storage technologies and to resolve potential network instability issues associated with intermittent generation.

Figure 1: Power System Resilience, 2010 versus 1990



Source: (IEA, 2013, IEA, 2012).
Note: Legend indicates majority of fuel source for generation; full colour greater than 50 percent, muted colour less than 50 percent

- Pursuing renewable and distributed generation addressed more of the challenges facing the industry, although options to deploy nuclear power and CCS should be kept open to ensure that deep emission reductions can be attained if necessary (Foster et al., 2013).

In this third paper, we seek to identify a pragmatic strategy to transition Australia to a resilient power economy at reasonable cost in an age of uncertainty. We focus on uncertainty because the provision of power in Australia faces multiple levels of uncertainty. These include:

Future carbon constraints and worldwide demand for coal

The predicted effect of carbon emissions on seas and ecosystems has been widely ignored in favour of continued development of fossil fuel resources. While the fossil fuel industries may not agree, the Carbon Tracker Initiative claims that current investment decisions are not factoring in the risk associated with future carbon constraints and the vulnerability of Australian coal investment, in particular, to reduced revenues if global demand for coal falls sharply. This could result in the emergence of expensive stranded assets in coal and gas production (Carbon Tracker and The Climate Institute, 2013).

International policies and growth of other nations

Globalisation has heightened competition, placing pressure on costs, so Australia faces an uncertain investment future dependent often on the policies and growth of other nations, rather than domestic policies.

Table 1: Forces driving the power system and how the different scenarios address these forces

Forces driving the power system	Ability to address forces driving the system				
Scenarios	**Base**	**Non-Renewable Centralised Power**		**Changing Technological Landscape**	
	Business-as-Usual	***Carbon capture and storage***	***Nuclear***	***Renewables***	***Consumer action***
Rising prices					
Fuel	✗	✗	✗	✓	✓
Distribution	✗	✗	✗	✗	✗
Carbon constraints	✗	✓	✓	✓	✓
Infrastructure renewal	✓	✗	✗	✗	✓
Public support for renewables	✗	✗	✗	✓	✓
Technology shift to renewables and distributed generation	✗	✗	✗	✓	✓

Impact of growing bills on low income budgets

Growing Gross Domestic Product (GDP) has not delivered greater equality, so Australians on the lowest incomes face uncertainty about how to fund growing household bills.

Political uncertainty and unpredictable markets

Voters give conflicting messages to politicians who deliver policies that have an uncertain tenure because they lack bipartisan support. Consequently, policy has moved away from regulation towards the use of market measures which reduce regulatory risk but introduce uncertainty in both effect and cost because the market response is unpredictable.

Carbon pricing

The proposed link to an international emissions trading scheme in Australia in 2014 or 2015 is forecast to decrease the carbon price for Australia. New investment in coal-fired generation will be unlikely and CO_2 emissions will not increase if demand for energy remains low and the Australian Government's Renewable Energy Target continues to encourage renewable energy investment. However, to reduce emissions there must be a shift away from coal-fired generation which will require a much higher carbon price than current market projections. A much higher carbon price will result in significant uncertainty for the power industry, and the Australian economy as a whole.

Changing energy behaviour

Evidence has emerged following major shocks from electricity price increases and the global financial crisis that behaviour driving electricity demand growth and load shape has changed. An increased focus on energy efficiency and uptake of rooftop photovoltaics (solar panels) has reduced growth in energy demand but the impact on load growth in the longer term is still unknown. Developing strategies for the long term under these circumstances is difficult.

The challenges of transformation

Changing to renewable and distributed generation presents management and engineering challenges for institutions and systems as the technological landscape is transformed. Utilities, meanwhile, will face financial consequences and require affordable capital and shareholder returns to make the change. This will lead to an uncertain and conflicted power system strategy, as consumers, utilities and shareholders will jostle to gain advantage, drawing on strategic responses that are yet to emerge.

So, what's the best way to develop a strategy in an environment of heightened uncertainty?

In understanding how to deal with uncertainty, we have drawn on the work of Austrian physicist and philosopher Ludwig Boltzmann and surprisal theory. In very broad terms, surprise is what probability is not. If something is highly probable it is not surprising.

To deal effectively with surprise it is important to move away from a single way of doing things and embrace diversity and spare capacity (Ulanowicz et al. 2009). This can be understood in terms of robustness – spreading your risk across a number of approaches – and responsiveness – the ability to switch to an alternative if your current approach breaks down.

It is important, therefore, to pursue diversity in both energy sources and policy implementation. Australia needs a technological portfolio strategy that keeps its options open, and avoids the trap of an energy impasse like that experienced by Japan after the 1970s (Molyneaux et al., 2012). By pursuing multiple policy options as a bipartisan strategy for Australian power, Australia will better prepare the power system and the economy for unpredictable future energy-related shocks.

We seek in this paper to identify policy that will deliver effective incremental steps to help achieve these goals, ensuring there is sufficient flexibility to manage change over multiple decades.

2. Policy for greater resilience

This series seeks to find the middle ground for shifting towards greater resilience, using the existing infrastructure to provide a foundation for, and reduce the cost of, a transformation to a sustainable, resilient power system.

2.1 The Energy White Paper's policy for resilience

The Australian Energy White Paper released in 2012 outlined the Government's strategy proposed for energy provision to 2050. It stresses the importance of reducing emissions associated with electricity generation while maintaining competitive prices. However, it advocates a relatively light regulatory approach, choosing to pursue an internationally-linked market mechanism after the more prescriptive 20 percent Renewable Energy Target (RET) expires in 2020.

The paper's proposed critical market mechanism is the carbon price, which is expected to internalise the cost of carbon dioxide (CO_2) emissions sufficiently to divert investment to clean(er) electricity generation. It proposes assistance for deploying immature technologies be provided either through institutional support from the Australian Renewable Energy Agency (ARENA), funding assistance for investment through the Clean Energy Finance Corporation (CEFC) or direct financial assistance for industrial scale demonstration of Carbon Capture and Storage (CCS) and solar power through their respective government-funded flagship programs.

The Energy White Paper cautions against infrastructure lock-in, and advocates a portfolio approach to electricity provision with a requirement to strengthen the resilience of the policy framework. However, it proposes Australia relies on a single market mechanism to deliver diversity and CO_2 emission reduction and focusses on the cheapest abatement option. In so doing it delivers neither diversity nor resilience.

Part 1 of this series showed that resilience requires not only efficiency, but also the more prescriptive elements of diversity and spare capacity. Investment projections to meet CO_2 emission reductions rely on ambitious international CO_2 permit prices. Considering the structural problems underlying current levels of the European Union's Emissions Trading System (EU ETS) CO_2 permit prices, it is worrying that more supportive measures to reduce uncertainty, ensure diversity or reduce emissions to boost resilience and meet ambitious CO_2 emission abatement goals, are not evident.

The Energy White Paper is based on a reliance on markets to stimulate innovation, offer better services and deliver adequate resources and investment. In fact, the market is to be the final arbiter on the provision of all services and strategies for energy in Australia. In terms of electricity, the paper states that electricity market reform has delivered competitively-priced electricity and it seeks to encourage full deregulation of the power system to complete the shift to private enterprise unfettered by government inadequacies.

From a policy perspective, a lack of transparency around the actual prices consumers pay makes it impossible to ascertain whether the move away from a regulated standing offer tariff has delivered benefits for Victorian consumers. Proceeding with deregulation in the rest of the states without greater transparency around the outcomes would not be based on sound evidence and is unlikely to stimulate investment for diversity and resilience.

2.2 100 percent renewable energy policy for resilience

As part of its Clean Energy Future Plan, the Australian Government commissioned the Australian Energy Market Operator (AEMO) to undertake a feasibility study into a power system reliant only on renewable energy, entitled the "100% Renewables Study". AEMO's draft modeling outcome included multiple caveats around the uncertain nature of predicting the performance of immature technologies based on hypothetical advances in efficiency and performance. Notwithstanding these concerns, the study suggested that under a 100 percent renewable energy system, operational issues appear manageable, and demand and load patterns are likely to evolve subject to the deployment of distributed and renewable generation.

It found that a wide range of technologies and locations and very high levels of capacity reserves would be required to meet reliability standards. Diversity in sources of fuel and technology, and high levels of spare capacity, are highly desirable for resilience, so the AEMO's observations suggest a positive outcome for power system resilience.

Importantly, the report highlights that:

- It has not modeled how a transition to 100 percent renewable energy might be achieved
- High reserve capacity is required to back-up intermittent renewable generation
- The potential for stranding existing assets will impose high costs on the system.

On this basis, this series seeks to find the middle ground for shifting towards greater resilience, using the existing infrastructure to provide a foundation for, and reduce the cost of, a transformation to a sustainable, resilient power system. Where the capacity requirements for generation in 2030 in the 100% Renewables Study are between 83GW and 98GW through investing in new plants, our modeling showed that investing in between 43GW and 52GW of new plant facilities could achieve high levels of resilience.

2.3 Policies to increase resilience

Looking to Europe can help us to understand the impact of policy on power systems. Germany, in particular, is undergoing remarkable change, largely due to increased diversity of energy sources and a shift to renewable forms of energy. The following section provides an analysis of a few notable countries' policies implemented to increase renewable energy deployment and resilience. We do not hold these case studies out as exemplars of policy implementation for power economy competitiveness, but rather use them to examine a range of approaches to achieving greater power system resilience.

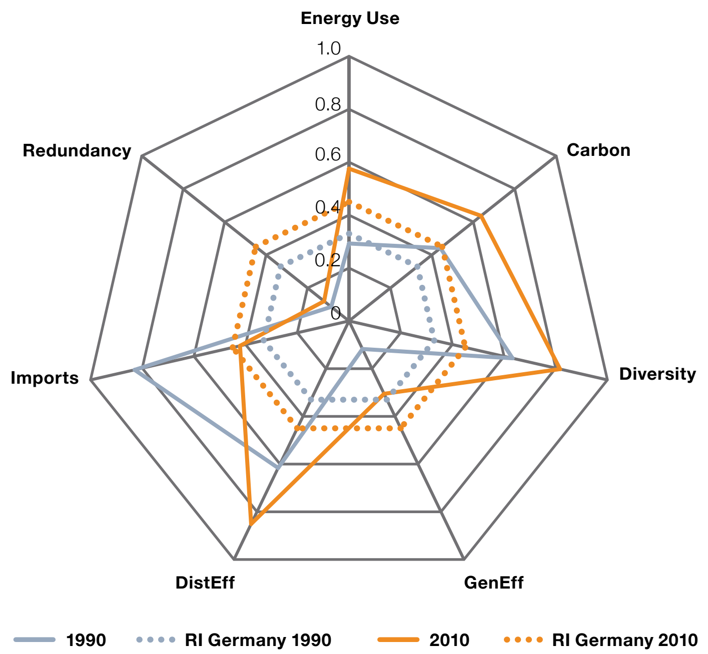
2.3.1. Case-study: Germany

In Germany, renewable energy has grown from three percent in 1990 in the form of hydro energy to 18 percent in 2010, including eight percent biomass, five per cent wind and two per cent solar. The target is 36 percent by 2020. According to our Power System Resilience Index, German energy resilience has increased significantly from 1990 to 2010.

The trend

The shift away from coal and nuclear to gas and renewables reduced Germany's consumption of non-renewable energy in electricity generation, improving the metrics for energy use, carbon emissions, diversity and generation efficiency. Electricity dependent on imported fuels and imported electricity increased from 15 percent in 1990 to 54 percent in 2010,

Figure 2: Power System Resilience in Germany, 2010 versus 1990



notably gas, coal and uranium, so the focus on domestic renewable resources is logical to improve energy security.

Germany has pursued diversification by guaranteeing remuneration to investors for renewable and distributed generation through Feed-in-Tariffs (FiTs) and through research and support for innovation. The FiT mechanism dates back to 1991 and took the form of a supply contract between a generator and the system operator, usually for 20 years.

The first version of the FiT law, Stromeinspeisungsgesetz (StrEG) triggered wind power development by granting priority to wind turbines in rural areas and providing investor security through stable pricing. This provided a mechanism to stimulate investment and innovation in different geographic areas. Introduced in 2000, the German Renewable Energy Act (Erneuerbare-Energien-Gesetz or EEG) differentiated support according to technology maturity, size and site. A subsequent revision to the feed-in law in 2004 provided momentum to solar and biomass. In May 2010, Germany reduced the support level from 43 cents (c) to 33c/kWh for photovoltaic (PV) feed-in, and introduced a target corridor for expected annual growth of 3.5GW.

Germany sets an annual degression rate, which is a percentage decrease payment over time at a pre-determined rate or according to level of installations and technology used (Hinrichs-Rahlwes, 2013; Huenteler et al., 2012; Wand and Leithold, 2011; Weigt, 2009).

Guaranteed prices for a fixed period are differentiated according to the type of technology, size of the installation, quality of the resource, and location of the project. This approach enabled a greater number and diversity of investors to participate and stimulated rapid renewable energy deployment in a wide variety of technologies. Significant private, residential investment has resulted, facilitating a shift towards democratisation of electricity supply. Renewable energy is generally immune to global energy market volatilities and inflation in fuel price and has been found to have a price-deflating influence on electricity wholesale markets (Weigt, 2009b; Würzburg et al., 2013; AEMO, 2012b).

Feed-in-Tariffs

FiTs have become the most widely used policy instrument to promote renewable energy deployment. Their success comes from the inherent revenue certainty for investors and the guaranteed grid access for electricity from renewable energy. There are few empirical studies on the cost-effectiveness of FiT schemes, possibly due to the complexity of the policy design and the lack of appropriate data.

The World Bank has analysed FiT for wind in Europe and found that high revenue returns have not yielded greater deployment of wind power (Zhang, 2013). Earlier studies pointed to the inherent problems with setting an optimal tariff that avoids excessive profit margins, enhances economic efficiency, promotes technology and achieves desired targets (Madlener and Stagl, 2000).

More recently, the Australian Productivity Commission released a report comparing carbon emission policies in key economies, including Germany, and concluded that FiT schemes in Germany provided abatement at considerably higher costs than abatement from the EU ETS (Productivity Commission, 2011).

The Productivity Commission's finding, however, requires clarification. Since its inception, the EU ETS permit price has traded at levels that could only secure abatement from fuel switching from coal to gas. As a result of Germany's lack of gas-fired baseload capacity, Germany was unable to benefit from fuel switching and thus sought abatement opportunities from more expensive options which required investment in new capacity and new technologies. The majority of academic analysis of the roll-out of renewable energy in the EU indicate that well-adapted FiT regimes are generally effective support schemes for promoting renewable energy (Haas et al; 2011, Batlle et al; 2012, Couture and Gagnon, 2010). Residential consumers pay a renewable energy levy which funds the FiTs, leading the EU to question whether industrial consumers are benefiting unfairly.

While the FiT has led to a sharp increase in renewable energy capacity, the roll-out of high levels of intermittent generation has had its technical challenges. In particular, grid congestion and security issues on both the main transmission network and the distribution network which experiences intermittent bi-directional power flow problems has required grid upgrades, unearthed many innovative operational solutions, and relied heavily on investments in research and development.

German government and industry have both invested heavily in research, development and deployment as a result of the technological challenges associated with the roll-out of novel energy technologies. More than €400 million per year of funding was made available for the advancement of renewable energy, fusion, efficiency and storage in the Fifth Energy Research Programme "Innovation and New Energy Technologies" from 2005 to 2010 to meet the requirements for secure, affordable energy and to mitigate against climate change (Federal Ministry of Economics and Technology, 2005). Investment in innovation and innovative capacity has:

- Increased employment in the renewable energy industry from 100,000 in 2000 to 382,000 in 2011
- Encouraged investment in new renewable energy of €19.5 billion in 2012 (€165.7 billion since 2000), more than half of which has come from private individuals and farmers
- Facilitated €12 billion of exports in plant and technology in 2008 (German Renewable Energies Agency, 2013)

Conclusions

The introduction of renewable energy into the generation fleet along with the democratisation of generation has impacted the German power industry in a number of ways. Residential energy prices have risen sharply to support generous FiTs, while wholesale prices have decreased, reflecting the impact of very low marginal cost generation on a market designed for traditional forms of fossil-fuel fired generation.

Potentially disruptive technology has been implemented at high concentrations leading to significant grid congestion and network security problems which have needed resolving, not in the laboratory, but in a challenging operational environment.

Revenues have shifted away from traditional industry participants to voters - householders, farmers, small communities and businesses. This democratisation of a significant portion of the industry has resulted in industry participants and electricity intensive industry seeking to wind back the policies for greater stability in the industry, and pitted the industry against voters who have invested heavily in the new structure. This is evidence of an industry and a country in the throes of change.

The lesson from the German energy transition (Energiewende) is that unleashing a disruptive democratisation process alongside a disruptive technology increases volatility and uncertainty, and ultimately may deflect a well-intentioned strategy from its intended pathway. Despite this, innovation policy has played a substantial part in building a renewable energy industry and helping to resolve operational issues as they arise.

2.3.2. Case study: China

Renewable energy in the Chinese power system has remained largely unchanged at 15 percent hydro in 1990 to 1 percent wind and 14 percent hydro in 2010. China has a renewable energy target of 20 percent by 2015. According to our Power System Resilience Index, Chinese energy resilience has increased significantly from 1990 to 2010.

The trend

The metrics for non-renewable energy use and carbon use reflect China's enormous investment in new coal-fired generation (including retirement of inefficient plants) which has delivered energy use efficiency improvements and reduced carbon emissions. The new plant investment has improved the spare capacity metric, while investment in transmission has improved the metric for distribution efficiency.

While China's route to resilience improvement differs from Germany's, its plans for the future include a focus on diversity and the environment, which will serve to strengthen its resilience metrics further.

China's energy policy as per the Twelfth Five-Year plan (2011-2015) is focused on:

- Giving priority to conservation
- Relying on domestic resources
- Encouraging diverse development
- Protecting the environment
- Promoting innovation
- Deepening reform
- Expanding international co-operation
- Improving people's livelihoods

A reliable and secure electricity supply is strongly linked to the Chinese government's fundamentals for policy-making, in particular social stability and economic growth. For this reason, China has sought to exploit its coal reserves for domestic power generation.

Imperfect supply chain

China has increased coal-fired power generation since 1990 by 575GW, but faces challenges around its coal supply chain. Coal mines are often far-removed from generation, which means that severe conditions in winter can block deliveries of coal. Recent sluggish demand for coal has reduced some of these logistical problems. Increasing prices for coal, meanwhile, have placed substantial financial pressure on utilities and state-controlled grid corporations responsible for delivering electricity at Government-regulated tariffs.

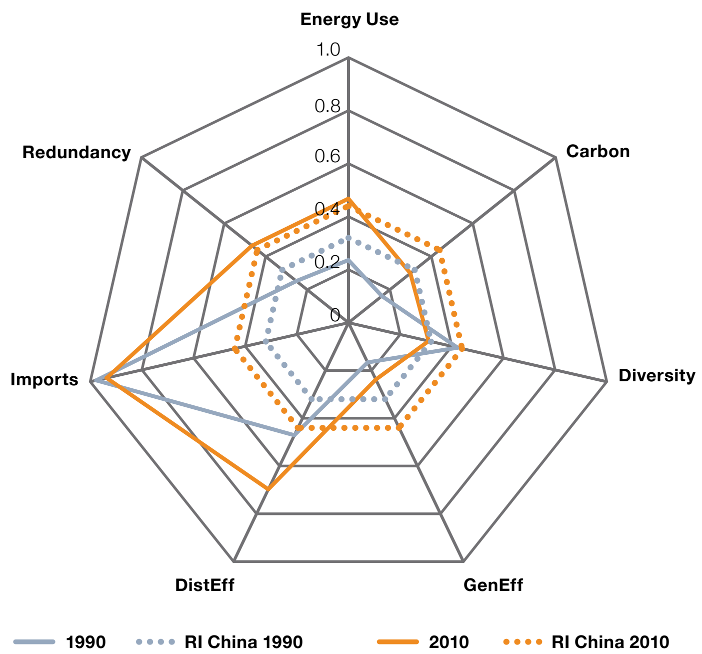
A focus on efficiency has led to the closure of many smaller, less efficient but flexible coal-fired power stations which have been useful in load-balancing. Concerns regarding the high price of gas and the security of supply have muted investment in gas-fired generation. Gas-fired generation has, therefore, focused on power system balancing rather than base-load supply.

Renewable energy

China has not focused only on investment in modern coal-fired generation. The Renewable Energy Law requires grid operators to buy renewable energy and provides the national renewable energy fund, discounted lending and preferential tax treatment for renewable energy projects. It has facilitated the deployment of 161GW of hydro, and 45GW of wind, in addition to 33GW of gas and 11GW of nuclear since 1990.

China now plans to rapidly increase the share of electricity generated from renewable sources. Targets for 2015 include adding 93GW of hydro, 55GW of wind, 30GW of nuclear and 28GW of solar. The Renewable Energy Law was amended in 2010 to co-ordinate grid planning with wind power generation to ensure that the wind power generated is used effectively. In addition, state owned generators are focused on developing wind power to increase market share, access Clean Development Mechanism revenue and reduce reliance on unprofitable coal-fired generation. China's 2012 energy policy lists the importance of promoting and developing distributed energy, and supporting innovation and research and development.

Figure 3: Power System Resilience in China, 2010 versus 1990



State-owned grid companies

China's power system is dominated by the state-owned grid companies, State Grid Corporation of China (SGCC); China South Grid Company (CSGC); and Western Inner Mongolia Grid Corporation. They are responsible for constructing and running trans-regional transmission, interconnection, ancillary reserves, capacity planning, dispatching and trading between 26 regional power networks. They are not compensated for maintaining reserves, must purchase energy from generators and provide power to consumers at government-specified tariffs.

Underlying the ambitious targets for wind and hydro power is an acceptance of the state grid companies' responsibility to build a "unified strong and smart grid" nationwide by 2020 with an ultra-high-voltage network at its core. This network development requires the provision of a larger balancing area for wind power deployed in the north of the country and the hydro power in the south-west of the country, with much already underway. In 2009 an estimated $US55 billion was invested in power transmission. Although small by comparison, storage includes current pumped hydro capacity of 14GW with 60GW planned by 2020; and a significant investment in joint ventures with American battery companies to develop many different technologies and production facilities.

Using the state-controlled grid companies to control the power system has ensured that China has met its targets and kept prices down to sustain economic growth. However, the targets were met subject to significant difficulties. Firstly, there is little incentive for SGCC and CSGC to co-operate as they have separate profit targets. This has minimised the benefit of a freely flowing network infrastructure. Secondly, quantity and prices of electricity are agreed to yearly, and are based largely on fixed capacity factors, with less than 20 percent traded outside of annual agreements. Variations in actual quantities of electricity available as opposed to those planned has led to substantial discarded wind energy with the associated revenue and profit loss for the generators. In addition, grid operators are required to pay higher prices for wind energy than coal-fired generation so there is an inherent incentive for grid operators to discard wind power in preference to directing a ramp down of coal-fired generation.

Government response

In response, the National Development and Reform Council has launched a trial to ensure dispatch of power in order of merit, thus giving wind, solar and hydro priority over schedulable generation. The trial has met with some resistance from coal-fired generators who are seeking compensation for increased coal consumption, reduced plant life and reduced revenue, as a result of having to run at less than full capacity and ramping generation in response to demand shifts associated with fluctuation in renewable electricity supplies (Cheung, 2011).

The institutional structure of China's power system is driven by centrally-managed target-setting five-year-plans. Targets are implemented using multiple levels of administration which have led to inefficiencies, including wasted energy as a result of the lack of transmission to deliver wind power to load centres. However, a very stable policy environment coupled with largely stable financial returns for investors in renewable energy have enabled a massive country like China to reach, and exceed, the targets required to underpin its economic activity.

Conclusions

China has invested heavily in power generation, using a command economy to direct investment according to centrally determined five-year-plans. This approach has resulted in substantial efficiency improvements as well as significant roll-out of generation from renewable sources.

State control of the grid, meanwhile, has enabled China to co-ordinate the power system according to strategies defined in the five-year plans.

2.3.3. Case study: California

Diversity of energy generation in California is high, with 28 percent from renewable, including 16 percent hydro; six percent geothermal; three percent biomass; and three percent wind in 2010. California has experienced a modest increase in resilience, as measured by the Power System Resilience Index, between 1990 and 2010.

There is now a greater proportion of gas in the mix which improves the metrics for energy use, carbon emissions and generation efficiency, but reduces the metric for diversity.

Renewable portfolio standards

California, like many states in the United States (US), has generally used renewable portfolio standards (RPS), which are similar to Australia's RETs. These have long-term contractual obligations to encourage diversity of generation. RPS require stakeholders to source renewable energy from certified units for periods of up to 20 years. In the US, RPS are pursued in preference to FiTs because the cost of the scheme is less visible.

Like Australia, California embarked on electricity market deregulation in 1998. Two years later, higher gas prices, stalled planning approvals for required new plants, steadily increasing demand, transmission constraints, limited hydrological flows and a multitude of flaws in market structure precipitated a sustained period of market volatility. This subjected Californians to electricity black-outs, substantial electricity price rises, and state bail-outs of the two largest privately-owned utilities.

The crisis led to a bi-annual Integrated Energy Policy process which in 2003 highlighted four overarching strategies to reduce California's vulnerability to a similar future crisis.

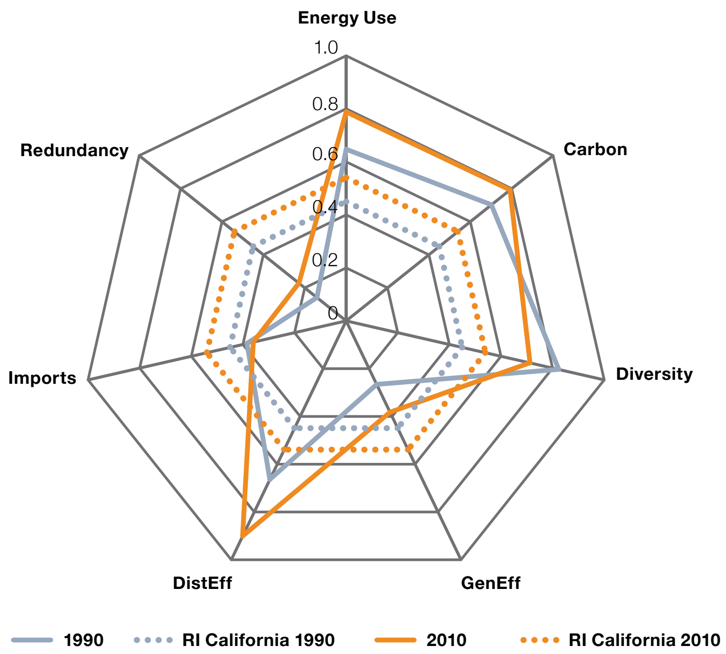
The strategies are to drive energy efficiency; diversify fuels for generation; enable consumer choice in choosing a retailer; and strengthen infrastructure. The RPS was seen as the centrepiece strategy to diversify away from gas-fired generation to renewable generation to protect against price volatility and help stabilise the market.

The 2012 Integrated Energy Policy Update remains committed to the same objectives and yet in-state generation from gas-fired generation has increased from 45 percent in 1990 to 54 percent in 2010, and 61 percent in 2012.

Multiple changes to RPS targets and resistance from utilities to California Energy Commission renewable energy preference strategies has limited the growth in generation from non-hydro renewable energy from two percent in 1990 to three percent in 2010, but with a surge to five percent in 2012 mainly as a result of wind power.

RPS targets have had to be enhanced by the California Solar Initiative, with $2.2 billion made available in the form of rebates for rooftop solar PV installations to achieve a target of 1.94GW of new solar generation capacity by 2017. The program is currently running ahead of schedule with 1.2GW already installed. Notably, prices paid for solar panels are around $6/watt which is considerably more than that paid in Australia.

Figure 4: Power System Resilience in California, 2010 versus 1990



California is also home to 125MW of parabolic trough and 370MW of tower (demonstration project) concentrated solar thermal power (CSP) and over 2GW of utility-scale PV installations due for commissioning before the end of 2013. A further 375MW CSP (parabolic trough) are due for commissioning in 2014, and 150MW of CSP with integrated storage due for commissioning in 2016. These projects have required significant support from federal programs.

Conclusions

A high-level assessment of the success of the RPS to deliver diversification of generation for California indicate it has been slow to deliver results, even with a number of enhancements. Targets were recently enhanced with rebates for the deployment of both rooftop and utility scale solar PV and large renewable energy projects have required significant loans or guarantees from governments to get underway.

2.3.4. Case study: Australia

Renewable energy in Australia was 10 percent (hydro) of power generation in 1990, and nine percent in 2010, including five percent hydro, two percent wind and two percent biomass. According to the Power Systems Resilience Index, energy resilience in Australia has improved only slightly in 2010 over 1990.

The efficiency, diversity and security measures show little change from 1990. Hydro has decreased as a proportion of generation but gas, biomass and wind have filled some of the reduction which has led to a slight improvement in diversity, non-renewable energy-use and carbon metrics.

Renewable Energy Targets

Australia has focused its national renewable energy policy on the RET. The mandatory RET was introduced in 2001 when renewable energy made up nine percent of electricity generated.

As part of this program, entities that purchased wholesale electricity (mainly electricity retailers) were required to surrender renewable energy certificates (RECs) to the Clean Energy Regulator each year. The program was intended to generate an additional 9,500GWh of electricity from renewables by 2010.

In 2009 the RET target was increased to 45,000GWh of electricity from renewable sources by 2020, which is an estimated 20 percent of electricity generation.

In addition, the Australian Government introduced the Solar Credits scheme which provided an upfront subsidy for small-scale solar panel units in the form of five renewable energy certificates. The RECs generated through the Solar Credits scheme were tradable through the REC market, and a rapid increase in RECs served to dilute the value of RECs which in turn discouraged investment in large-scale renewable energy projects.

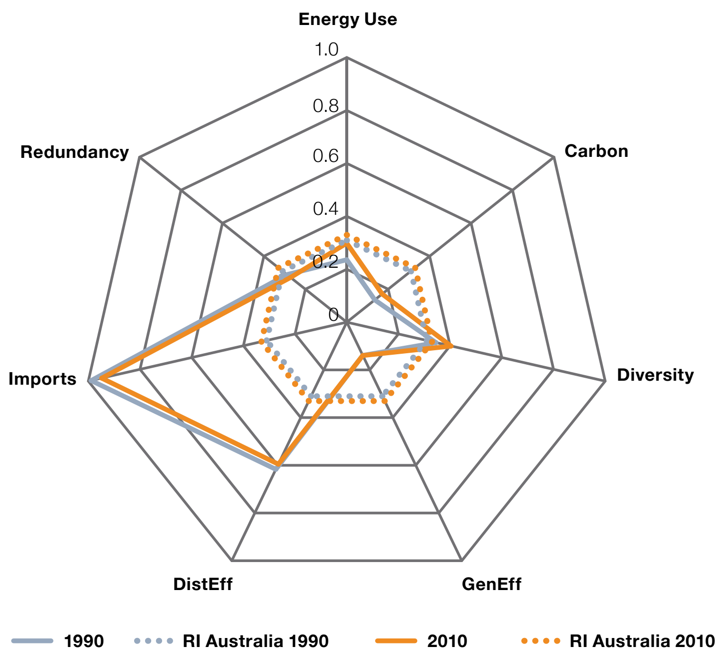
The Australian Government responded by legislating to separate the RET into the large-scale target of 41,000 GWh (LRET) and the Small-scale Renewable Energy Scheme (SRES), which set households and businesses a small-scale target of 4,000GWh and took effect in 2011.

From July 2008, various Australian states introduced renewable energy policies that promoted FiTs for rooftop solar PV. Tariffs were set at generous levels to encourage domestic investment. As in Germany, the policies were popular with Australian voters. A sharp increase in electricity prices and a dramatic decline in the cost of PV thanks to global production investment, spurred significant interest. Targets and, more importantly, budgets to fund the policy were soon overwhelmed as 2,186MW (of a cumulative total of 2,298MW) was installed between 2010 and 2012.

By the end of 2012, FiTs were reduced to an average of 8c/kWh. In 2012, electricity generation from solar PV was estimated at 2,368GWh (CEC, 2012), up from 680GWh in 2011. This amounted to approximately eight percent of generation from renewable sources.

FiTs have been accused of having a disproportionate impact on recent electricity price rises. Figure 6 shows the size of the increases in price from solar FiTs, RET and carbon price versus those from increased network and retail costs between 2010 and 2013. Queensland network prices for 2012/13 included in Australian Energy Market Commission (AEMC) calculations as detailed in Figure 6 were not passed through in full but accumulated until 2013/14.

Figure 5: Power System Resilience in Australia, 2010 versus 1990



Conversely, Queensland Solar Bonus Scheme charges were in arrears such that FiTs charges for Queensland should have been 0.7c/kWh instead of the 0.1c/kWh as reported by AEMC.

Policy has directed investment in solar PV to domestic home owners instead of providing incentives to commercial and industrial scale opportunities. Yet while commercial and industrial scale investment in solar may have delivered energy at a lower cost, the benefits of solar PV investment should not be overlooked. It has driven a promising industry providing employment for more than 17,000 in 2012 and attracting investment of more than $8 billion from 2011 to 2012. It has also relieved pressure on the Queensland energy network in summer as our case study demonstrates, reducing:

- Cost and risk for retailers in energy purchases
- The required investment in distribution
- Wholesale prices from greater competition amongst generators

Since a particularly hot summer in Queensland in 2003/04 trigged increased use of air-conditioning, energy companies were forced to invest heavily to accommodate rising peak demand during a few hot summer days each year. As solar PV generation peaks on hot days, it has helped relieve pressure on networks, reducing cost and risk for retailers in energy (CEC, 2012).

The carbon price was introduced on 1 July 2012, as part of the Australian Government's Clean Energy legislation. It set a fixed carbon price, starting at $23/ tCO_2, which is subject to fixed annual increases until 2015 when it is linked to international emissions trading scheme(s).

Wholesale prices in the National Electricity Market, which were generally low and constant for two to three years, increased predictably in line with the expected pass-through of the carbon price and a downturn in demand for energy. The downturn was a result of a number of factors, including slow economic growth, large electricity price increases, efficiency measures and investment in rooftop solar.

Approximately 2GW of older, high CO_2 emitting coal-fired generators are either being closed or mothballed due to the surplus of capacity, coupled with the cost burden of the carbon price. The introduction of the carbon price helped continue the trend of decreased coal-fired generation, which fell from 77 percent in 2006/07 to 69 percent in 2011/12.

Much of the Australian Government's support for renewable energy has centred on establishing institutional structures, with few large-scale renewable energy projects delivered. For instance, only one project has thus far survived the Solar Flagships process, and the Australian Greenhouse Office focused on managing voluntary abatement, which was generally unsuccessful in delivering abatement.

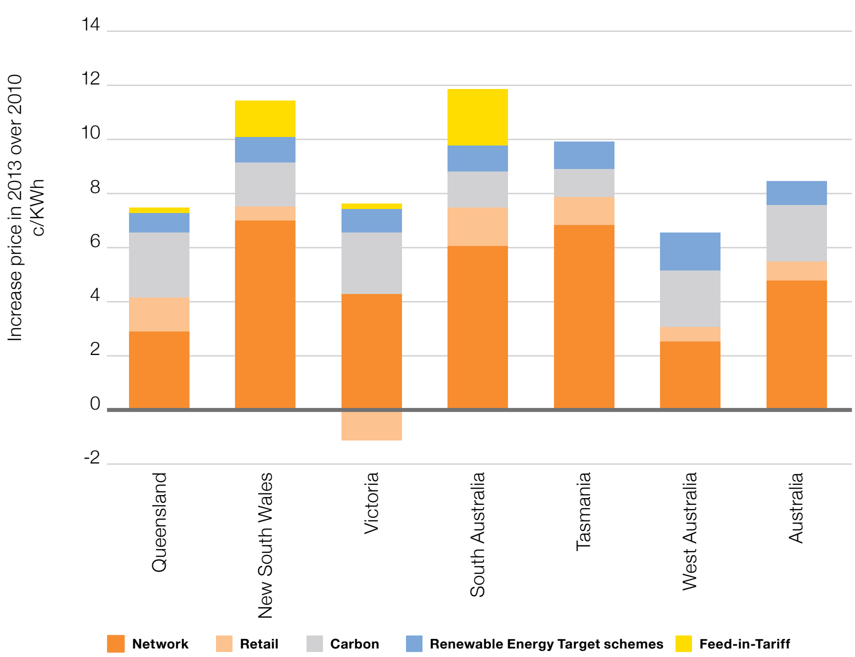
ARENA was established in 2012 as part of the Australian Government's Clean Energy Future package. It is tasked with improving the competitiveness of renewable energy technologies and increasing the supply of renewable energy in Australia. ARENA is an independent authority with approximately $3 billion to provide long-term funding and policy certainty for the renewable energy industry.

The Clean Energy Finance Corporation (CEFC) is also part of the Clean Energy Future package. It was established in July 2013 to facilitate an increased flow of funds for the commercialisation and deployment of Australian-based renewable energy, low emissions and energy efficiency technologies. CEFC has a budget of $2 billion per year to invest in clean energy. These institutional structures need bipartisan support to be successful. While the CEFC does not have bipartisan support, ARENA may be subject to budget cuts if the carbon price legislation is changed or dismantled.

National data for 2012/13 was not available at the time of writing. AEMO data, however, shows that nine percent of electricity in the NEM was sourced from renewable energy during that financial year. The Clean Energy Council, which adjusts for energy from rooftop solar PV and hot water, reports that 13 percent of energy was from renewable sources in 2012 (CEC, 2012).

Current renewable energy projects underway indicate cumulative deployment of around 3GW of wind power by the end of 2013. With surplus capacity in the NEM, however, commitment to a further 13.4GW of proposed wind projects is slow. AEMO

Figure 6: Comparing the impact of Feed-in-Tariffs to Network costs



Source: AEMC, 2012, AEMC, 2011

Case study
A hot day in Queensland

Before solar panels – 2008

In June 2007, the Queensland government restricted water for generation at Tarong, Tarong North and Swanbank power stations as a result of the drought, which had lowered dam levels and reduced output from the Snowy hydro. The market responded to news of Queensland's reduced energy capacity by lifting energy spot prices to an average of $218/MWh. By December 2007, however, spot prices had returned to an average of $41/MWh, buoyed by the commissioning of Kogan Creek and the lifting of water restrictions to Tarong to meet the summer demand. At the end of 2007, Queensland had 1MW of solar PV installed.

The summer of 2007/8 was relatively mild, with just 22 days reaching a maximum of more than 30 degrees Celsius (°C) and only one day where the maximum exceeded 35°C in Brisbane. However, Saturday, 23 February was particularly hot, with a maximum of 39.5°C. By 9.30am load was at 7,158MW and by 11.30am it had increased to 7,618MW. The spot price had surged from $39.34 to $2,427/MWh. Demand increased by a further 374MW over the heat of the day and at 2pm spot price peaked at $9,154/MWh.

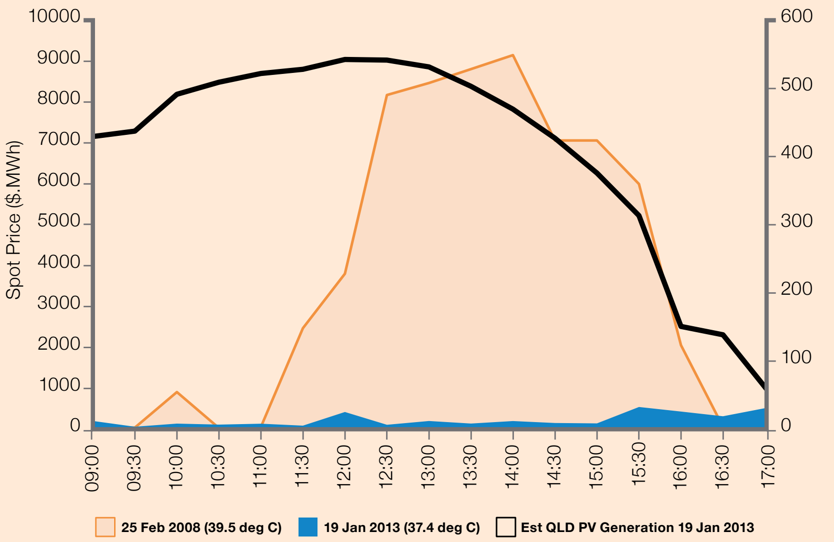
After detailed analysis of the bidding behaviour on the day, the Australian Energy Regulator (AER) instituted proceedings in the Federal Court against Stanwell Corporation for failing to act according to the good faith provisions in the National Electricity Rules to facilitate the efficient dispatch of available energy to meet demand. The case was dismissed (AER, 2011). As a result, we are left with the explanation that it was because it was a hot day that spot prices increased dramatically, in spite of adequate reserve capacity being available (AER, 2008).

After solar panels – 2013

By the end of 2012, excess capacity in the National Energy Market (NEM) resulted in the mothballing of 700MW at Tarong power station and the closure of Collinsville (180MW). FiTs, meanwhile, had encouraged the installation of 718MW of solar PV in Queensland.

The summer of 2012/13 was a great deal hotter than 2007/08. The maximum temperature in Brisbane exceeded 30°C on 46 days, five of which were over 35°C. Saturday 19 January was a hot day which boasted a maximum temperature of 37.4°C. By 9am load was at 6,252MW and by 11.30am it had increased to 6,829MW. The spot price, however, had reduced from $202.67 to $87.76/MWh. Demand increased a further 697MW over the heat of the day, with spot price peaking at $544.18/MWh at 3.30pm.

Figure 7: A hot Saturday in Queensland, 2008 versus 2013



Source (AEMO, 2013, CEC, 2012, UQ Solar, 2013) expects increased interest in wind generation investment by around 2016, with a potential shortfall in capacity to meet the RET emerging in the second half of the decade (AEMO, 2012a).

A number of large generators and retailers are actively lobbying to reduce the RET, which because of its expression in absolute terms and the reduced growth in energy consumption, is likely to exceed 20 percent significantly by 2020. Generators with investments in renewable energy complain that discussion around changing RET targets increases uncertainty and decreases investment.

Conclusions

Australian state and federal policies to encourage investment in renewable energy have delivered an additional 10,800GWh of renewable energy (7,700 GWh from wind) since 2000, increasing the proportion of renewable energy in the generation mix from nine percent to 13 percent. Much of this change has occurred since 2010, after the changes to the RET and the introduction of the Clean Energy Futures package.

Electricity price increases, meanwhile, have led to reduced demand and investment in rooftop solar.

While the carbon price legislation encourages investment in gas-fired generation and the RET encourages investment in wind power, there are few policy levers to encourage significant diversification to industrial scale solar power, storage, biomass and other forms of generation.

2.3.5. Comparisons

In environments of uncertainty, investors must be offered security to ensure deployment of energy sources that will increase resilience. A benefit of reducing uncertainty is that the resulting greater security will lead to reduced premiums to cover risk. Policies that legislate to guarantee new technology generators access to the grid offer the greatest security to investors. The countries most successful at significantly diversifying generation have used FiT's (and Feed-in-Premiums) and have focused on domestic and small business investors.

Table 2 provides a summary of the main differences in the policy measures taken by the countries studied and resulting Power Resilience Index outcome.

Table 2: Comparing country policy with resilience measures

	California	China	Germany	Australia
Main policy tool for diversification	RET	5 year plan	FiT	RET
Probability of energy from different fuel source	1990: 0.73 2010: 0.66	1990: 0.42 2010: 0.34	1990: 0.58 2010: 0.74	1990: 0.36 2010: 0.41
Energy from imported sources %	1990: 58% 2010: 61%	1990: 1% 2010: 2%	1990: 15% 2010: 54%	1990: – 2010: –
Carbon emissions gCO2/kWh	1990: 313 2010: 268	1990: 792 2010: 723	1990: 240 2010: 183	1990: 815 2010: 841
Spare capacity kWh/$	1990: 0.14 2010: 0.16	1990: 0.2 2010: 0.27	1990: 0.11 2010: 0.11	1990: 0.22 2010: 0.18
Non-renewable energy usage (tonnes of oil/GWh)	1990: 127 2010: 110	1990: 258 2010: 220	1990: 240 2010: 183	1990: 258 2010: 278
Composite resilience index	1990: 0.45 2010: 0.54	1990: 0.32 2010: 0.44	1990: 0.33 2010: 0.45	1990: 0.31 2010: 0.33

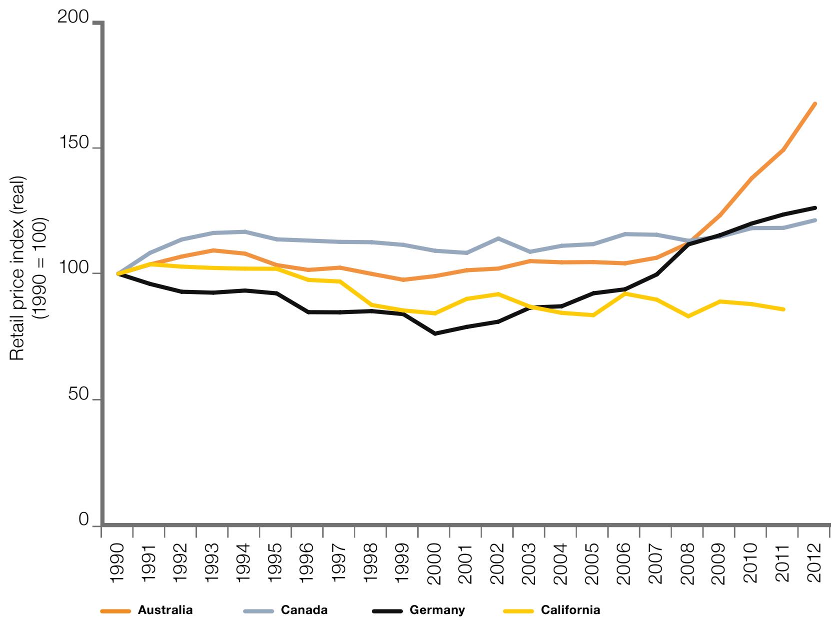
Some of the findings include:

- California has increased its resilience as a result of a shift to gas, which has reduced emissions and non-renewable fuel usage. The California Energy Commission, however, remains concerned about its reliance on gas, which renders it vulnerable to global energy volatility.
- China's increase in resilience is largely due to improved efficiency of its coal-fired fleet, which has reduced energy usage and carbon emissions.
- Germany has improved resilience because of a shift to gas and renewable energies, which have decreased emissions and non-renewable fuel usage.
- Australia has seen little improvement in resilience.
- Germany and China have been most effective at increasing their resilience since 1990.

Figure 8 demonstrates the impact of policies on retail prices. Unfortunately, price data for China is not readily available. Recent price rises in Australia reflect the impact of network expenditure to meet stringent reliability standards and an inflexible network pricing regulatory structure, more than policies to diversify and decarbonise the generation fleet.

The cost of Germany's Energiewende or Energy Transformation is hotly debated. Some people believe it places an unacceptable financial burden on the network companies which must pay to transmit wind power across the country; upgrade the distribution network to support solar panel deployment; and reduce wholesale costs.

Figure 8: Average annual power price increases, 1990 to 2011



However, proponents of the system claim that renewable energy has created a manufacturing base and a 'prosumer' model for energy with high levels of individual ownership and that electricity retailers and industrial consumers have benefitted from the resulting wholesale prices. They point to residential consumers bearing the cost of the renewable energy surcharge and those residential consumers show high levels of support for the transformation despite the cost to them (TNS Infratest and Renewable Energy Agency, 2012).

Whatever the views on the costs, Germany is engaged in a transition to a more diverse power system. Considering the conflict that has emerged between large industry and small private generators, it makes sense to seek to avoid much of the complexity that the German implementation has exposed. A more managed transition to greater diversity should attempt to support the industry to make the transition rather than pit industry against small domestic actors. The coherent long term policy framework for Australia must focus on a managed transition to a more resilient power system at the lowest possible cost, rather than a revolution.

3. A transition to resilient power

Maximising diversity of generation at the lowest possible cost should be the major goal for power in Australia.

Australia is heavily reliant on generating electricity from coal. This places its electricity industry and its economy in a vulnerable position in the event of global action on climate change or steep increases in coal price. Germany faced a similar dilemma in the early 1990s, and has put in place two key groups of policies to help it transition towards energy independence, international competitiveness and climate change mitigation. These are:

1. Incentives for energy from renewable sources
2. Government funding for research to underpin affordability and innovation

This combination of policies has directed investment towards a variety of new technologies and investors, underpinning a new industry funded largely by small private investors and residential consumers.

Germany's reliance on imported fuels and concerns over nuclear power has driven a challenging, and some would say overambitious, timetable to implement a power system founded on new technologies even as the technologies are still under development in laboratories. For now, the majority of the German public still supports this ideal.

Australia must also face the challenge of transforming its power system to make it more resilient, although it should learn from the German experience and support its electricity industry through a transition, rather than drive a revolution.

Australia has a number of advantages over Germany in transforming its power system. The advantages include:

- Australian power is not dependent on energy imported from distant countries subject to global energy price volatility. Continuing to use domestic coal as a low cost fuel for legacy generation, until a full transformation to low carbon generation is affordable, can help balance the higher investment costs of the new technologies.
- Australia has superior renewable energy resources which will make electricity generated from renewables more affordable.
- Australia has a highly advanced resources sector that will be instrumental in transporting and sequestering carbon dioxide (CO_2) once carbon capture becomes affordable.

Despite these advantages, Australian energy policy lacks a long-term commitment to targets that recognise the requirement to reduce CO_2 emissions by adopting a portfolio approach to energy generation, at the same time as inventing new ways to do business and drive the economy, with a reduced dependency on fossil fuels.

The Energy White Paper discusses the benefit of investing in energy innovation but is defined more by its support for privatisation and the development of fossil fuel (especially gas) resources rather than its long term strategy for security, climate change mitigation, international competitiveness and alternative industry development. The Liberal/National Coalition Government proposes to replace the carbon price and Clean Energy Future legislation with its Direct Action Plan which as yet offers limited detail on how it will address climate change mitigation and international competitiveness.

Both Germany and China have achieved their objectives in energy production over the last decade. China's implementation success is enhanced by having a command economy that is directed according to strategic goals, while Germany has implemented policy that has resulted in industry upheaval. To achieve its objectives, Australia needs to invest in research and development in renewable energy, geo-sequestration and increase its nuclear energy skill set with the goal of creating new industries. At the same time, Australia must set goals around its generation diversity and CO_2 emissions from electricity generation. In Part 2 of this series, we found that resilience is best pursued through a portfolio approach to power generation.

Maximising diversity of generation at the lowest possible cost, therefore, should be the major goal for power in Australia.

To implement this diversification strategy, funding for research, development and deployment needs to be committed and protected from political interference. At the same time, incentives should be continued to facilitate the measured roll-out of technologies currently available. However, instead of forcing electricity consumers to pay additional amounts for Feed-in-Tariffs, the program should be funded directly from existing carbon price revenue.

To achieve a competitive and resilient power system, Australian strategy needs to focus on:

- Increasing the diversity of its energy fleet
- Decreasing the carbon dioxide (CO_2) emissions of its energy fleet
- Increasing the security of its fleet through robust storage options
- Improving the distribution efficiency of its power system

Specific policy measures to achieve these goals should:

- Reduce reliance on coal-fired generation. The Renewable Energy Target (RET) and the carbon price legislation have been fairly successful in encouraging investment in alternative forms of generation, although potential changes to both of these policy levers threaten their ongoing effectiveness, and the current structures of the RET and carbon price do not encourage investment in energy sources other than wind and gas.
- Regulate that new coal-fired plant can only be licensed if it meets world class efficiency and environmental standards and is fitted with CCS.
- Invest in community consultation with respect to acceptance of nuclear power, and the siting studies and regulatory frameworks required to enable a future option for nuclear power generation.
- Encourage participation in global research and development communities where a technological option exists but is as yet too expensive or too immature to deploy. This will keep the options open while Australia benefits from the knowledge gained from the combined research efforts of a multitude of larger nations.
- Foster bipartisan support to fund and direct the deployment of those technologies available now to benefit from increased diversity of generation, as well as reduced carbon emissions.
- Pursue pragmatic actions by using small, incremental steps (which are simpler to fund and implement than large, transformative change) to work towards the strategic goal of greater power system resilience.

3.1. Implementing incentives to deliver a resilience strategy

With much of the coal-fired generation fleet nearing retirement within the next decade, Australia has an excellent opportunity to replace the ageing, inefficient and carbon dioxide (CO_2) emitting plant with efficient, low carbon emissions generators. However, low carbon technology investment requires support because generation with low CO_2 emissions comes at a cost premium which will require funding.

Generally, customers ultimately fund investment in electricity provision. However, to divert investment from high CO_2 emitting plants to low CO_2 emitting plants, economists have proposed a carbon price which seeks to even out the costs of generation between the plants, and, therefore, remove the cost premium associated with the non-polluting plant. The carbon price functions as an input cost added to represent the cost of CO_2 emissions. Whether it takes the form of a government tax or price determined by market subject to government-set emissions constraints (i.e. an Emissions Trading Scheme or ETS), has been the subject of much debate. Although Australian electricity customers have already started funding the investment required for the transformation to a low-carbon economy through the carbon price, most of those funds have been diverted to other initiatives.

Generators, distributors and retailers who are prepared to risk adopting new technology that will benefit society in the future should be compensated.

3.1.1 The emissions trading and carbon tax theories

There is substantial evidence that environmental taxes have successfully reduced pollution but little evidence that ETS have been successful. The United States (US) Sulfur Dioxide (SO_2) program was the first implementation of an ETS in 1995 and the basis for the belief that an ETS will deliver abatement at lowest cost. It provided permits to emit SO_2 to generators at no cost. This system encouraged fuel cost switching to reduce emissions of SO_2, but did not deliver changes in technology, a requirement for carbon abatement.

The primary example of CO_2 trading in operation, the European Union (EU) ETS has shown no ability to reduce emissions since its implementation in 2005. In the initial stages of the EU ETS, emission allowances were given free of charge to power generators. The opportunity cost of emission allowances was priced into wholesale costs leading to windfall profits for generators. However, the real structural problem with the EU ETS was that it set unchallenging quotas for emissions which led to an excess of emission allowances and low permit prices. The scheme was hindered by further complications as the global economic slowdown reduced electricity demand, generation and hence CO_2 emissions which has led to a growing surplus of permits and further reduced their market value. Uncertainty about the appropriate level of emission quotas has rendered the EU ETS ineffective in reducing emissions and the low permit price has failed to shift generation to more efficient but expensive technologies.

In effect, the outcome of the EU ETS was predicted by Martin Weitzman's research decades ago when he demonstrated that in states of uncertainty, it is necessary to have policies that involve both price and quantity control to be effective (Weitzman, 1978). Weitzman continues to publish his research into the long chain of structural uncertainties that are overlooked in current climate change economics. He highlights that the extreme outcomes associated with climate change favour more aggressive policies to lower greenhouse gas emissions (Weitzman, 2011, Weitzman, 2012). A practical application of Weitzman's findings therefore implies that an incentive for investment must accompany a carbon price (either tax or ETS) to overcome the paralysing effect of uncertainty.

3.1.2 Gaps between theory and applications in the real world

Whilst the EU ETS has had little success in reducing emissions and diversifying to new technologies for electricity generation, European countries in the Organisation for Economic Co-operation and Development (OECD), in particular Germany, have had significant success with diversifying the source of fuel for, and reducing emissions from, electricity generation through the application of Feed in Tariffs (FiTs) over many years. Applying FiTs over and above the opportunity cost of the emissions permits has effectively meant that German residential consumers have paid twice for carbon emissions. This shows then that a carbon price is useful but not sufficient to deliver the primary energy and technological changes required to reduce CO_2 emissions.

The Climate Change Levy (CCL) on electricity consumption in the United Kingdom (UK) provided an early warning of the gaps between the predictions of economic theory and experience from the real world. After the introduction of the CCL, firms did not reduce electricity usage when the prices increased as a result of the levy. Instead, it was found that they needed additional incentives to invest, change behaviour and reduce electricity consumption. Investment in low-carbon electricity generation in Australia has shown similar tendencies. For this reason, generators, distributors and retailers who are prepared to risk adopting new technology that will benefit society in the future should be compensated for the additional risk (and costs) that they are taking on.

The introduction of the carbon price in July 2012 provided Australia with a funding mechanism to pay for new technology incentives. However, much of the revenue has been diverted into compensation to consumers for electricity price increases. A carbon price in the form currently legislated in Australia is not the only possible mechanism for funding investment to deliver reduced emissions from the provision of power. There are many alternatives for effectively funding investment in abatement, including an initiative like the UK's Climate Change Levy on electricity consumption, or a tariff on consumption based on aggregated CO_2 emissions across all goods and services.

The benefit of the carbon price legislation is that it is already enacted in law, included in electricity prices and generating revenue. Any new or different funding mechanism would re-introduce uncertainty for investors, planners and providers of electricity which ultimately will increase the cost of transforming the power system to increase its resilience.

3.1.3 Plugging the gap between the theory and real world application

While Germany's FiTs delivered diversity at high costs which were passed on to residential consumers, Spain's FiTs have delivered diversity at a very high cost to utilities which have not been able to pass on the costs to consumers. To manage this challenge in Australian, the Australia Capital Territory (ACT) enacted the Electricity Feed-in (Large-scale Renewable Energy Generation) Bill 2011 to promote the deployment of large-scale renewable technologies (more than 2MW but less than 210MW) that will reduce reliance on non-renewable fuels and address emission reduction targets at a reasonable cost to consumers.

Investors that seek to provide renewable energy to distributors in the ACT participate in an auction to provide renewable energy at specified FiTs. The difference between the ACT's FiT

Case study
Electricity market reform in the United Kingdom

Through its Electricity Market Reform policy, the UK Government seeks to deliver secure energy and drive ambitious action on climate change. In so doing, it is addressing both security of supply and climate change challenges while maximising the benefits and minimising the costs for consumers and taxpayers. A lack of investment in electricity infrastructure over the last decade means that the market reform needs to encourage huge investment in electricity infrastructure. This is in the face of pervasive uncertainty caused by high upfront capital costs, risks associated with deploying early stage technologies, gas and carbon price volatility. Their view is that they cannot rely on any single form of generation and that they need to pursue a portfolio approach to balance the risks and uncertainties through a diverse mix of technologies and fuel sources.

The Electricity Market Reform policy introduces two new market mechanisms:

- Long-term Contracts for Difference (CfDs), which include FiTs
- Capacity Markets to provide reliable capacity and security of supply

The mechanisms are supported by a tax on fossil fuels used to generate electricity, called the carbon price floor, which underpins the EU ETS and an Emissions Performance Standard. The carbon price floor prevents investment in coal fired generation without carbon capture and storage (CCS).

Unlike Germany's FiTs, FiTs under CfDs are intended for large generators rather than small residential, community and commercial investors. They seek to provide certainty for both generators in revenue projections and the system operator in paying for diverse and low-carbon energy in long-term contracts.

The UK Government seeks, therefore, to facilitate substantial investment in low-carbon generation through removing exposure to electricity price volatility, stabilising returns for generators; lowering the capital cost for generators; retaining short-term market signals for efficient operation; and reducing the cost impost for consumers.

In principle, the CfD will be standardised across technologies although it is understood that initially there will be variations in recognition of their different risk profiles. While the plan is to shift to technology-neutral auctions in the future, in the first implementation technology quotas the government will set the "strike price" (the agreed price to a generator for the term of the contract).

system and Germany's FiT system is that the ACT employs Contracts for Difference (CfD), that is payment to generators at the sum accepted at auction, less the National Electricity Market (NEM) spot price when the energy is sold into the market.

The use of CfDs provides certainty for both the distributor who is required to buy the energy from the generator, and the generator who requires a clear, stable and predictable revenue stream from a new technology and fuel source. The UK has also proposed to contract for low-carbon generation to institute market reform to decarbonise the electricity sector and focus on new generation investment (see "Electricity market reform in the United Kingdom" case study).

FiTs with CfD ensure that the deployment of diverse technologies can be carefully managed within a defined budget, funded by a carbon price or carbon consumption tax, such that consumers are not subjected to significant price rises like those that German residential consumers experienced. We propose to call these differentiated Power Purchase Agreements (dPPA), since they are targeted at industry rather than domestic investors.

3.1.4 Real world incentives for diverse energy in Australia

Given diversity is at the heart of a shift to resilience, it is important to provide a framework to secure that diversity. Until July 2012, Australia's NEM has made no provision for externalities associated with CO_2 emissions, which meant that generation tended towards cheap coal. However, a lack of growth in demand as a result of sharply increasing electricity prices and Renewable Energy Targets (RET) and FiTs generated investment has reduced any requirement for investment in coal-fired generation. In its current form, the RET has made no provision for diversity other than a requirement for renewable energy. Currently, wind power is the most mature renewable energy technology and provides the cheapest way to meet the target. While wind and solar photovoltaic (PV) power provide a start toward diversification, without significant storage or complementary generation to smooth the delivery of energy according to load, their intermittency reduces their usefulness within the electricity system. Emerging technologies like solar thermal with storage, or just storage, can substantially overcome the intermittency and scheduling issues.

To increase the resilience of its power system, Australia needs to take into account the following objectives when replacing retiring plant or meeting demand growth:

- Increased diversity of its fleet
- Decreased emissions from its fleet
- Increased absorptive capacity (e.g. storage) within its fleet
- Improved distribution efficiency of its power system by deploying distributed energy

Incentives for investment in new technologies should be ranked according to these key resilience benefits and costs. For instance, while wind power would meet the first two objectives of resilience listed here it would be less desirable than solar thermal power with storage which would meet three of the four objectives. Storage or network ancillary services would meet all of the power system objectives making it highly attractive, although at this stage, very expensive. Therefore, when there are constraints or choices to be made, decision making should be based on an assessment of which option supplies the highest adherence to resilience targets at the lowest possible cost.

3.1.5 Why we need to fund differentiated Power Purchase Agreements from a carbon price

Firms that emit CO_2 have to pay for their emissions, so coal-fired and gas-fired generators face the following profit equation:

Profit =
Revenue – Operational costs –
Carbon costs (carbon price)

The carbon price raises the funds corresponding to the environmental cost of CO_2 emissions. We are paying the carbon price to encourage efficiency in end-use and investment in technologies that have a lower environmental impact. These low-carbon generation technologies are more expensive because they are novel and untried, and face the following profit equation:

Profit =
Revenue – Operational costs –
Early adopter costs

With evidence that pursuing funded incentive schemes has resulted in multiple successes in reducing environmental costs, it is sensible to apply those principles again. On this basis, it is logical to use the carbon costs to fund the early adopter costs through dPPAs.

Under the current legislation, Australia uses the bulk of its carbon price revenue (carbon costs) to fund tax reductions for low-income consumers to pay for electricity price rises that the carbon price has caused. However, RET costs result in consumers having to pay the early adopter costs in addition to the carbon price, as has happened in Germany, inflating prices unnecessarily. So, in its current form in Australia, the carbon price is a redistributive tax and the RET is an environmental tax. It would be considerably more effective, understandable for consumers and prudent for balancing budgets if the carbon price only encouraged deployment of low-carbon technologies rather than supported other social mechanisms. If the carbon price is applied to early adoption of new technologies, then the impact on low-income earners will also be reduced.

The challenge is to calculate and deliver the subsidy required for early adopter costs, accurately and effectively, encouraging investment in multiple technologies ready for deployment, and reducing the risk of investing heavily in only one alternative. Each new technology will have a different early adopter cost, so it is important to establish different categories of dPPA. Auctions or tenders for each category of dPPA are the best way to ensure transparency by firms since firms will compete with each other to be awarded dPPA rather than engage in strategic behaviour to improve their profit margins at the public's expense.

3.1.6 How it might work

Independence from political intervention

To avoid short-term manipulation of policies and targets, it is essential that abatement is managed outside of the political framework. An independent regulator needs to set targets, manage auction/tenders, collect carbon price revenues and conclude contractual arrangements with new technology generators.

Planning for the cost of differentiated Power Purchase Agreements

The independent regulator would analyse tenders received from firms and preside over the allocation of early adopter subsidies (dPPAs) with an indicative control cost to guide acceptability of the bids calculated as follows:

Early adopter subsidy (dPPA) =

$$\left[\frac{\text{Capital cost of the new technology plant}}{\text{Projected lifetime energy supplied to the network of the new technology plant}}\right] - \left[\frac{\text{Capital cost of the benchmark technology plant}}{\text{Projected lifetime energy supplied to the network of the benchmark technology plant}}\right]$$

We suggest the benchmark technology is Super Critical Pulverised Brown Coal (SCPf) as this is a mature technology with a fuel that has close to zero opportunity cost internationally.

To ensure that the dPPA does not become a potential loss for society, it should only be paid to generators for power produced during the economic life of the plant, not for the funding of development.

With SCPf as the benchmark, indicative values for dPPA based on Australian Energy Technology Assessments (BREE, 2012) are detailed in Table 3.

Providing each new technology generator with an appropriate early adopter premium would facilitate the deployment of multiple new technologies from multiple new sources of energy, thus increasing the diversity and resilience of the generation fleet.

A managed reduction in emissions through commercial deployment

The Australian Government has announced its intention to reduce its emissions from its power fleet by 80 percent by 2050 (unless it chooses to outsource Australia's abatement responsibility and buy emissions reductions from developing countries). Without the certainty of being able to implement a backstop technology like CCS and/or nuclear power, which would continue to render Australian power vulnerable to the shortcomings associated with single fuel reliance anyway, a measured approach would be to seek to decrease emissions by, say, two percent per year. To do this, Australia would need to displace around 4.5mtCO_2 per year which would equate to around 3.2TWh per year of brown coal generation. Table 4 below outlines how 3.2TWh of generation might be directed towards diverse fuels and technologies.

Funding an annual reduction would depend on the availability of funds raised from the carbon price. A fixed carbon price would provide more certainty for business and the funding of abatement targets, whilst the revenue generated from participating in an international carbon trading scheme would introduce uncertainty into both compliance and abatement costs. Therefore, the regulator should set an annual abatement target, with auctions held in each technology/fuel group that is able to deliver power.

As an example, emission reduction could be sought from the following groups:

- Solar
- Marine
- Geothermal
- Storage/network augmentation
- Nuclear (small modular reactor)
- CCS

If 3.2TWh of annual brown coal fired generation was replaced, auctions could be held in each of the six groups for contracts to deliver 500GWh per year of generation.

The funding requirements for a progressive annual roll-out of this sort for a period of five years would amount to a total of $3.6 billion and would then have a 20-year contract roll-out cost of a further $20.4 billion against $22.9 billion raised in five years (assuming a carbon price of $23/t$CO_2$ increasing by 2.5 percent per year in real terms) from electricity generation emissions only. This is as close as it gets to a balanced budget for a 10 percent reduction in emissions, and a 17 percent increase in diversity of, electricity generation. Without a fixed carbon price, the regulator would have to estimate the budget available and negotiate contracts appropriate to that budget.

With an inbuilt renewable energy target as part of the subsidy scheme, we suggest that the RET can be discarded as a policy measure after 2020.

Table 3: Feed-in-Tariff indicative values

Available now		Available post 2025	
Fuel/technology	**dPPA ($/MWh)**	**Fuel/technology**	**dPPA ($/MWh)**
Wind	$6.06	**CCS (Retrofit)**	$27.86
PV	$41.01	**Geothermal**	$33.93
CST (with storage)	$65.34	**Marine**	$43.84
Storage	Not yet available	**Nuclear (Small modular reactor)**	$3.35

Note: These values would need to be revised with every iteration to capture cost reductions as technologies mature.

Table 4: Contracts to deliver managed abatement

	Solar	Geothermal	Marine	Storage	Nuclear	CCS
GWh required	500	500	500	500	500	500
MW Capacity	136	68	161	160	68	100
FiT $/MWh	$50	$34	$44	$318	$3	$28
Funding/yr ($m)	$25	$17	$22	$159	$3	$14

3.2 What others have said

In July 2012, the Grattan Institute released a report entitled "Building the bridge: A practical plan for a low cost, low-emissions energy future". The report highlighted the need for government to intervene to remove the uncertainty that currently inhibits decisions to invest in renewable and low carbon generation.

The centrepiece mechanism – the "bridge" to deploy a portfolio of technology options – is a regular auction system to contract with companies to generate electricity from low-emission technologies.

While there are differences between our proposals and the Grattan Institute's auction system, the concepts are similar. Both suggest a portfolio approach to focusing investment on a diverse range of technologies with funding to support early investors who compete to provide the lowest cost generation within their technology or fuel group. Where the mechanisms appear to differ, is that our report sees no purpose in linking support for investors to a global carbon price which will provide investors with little certainty. We believe that more structured abatement would provide stronger targets for reduction rather than the unchallenging targets suggested by the Grattan Institute.

3.3 Research to underpin affordability and innovation in energy

It is widely accepted that innovation is critical for economic growth and a vibrant and productive society. However, successful innovation needs to proceed from idea creation through pilot-scale demonstration of viability and scaled-up production before being able to reap the benefits from commercial production and economies of scale. This is particularly the case in the clean energy space where good ideas abound but true innovation through to scaled-outcome is a rare event. The Cutler Report for the Rudd government's National Innovations Systems Review highlighted a global and systemic funding gap in the availability of capital for immature ventures where research points to the potential but commercial application remains uncertain (Cutler, 2008). This is supported by a recent Massachusetts Institute of Technology (MIT) Taskforce report which identified a decline in innovation production competency in the US, pointing to financial market requirements for "asset light" companies as a compelling factor in propelling corporations to reduce long-term research and resource commitment to scale-up to commercialisation in favour of heightened near term returns (MIT Taskforce, 2013).

In the Preview of the MIT Production in the Innovation Economy Report (PIE), innovation resources in the US are compared with those in Germany. It finds Germany's manufacturing industry is rich in 'complementary capabilities', with trade associations, research consortia, university-led collaborations and technical advisory committees facilitating critical scale-up stages like prototyping, pilot production, demonstration and early manufacturing. This makes it successful in delivering the economic benefits from innovation.

Germany's ability to transform its old manufacturing capabilities into new innovations is a result of its long-term commitment to nurturing innovation. This commitment is exemplified in its Sixth Energy Research Programme which identifies investment in technologies around energy efficiency and renewable energy as critical to the future in a carbon-constrained world. Almost 80 percent of Germany's federal research funding in 2014 is reserved for energy-related research and development to meet both their need for secure, affordable energy and to mitigate against climate change. The German Government does not shoulder this cost and responsibility on its own; almost 70 percent of gross domestic expenditure on research and development is financed by industry (Federal Ministry of Economics and Technology, 2011).

The Cutler Report found that Australia's 'absorptive capacity', that is the country's ability to realise the value of unfolding research findings and apply them to commercial ends, is increasingly fragile. Expecting to free-ride on global technological developments will fail to increase the diversity and range of innovative skills, manufacturing capacity, investments and firms in the Australian economy. Success in deriving economic benefit from research conducted in Australia is dependent on building 'complementary capabilities' like those found in Germany. In clusters of innovation in the US, MIT's PIE report found that successful innovation is characterised by building 'complementary activities' like:

- Convening, where a private company or a public institution takes the lead in providing resources for others to use and from which to gain benefit
- Co-ordinating, where existing resources are coupled with research or novel concepts from diverse sources
- Pooling and sharing risk amongst collaborators
- Bridging the gap to commercialisation

What is striking about these 'complementary activities' is that they provide a service which becomes a public good, but is not funded by the market. In the successful clusters in the US and in Germany, the responsibility for providing this public good is accepted by both public and private concerns.

To be competitive in the decades to come, Australia needs to increase the resilience of its power system, and actively foster 'absorptive capacity' of its renewable energy and CCS potential. The institutional structure for funding research, development and deployment of immature renewable energy technologies is developing through the Australian Renewable Energy Agency (ARENA), and CCS through Australian National Low Emissions Coal Research and Development (ANLEC R&D). However, there is little institutional capability to co-ordinate and deliver the prototypes, pilots, demonstrations and early manufacturing capacity.

Singapore has established A*STAR, the Agency for Science, Technology and Research, which seeks to support Singapore's key economic clusters through Research Entities which place emphasis on translating new knowledge and technologies created at the "benches" into new workable applications; and commercialisation entities which facilitate the efficient transfer of A*STAR's technologies to industry. A*STAR's philosophy is indicative of broader Singaporean attitudes to innovation and new industry development. Singapore's only resource is its people, and investment in intellectual capital is therefore paramount. A*STAR also actively "recruits" new technology and companies into Singapore, preferring to concentrate on metrics of skilled job creation rather than attempting to capture and own intellectual property which may or may not deliver an outcome, or indeed exploit an import for short term gain. It is not clear that Australia's current innovation system of Commonwealth Scientific and Industrial Research Organisation (CSIRO), small government laboratories, isolated industry activity and competing universities can accommodate the type of philosophical shift needed to truly increase our innovative capacity and fully capitalise on an immense intellectual resource.

In the renewable energy space, ARENA is almost certainly a step in the right direction. Its mandate is to co-ordinate and promote innovation (technology, systems and processes) throughout the early stage of technology readiness levels (TRLs – Figure 9) through to pilot-scale realisation. In principle, ARENA should dovetail with the research and discovery focused activities of the National Research Councils (the Australian Research Council in particular); the early stage proof-of-principle commercialisation focus of schemes like AusIndustry's Clean Technology Innovation Program (CTIP), and the full-scale deployment support afforded under the Clean Energy Finance Corporation. An interesting aspect of ARENA's current portfolio is the Renewable Energy Venture Fund (REVC) – a $200 million Venture Capital investment vehicle managed by the US-Australia Southern Cross Venture Capital (SXVP) with funds also provided by SoftBank China. Disappointingly, the REVC, which has been running for nearly two years now, has had a relatively modest deal flow, with only two announced investments to date: Brisbane Materials Technology Pty Ltd and Hydrexia Pty Ltd. Why, if Australians are so innovative, has the REVC had such limited impact?

At the other end of the scale, ARENA has now absorbed the Solar Flagships Program (SFP). The SFP was a Labor Government initiative which aimed to deploy up to 1GW of utility-scale solar thermal and solar PV in four plants over the next decade. The scheme was a grand vision, and attracted significant international interest for the world's largest solar companies. Initially, $1.2 billion was sequestered in the SFP fund with a further $200 million allocated from the Education Investment Fund (EIF) to underpin research and development, as well as capacity building. The Solar Dawn and Moree Solar Farm consortia were the first successful projects to be chosen in a highly competitive round one tender process during 2011. However, neither project reached financial closure and both were abandoned by mid-2012 when the SFP was transitioned into ARENA's portfolio.

A further PV project, the AGL/First Solar Nyngan-Broken Hill Project, was funded to replace the Moree Solar Farm and is expected to reach financial closure in July 2013. This project will deploy 159MW of flat panel PV (First Solar thin film cadmium telluride) at two NSW sites. The project will cost approximately $450m with approximately $200m of support from the Australian and NSW governments. The University of

Queensland will partner with the University of New South Wales in creating a large (3.25MW) research pilot plant at its Gatton Campus west of Brisbane. This will be Australia's first national solar research facility for pilot-scale innovation and arguably the largest and most sophisticated of its kind anywhere.

The eagerly anticipated success of the AGL PV project aside, the SFP demonstrated a somewhat obvious truth – renewable energy projects at the utility-scale whether subsidised by the public purse or not, require solid and financially viable off-take agreements. Both the Moree and Solar Dawn projects failed on this critical element. AGL, being a large retailer provides its own off-take. With the current regulatory and market structure in Australia, and with a small number of large, dominant retailers, does this mean that only parties that can buy their own energy via "internal power purchase agreements" or direct merchant trading will finance and build utility-scale renewable power plants? This is a critical policy and regulatory hurdle requiring a new level of market innovation.

Since innovation in Australia's productive capacity will deliver greater economic benefit, there is reasonable justification for funding programs that seek to increase innovation in energy from general revenue rather than tightly coupled to carbon price revenue. Inevitably, there will be some overlap between commercial deployment of new technologies and developing emergent technologies and while flexibility is needed to allow projects access to multiple programs, measures should be taken to avoid duplication in project funding from public money.

We strongly recommended that innovation is not limited to supporting the development and demonstration of renewable energy and distributed generation. The Clean Energy Future Plan provided funding for research, development and demonstration programs for CCS, i.e. the CCS Flagships program, the National Low Emissions Coal Initiative, the National CO_2 Infrastructure Plan and funding for the Global CCS Institute.

The CCS Flagships Program has $1.68 billion to support two-to-four large-scale integrated CCS demonstration projects in Australia. Indicative priorities of the CCS Flagship projects include:

- Multi-user infrastructure for greenhouse gas storage sites in high-emission regions, with pipeline infrastructure to support the transport of CO_2 from regional emissions sources
- Integrated capture and storage projects that may include coal gasification, post-combustion capture and oxy-firing integrated with geological storage

These programs are supported by various state government programs and the Australian Coal Association Low Emissions Technologies (ACALET) Fund which will commit approximately $1 billion to the development of CCS and other low emissions coal utilisation technologies. Like the Solar Flagships program, the CCS Flagships program has also seen limited success with projection cancellations and delays.

Australia must prioritise the characterisation of CO_2 geo-storage resources. Such exploration and appraisal efforts take time and significant funding, and thus the continued provision for investment of this nature needs to be made as assured as possible. Equally importantly, if Australia wishes to lengthen the potential for its lucrative fossil fuel export market, is investment in the technological advancement of carbon capture from generators. Reducing carbon capture costs would provide significant opportunity for Australia to roll-out its innovations world-wide and benefit from a massive market opportunity to capture and store carbon from a global fleet of more than 1.7TW of coal-fired power stations.

Similarly, developing the option to deploy nuclear power would guarantee greater diversity for Australian energy. Despite disagreement on the deployment of nuclear power, public perception could change quickly if the consequences of global warming assumed greater significance. To retain all options it is important to build 'absorptive capacity', invest in skills, knowledge and research into the safe provision of nuclear power.

In summary, significant investment over several decades in our energy technology innovation system has failed to deliver substantive outcomes. Fragmented and uncoordinated state and federal policies, unilateral partisan positions in successive administrations, a stranglehold by the large incumbent retailers and suppliers, and a clumsy regulatory environment have conspired to suppress innovation and deployment. ARENA is an attempt to address these issues (for renewable energy only) and will hopefully enjoy a degree of consistency and bipartisan support to allow it to do its job and expand its mandate to support low emissions technologies more generally.

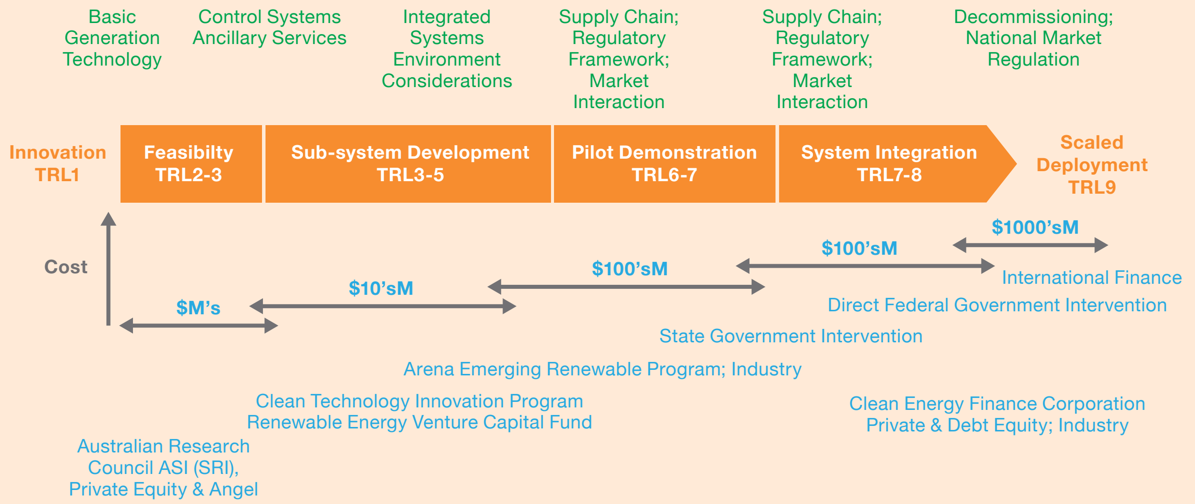
Case study

From evolution through collaboration to innovation

Figure 9 provides stylised view of the well-defined process moving through levels of technology readiness from idea creation and laboratory research through to full-scale exploitation.

Figure 9: Scaling up from ideas to exploitation

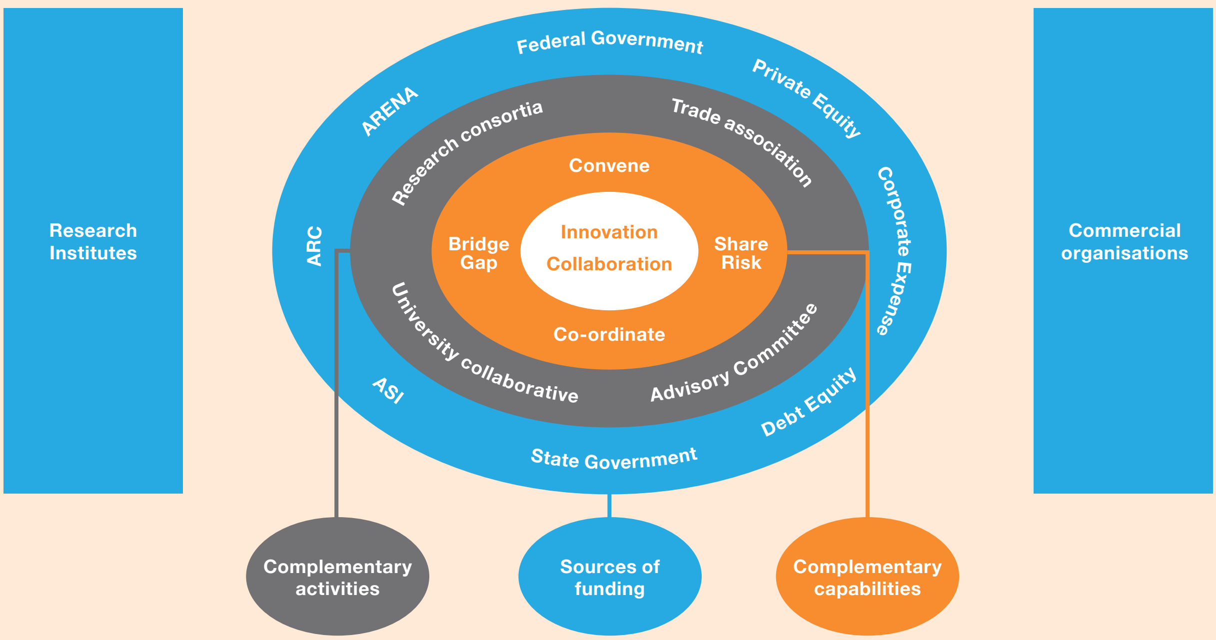
Clean Energy Technology Evolution Pathway: "From Lab to Load"



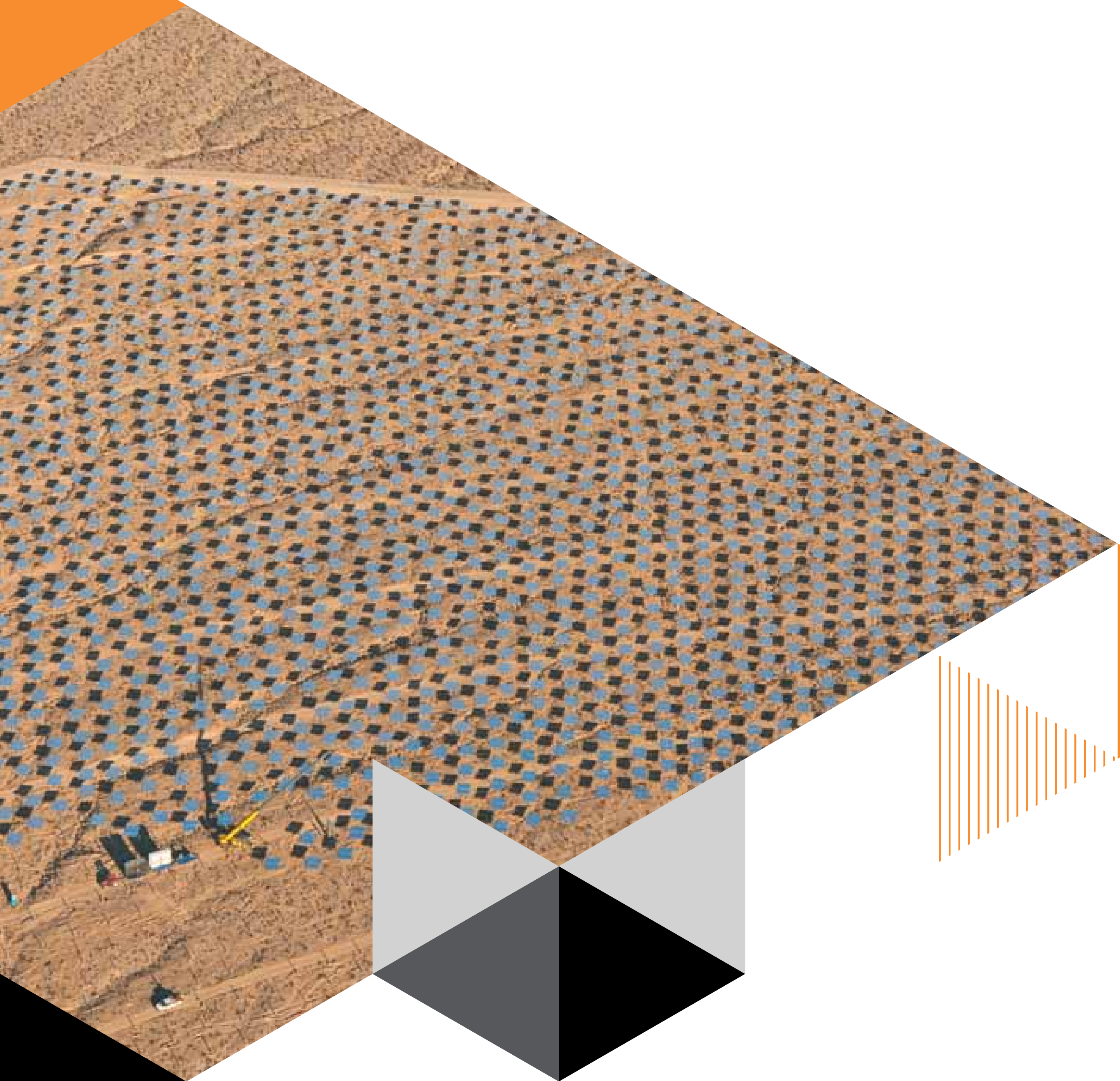
Activities for developing 'complementary capability' need to be super-imposed on this framework to build 'absorptive capacity'. Figure 10 provides detail on how an innovation collaboration might be structured to deliver 'complementary capabilities' to energy research, development and deployment.

Figure 10: Institutional structure for innovation collaboration

Clean Energy Technology Evolution: Institutional Collaboration



4. The need for a strategic system view



Just as firms will not invest to reduce externalities unless regulation requires them to do so, few firms will invest in new, untried, diverse technologies unless some kind of incentive exists. Australia, therefore, needs to develop a strategic view of where it wants to be in 2035 and establish policies that will help it get there. The UK's Royal Institute of International Affairs, Chatham House, has put forward a concept which they refer to as 'investment grade' energy policy which is based on the concept that 'financeability' must be central to policy making where investment is a significant issue. This is because a simple 'low carbon' approach or carbon price will not overcome the market risks associated with new technologies, or drive the underlying infrastructure requirements. Thus, Chatham House suggest that public finance tools for investment in infrastructure as well as support for innovation are essential to meet climate change goals (Hamilton, 2009).

In Part 2 of this series, we found that investment in renewable and distributed generation offered a strategy to increase resilience. We also highlighted that CCS and nuclear power could increase resilience, although the ability to deploy CCS and nuclear are dependent on research and development for CCS and addressing public skepticism about nuclear.

A strategy to deploy a diverse range of renewable and distributed generation little by little over the next decade, coupled with characterisation of carbon geo-storage and geothermal resources would provide Australia with a manageable, funded and therefore affordable path toward a resilient and competitive power system.

Using an existing funding mechanism like the carbon price would help protect consumers from sharp increases in electricity prices. At the time of writing, both political parties are committed to maintaining current tax benefits to low-income earners, rolled out as part of the carbon price legislation, despite election commitments to change or abolish the carbon price. Both parties commit to fund the tax benefits through budget savings elsewhere in the event of reduced or no carbon price revenues. It seems there is bipartisan support for funding current tax benefits from outside the carbon price process. This tax subsidy scheme, therefore, effectively combines the divergent policies of the major Australian parties by coupling the carbon price mechanism of the Labor Party with the direct action plan of the Coalition. This way each party will have contributed a significant construct to a workable price and quantity mechanism that could deliver a resilient, competitive power system in the decades to come.

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The Global Change Institute at The University of Queensland, Australia, is an independent source of game-changing research, ideas and advice for addressing the challenges of global change. The Global Change Institute advances discovery, creates solutions and advocates responses that meet the challenges presented by climate change, technological innovation and population change.

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