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Author

Nelson, T, Pascoe, O, Calais, P, Mitchell, L, McNeill, J

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Efficient integration of climate and energy policy in Australia's National Electricity Market

Tim Nelson, Owen Pascoe, Prabpreet Calais, Lily Mitchell and Judith McNeill♣
Level 5, 201 Elizabeth Street
Sydney, NSW, 2000
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Australian climate change policy has been applied haphazardly to Australia's electricity markets for almost two decades. Federal and state level emissions trading frameworks have been introduced and subsequently repealed. Several studies have pointed to the significant costs imposed by such policy discontinuity. This article demonstrates that the use of production subsidies has also resulted in a 'disorderly' transition and has broken the link between the financial incentives for decarbonisation activities and the physical needs of the electricity system. We evaluate the various options for correcting this by introducing a stable, long-term climate change policy that integrates efficiently with electricity policy objectives. By applying a broad assessment framework, we are able to establish that a market mechanism aimed at pricing the externality implied by an independently set carbon budget, is the most efficient policy response.

Keywords: carbon pricing; renewable energy; electricity markets
JEL Codes: D04, D47, Q40, Q41, Q48

1. Introduction

Australia's east-coast electricity market was progressively deregulated in the 1990s as part of the Hilmer microeconomic reform process endorsed by the Council of Australian Governments (CoAG). The Hilmer Reforms were promoted as having delivered significant savings for consumers through improvements in allocative efficiency (see Parer, 2002 and Abbott, 2002). But Australian policy makers struggled to integrate a comprehensive climate change policy within an energy market framework. Pollitt and Haney (2013, p. 9) note that when markets such as the Australian National Electricity Market (NEM) were liberalised, 'competitiveness was the overriding priority. Today, competitiveness, energy security and decarbonisation are the three main energy policy priorities.'

There is some degree of urgency required by policy makers in properly integrating energy and climate policy. A host of organisations have found that the impact of human activity on climate is unequivocal (see IPCC, 2018). Australia, through the United Nations Framework Convention on Climate Change (UNFCCC) and Conference of the Parties (COP) process, has agreed:

- Warming should be limited to 2 degrees Celsius above pre-industrial levels with an aspiration to limit to 1.5 degrees; and
- Australia's initial target is to reduce emissions by 26-28% relative to 2005 levels by 2030.

[♣] Tim Nelson is Executive General Manager – Strategy and Economic Analysis at the Australian Energy Market Commission (AEMC) and an Associate Professor at Griffith University. Owen Pascoe is Director- Retail and Wholesale Markets at the AEMC. Prabpreet Calais is Senior Adviser – Retail and Wholesale Markets at the AEMC. Lily Mitchell is a Senior Advisor, Legal and Governance at the AEMC. Judith McNeill is Adjunct Senior Research Fellow at the University of New England (UNE). All views, errors and omissions are entirely the responsibility of the authors, not the AEMC, Griffith or UNE. Correspondence to t.nelson@griffith.edu.au.

Consideration of the interrelated nature of these commitments is absent from meaningful discussion about Australia's optimal climate change policy. Based upon a two-thirds probabilistic chance of limiting warming to 2 degrees Celsius, the IPCC (2018) has determined that a global 'carbon budget' of around 1,700 gigatonnes (Gt) would be required for the period 2000 to 2050. Based upon the work of the Climate Change Authority (CCA, 2014), a linear trajectory between now and 2050 may require emission reductions of around 50% relative to 2005 levels by 2030. As such, the existing 26-28% target implies relatively rapid decarbonisation beyond 2030. This is an important conclusion for the NEM as around one-third of Australia's greenhouse gas emissions are produced by electricity generators.

Without a comprehensive national climate change policy framework, a proliferation of piecemeal public policies aimed at encouraging the adoption of new low-emission supply options have added material quantities to the existing generation capital stock. The cost structure of these technologies is distinctly different to existing and competing thermal (coal and gas) units. Fuel is free (i.e. wind and sun) but there are large up-front capital costs. At a peak, there were six policies in place to drive capital substitution or addition, including: the NSW Greenhouse Gas Abatement Scheme (GGAS); the Large-Scale Renewable Energy Target (LRET); the Small-Scale Renewable Energy Target (SRES); the QLD 13% Gas Scheme[1]; various energy efficiency policies (e.g. Victorian Energy Efficiency Target or VEET); and premium solar feed-in tariffs (PFiT). A carbon price was also introduced via the Clean Energy Future package but subsequently repealed within a three-year window.[2]

None of these polices has been grounded in an actual public policy objective relating to Australia's international emissions reduction obligations. Furthermore, by focusing purely on the supply-side, and with a particular focus on renewable generation, two real-world problems have manifested. First, the nature of the supply-side policies introduced has broken the implicit link between financial risk management and the physical needs of the electricity system. Long-term 'energy' contracts have been written that do not differentiate pricing on the basis of when it is delivered. The 'semi-scheduled' nature of variable renewable energy means that it is supplied irrespective of whether the system requires it at the time. And second, the significant subsidisation of embedded household PV has resulted in customers with PV benefiting substantially at the expense of those without it due to the nature of network tariff design (see Simshauser, 2018).

While policy makers may be struggling to integrate energy market operations with climate change policies, the risks associated with implied rapid decarbonisation under the UNFCCC framework are manifesting in capital markets. Bloomberg New Energy Finance (2019) has noted that the spread for clean energy projects above the US Libor has narrowed from 330 basis points (bps) in 2006 to 245 bps today. Over the same time period, the spread for coal-fired generation projects has increased from 285 bps to 433 bps. The incompatibility of traditional relatively high-emitting coal-fired generation with the carbon budget concepts implicitly agreed to by governments through the UNFCCC process presents stranded asset risk to investors.

[1] The original 13% scheme was subsequently increased to 18%.

[2] Globally, the use of subsidies for renewable technologies can have a material impact on energy poverty (see Bhide and Monroy, 2011, for an example of this argument)

The purpose of this article is to describe Australia's ad hoc emission reductions policies, analyse their impact on the electricity market and then develop an assessment framework to facilitate rationalisation of existing polices so that Australia's international emissions reduction commitments are achieved at least cost. Section 2 provides a brief literature review and an outline of the many types of emission reduction policy instruments used in Australia. The economics of electricity generation is presented in Section 3, with a particular focus on the way in which the implicit link between financial risk management and the physical needs of the electricity system has been broken. Various policy options are evaluated against an assessment framework for determining an optimal climate change policy in Section 4. Concluding remarks are provided in Section 5.

2. Brief literature review and outline of climate policy instruments in Australia

A by-product of burning carbon-based fuels is an increased concentration of greenhouse gases in the atmosphere. The subsequent effects on the climate create an 'externality' or 'external cost', a term first introduced by Marshall (1890). Three features in particular add to the many complexities of dealing with the external costs of greenhouse gases: the problem is global; it is the *stock* of emissions accumulating in the atmosphere not *the flow* in any year that influences the extent of the change; and the costs of mitigation are imposed immediately, but the benefits are felt much later (Garnaut, 2008, 2014: pp.12-13).

The fact that the stock of accumulated emissions may last many hundreds of years means that turning off the flow today, even if it were possible, will still leave many years of potential future climate change. The extended time distance between costs and benefits means that convincing citizens to incur costs now, for benefits in the future, is inherently difficult. Yet not taking early action to mitigate is, in fact, a decision to defer the costs of inaction to later generations (Spash, 2002, p.158).

It is these features, together with the difficulties scientists face in being precise about the damages, which make the problem 'diabolical' (Garnaut, 2008, p.287ff); stand apart in 'sheer scale, complexity and economic significance' (Hsiang and Kopp, 2018, p.3); and 'the biggest environmental failure in human history' (Auffhammer, 2018, p.33 echoing Stern, 2007). A number of policy options to reduce greenhouse emissions have been discussed and implemented in Australia. These are outlined below under the headings of tax and trading schemes, direct regulation and subsidy schemes.

2.1 Tax and trading schemes

Pigou (1920) laid the intellectual framework for dealing with damages arising as a by-product of a production process. A tax which recoups the damage inflicted could 'internalise' the externality and equate private marginal costs (costs of the firm) to social marginal costs (costs to society). Coase (1960) demonstrated the significance of clearly defining legal rights. With such rights in place, a Pigovian tax approach was found to be an efficient solution to the problem of externalities in instances where transactions and information costs are too high to allow simple bargaining.

The literature on Pigovian taxes and other policy options to internalise greenhouse gas emissions is vast, and now spans many decades. It ranges from advice from the large multidisciplinary Integrated Assessment Models - IAMs (see, for example, the DICE model in Nordhaus, 2008, 2018; but see also Pindyck, 2017 for a critique of the IAMs); through innumerable government and non-government organisation reports; to many valuable single contributions. Nicholas Stern's report to the United Kingdom government (Stern, 2007) was a major contribution stimulating much follow-up activity.[3]

In Australia, the Garnaut Review, commissioned by state and federal governments in 2007 (Garnaut, 2008), and its update (Garnaut, 2011) provided a comprehensive review of the issues. The Review argued the case for pricing carbon as the preferred policy option, a point on which there is a general consensus in the economics literature. The Australian Treasury (2011) modelled comprehensively the economic impacts of a carbon price. Since the Garnaut Review there have been many other contributions. Those focussing particularly on national carbon pricing include: Freebairn (2012, 2014a, 2014b, 2018); Garnaut (2011, 2014, 2015); Holden and Dixon (2018); Quiggin et al. (2014); Wood and Blowers (2016); Naughten (2013); The Climate Institute (2013); Kember et al. (2013); and Clarke (2011). The Australian CGE literature on the economic impacts of a carbon price includes Adams (2007, 2013, 2014) and Meng et al. (2013). McKibbin, Wilcoxen and colleagues have been contributing substantially to the carbon pricing literature since the 1990s (see for example, McKibbin et al. 2002a, 2002b, 2009, 2012, and 2014; Pearce and McKibbin, 2007).[4]

Pricing carbon emissions is considered environmentally effective, economically efficient and, especially if the revenues from the tax (or sale of permits) are used appropriately, it can be distributionally progressive (or neutral).[5] A carbon price implements the 'polluter pays' principle. It is economically efficient because it signals to the market a change in relative input costs – the higher the carbon content, the higher the relative cost. As producers and consumers substitute away from higher costs, or bear these costs, feedback effects alter producer and household incomes, industry innovation and profitability, consumer spending, savings and government revenues.[6] Freebairn (2014a, pp.70-77) explains these economy-wide effects. In general, the entity that is liable to pay the carbon price should be that which has the greatest knowledge and control of abatement costs.

Firms that can abate emissions for a lower cost than the tax or permit will abate, whilst those that cannot afford to abate at this cost will choose to pay the tax. In this way, the tax encourages lower cost abatements to take place first. This ensures a more efficient outcome than, say, government regulation obliging all firms to abate the same amount regardless of abatement costs. By pricing carbon, efficiency is achieved without the government having to know anything about individual firms' costs.

In 2003, the New South Wales Government implemented the Greenhouse Gas Abatement Scheme (GGAS) which was claimed to be the first mandatory greenhouse gas emissions trading scheme in the world. The scheme operated until 2012, when it was closed to avoid duplication with prospective national policy (Nelson, 2015). It was a baseline and credit scheme where a market is created for certificates representing a reduction in greenhouse gas emissions against a baseline scenario. An analysis of the scheme by Passey, MacGill and Outhred (2008) found that some of the certificates were unlikely to correspond to the claimed abatement.

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[3] Recent international literature advocating carbon pricing includes Metcalf (2019); IPCC (2018); OECD (2018, 2019); Stiglitz and Stern (2017); Klenert et al. (2018); World Bank (2018); Rezai and van der Ploeg (2017); Weitzman (2011); Wagner and Weitzman (2015); Helm (2012); and Stern (2015, 2009). The 2018 winner of the Sveriges Riksbank prize (in memory of Alfred Nobel), William Nordhaus, has been contributing to the literature since 1976 (see, for example, Nordhaus 2018, 2013).

[4] Both McKibbin (in general) and Nelson (2015) make the point that mitigation impacts on Australia are likely to be mostly incurred through other countries shifting their energy mix away from coal and gas, two large sources of export revenue.

[5] Metcalf (2018, pp. 93-95) reports an Office of Tax, US Treasury (2017) analysis which demonstrates, against the conventional wisdom, that when taking into account wages and returns to capital, the burden of a carbon tax falls more on those with higher incomes, even if we ignore how the carbon tax revenue is redistributed.

[6] Recent research has also been drawing attention to the 'co-benefits' of policy to reduce emissions (Parry et al. 2015; West et al. 2013; Haines et al. 2009). Co-benefits are, for example, improved health arising from less air pollution. These benefits can be significant. For example, Liu et al. (2019) explore the economic and environmental implications of the Paris Agreement pledges, taking co-benefits into consideration. They find that 'co-benefits from reductions in conventional pollutants are sufficiently large that

even without accounting for reductions in climate change, every region receives a net benefit from participating in the agreement' and that even the world's largest emitters, China and the United States, 'are both better off participating in the agreement than withdrawing' (Liu et al. 2019 p. 38).

As noted earlier, Australia did implement a national carbon price for a short period of time. Commencing on 1 July 2012 and repealed with effect from 1 July 2014 after a change of government, the scheme commenced with a $23 per tonne of carbon dioxide equivalent (CO_2-e) ‘fixed price’ tradeable permit, which became known as the ‘carbon tax’ (see Simshauser and Tiernan, 2019). The original intention had been for the scheme to link with the European Emission Trading Scheme (EUETS) after three years. The tax applied to about 350 large businesses which between them produced around 60 per cent of Australian emissions. Australian emissions intensive industries (coal mining, aluminium, civil aviation, steel and diversified mining) were ‘shielded’ from the impact of the tax with prescribed financial assistance (Freebairn, 2014a, p.76).

Transitional assistance was also provided to highly emissions intensive coal-fired electricity generators in the form of cash payments and free permits, together valued at around $5.5 billion (Combet, 2012, p.32). Carbon tax revenues were returned to taxpayers in various forms of assistance, most notably, a large increase in the threshold applying before personal income tax becomes payable. These measures were not reversed on repeal of the tax.

2.2 Direct regulation

Direct regulations, or command and control approaches, can be used to ban certain types of technology and production processes or place absolute limits on the pollutants that can be emitted by certain facilities. The disadvantages and relatively higher costs of direct regulatory approaches to controlling pollution are well known (see for example Tietenberg, 2003; Daly and Farley 2011, pp. 428-9). Direct regulation ignores the fact that businesses and households have a wide variety of options to reduce greenhouse gas emissions (Freebairn, 2012). There is also a risk with direct regulation that low-cost abatement opportunities are missed and that costs are unevenly spread across sectors and facilities. Regulatory approaches also have difficulty responding to changes in technology and consumer preferences (Garnaut, 2008, p. 308).

Within Australia, direct regulation approaches were considered through subsidies for the closure of coal-fired power stations and application of emissions baselines. In 2011, the Australian Government began implementing the contract for closure program, which aimed to negotiate the orderly closure of up to 2,000 MW of high emissions-intensive generation capacity from the NEM (Combet, 2012). Ultimately, the Australian Government did not pay any generators to close as it was unable to agree on a price. Four of the five generators that were invited to proceed to the negotiation phase (Combet, 2012) have subsequently closed without subsidies.

2.3 Subsidy schemes

The most commonly utilised policy mechanisms to reduce emissions within Australia have been subsidies, with a particular focus on renewable energy. Various approaches to subsidies have been implemented, including:

- funds to pay for emissions reductions measures (e.g. Emissions Reduction Fund)
- market based approaches that create a price for cleaner generation (e.g. Large-Scale Renewable Energy Target, Queensland 13% Gas Scheme);
- reverse auctions, contracts for difference (CfDs) and energy generation subsidies funded by governments (e.g. reverse auctions in the ACT, Victoria and Queensland for large scale renewable energy);
- premium feed-in-tariffs (PFiTs) (e.g. various state-based feed in tariffs for household solar);
- direct research and development funding (e.g. Australian Renewable Energy Agency: ARENA)

- subsidised financing for certain technologies (e.g. Clean Energy Finance Corporation: CEFC).

Direct subsidies to individual businesses or households have often been used as an inducement to undertake emission reduction measures. There are a number of problems with the approach, however. To provide subsidies efficiently, governments will generally need to know individual firms' costs of abatement, so that cheaper abatement can occur first. Moreover, because there is no market price signal, emission reductions are confined only to the entities and sectors covered by the subsidy. There is no signal that 'taps into a much larger set of decision options to reduce pollution' (Freebairn, 2012, p.101). Subsidies can impose additional economic costs when, to meet an objective of fiscal neutrality, the rates of existing distortionary taxes in the economy have to be raised (Freebairn, 2014b). Subsidies also violate the 'polluter pays' principle, but this may be because it is deemed 'politically efficient' to avoid any increase in consumer prices (Pearce, 2005, pp.10-12) and to have less impact on import and export competing businesses (Freebairn, 2014b). Finally, 'additionality' is difficult to establish when using subsidies: that is, it is often unclear whether the subsidised activities would have occurred, at least in part, without the subsidy (Freebairn, 2014b).

Evaluation of subsidy mechanisms is also complicated by the multiple objectives these policies aim to meet, such as additional clean energy generation, industry development and job creation. That said, subsidies 'pick winners' in relation to the optimal capital stock required to reduce greenhouse gas emissions. In general, subsidy-based policy approaches do not deliver lowest cost abatement and can create 'disorderly' capital stock transitions in the electricity sector (see Simshauser and Tiernan, 2019).

The $2.55 billion Emissions Reduction Fund was established by the Commonwealth Government in 2014[7] to provide subsidies via reverse auctions for a range of organisations and individuals to adopt new practices and technologies to reduce their emissions. The first eight auctions contracted 193 million tonnes of emissions reductions, largely through vegetation projects, at an average price of $12 a tonne (Department of the Environment and Energy, 2019). In February 2019, the Federal Government announced a further $2 billion over 10 years to build on the fund.

In an attempt to ensure that emissions reductions purchased by government are genuine, and not offset by emission increases elsewhere, the Emission Reduction Fund uses the Safeguard Mechanism. Baselines were initially set to reflect the highest level of reported emissions for a facility over the historical period 2009–10 to 2013–14. Baselines are now determined based upon forecast or actual production levels and default emission intensity values, or on best-practice benchmarks (for new or expanded facilities). Baselines can be adjusted to accommodate economic growth, natural resource variability and other circumstances. If an entity exceeds its baseline it can apply for a new baseline, surrender Australian Carbon Credit Units (ACCUs), apply for additional time to reduce its emissions or apply for an exemption (in exceptional circumstances).[8] Even if the limits were more effective in constraining emissions, the costs would be substantially higher than those incurred through a carbon price. For example, the Safeguard Mechanism does not permit firms with lower abatement costs to undertake additional abatement that can be sold to participants with higher abatement costs.

Nong (2019) examines the economic impacts of the ERF through a general equilibrium impact study and finds these are relatively immaterial as the fund is small compared to the size of the economy, though these vary by sector. Nong and Siriwardana's (2017) modelling of the ERF budget of $2.55 billion found it would be sufficient to achieve a minimum estimate of Australia's cumulative abatement task to 2020 (225 Mt CO_2-e), but more funds would be needed to meet a maximum estimate (279 Mt CO_2-e).

The Large-Scale Renewable Energy Target (LRET) requires retailer to purchase prescribed volumes of large-scale renewable energy. Mechanisms such as the LRET differ from general subsidies and reverse auctions because they oblige energy retailers to provide the subsidy to cleaner generation, with the costs generally passed on to consumers. These mechanisms can overlook opportunities for abatement (e.g., fuel switching from coal to gas) due to their focus on new capacity (Freebairn, 2018). Mechanisms that subsidise technology can lower wholesale prices in the short term, in the absence of generator retirements (Bell et al, 2017), but this can have the perverse effect of encouraging electricity consumption and more pollution intensive choices by consumers (Freebairn, 2018). As generators exit the market, wholesale prices can be expected to rise to the cost of the new generation mix (see Nelson et al, 2018). Modelling exercises have found that LRET style mechanisms are expected to have higher average costs of abatement than tax and trading mechanisms such as an emissions intensity scheme and can fail to meet stated objectives (Buckman and Diesendorf, 2010). Furthermore, production subsidies such as LRET can break the link between the financial incentives facing participants and the physical needs of the electricity system and significantly reduce electricity market contract liquidity (see Simshauser, 2019).

Benefits of LRET-style production subsidies are also worth noting. The LRET has been found to have spurred significant investment, particularly wind power, and, in some time periods, put downward pressure on wholesale prices (Cludius et al, 2014). Bell et al. (2017) found that increasing wind power penetration through mechanisms such as LRET can lower wholesale spot prices. It may well be that design flaws of LRET-style production subsidies have contributed to sub-optimal outcomes (see for example Simshauser and Tiernan, 2019; Buckman and Diesendorf, 2010). Jones (2009, 2010, 2014) highlights the uneven development of renewable energy targets in Australia and the difficulties in coordinating between federal and state governments.

CfDs have also been used by state governments to drive investment in renewable energy. Whilst CfDs may reduce risks from a LRET style floating renewable energy certificate price (Woodman and Mitchell, 2011), Bunn and Yusupov (2015) show that, with the negative correlation between renewable output and wholesale prices, tradeable certificates can offer lower investment risk than feed-in tariffs or contracts for difference. Simshauser (2019) finds that in an energy-only gross pool market, such as the NEM, increasing use of CfDs can lead to shortages of 'primary issuance' hedge contracts in the forward market, which can harm consumer welfare. This is one of the issues we build upon in Section 3.

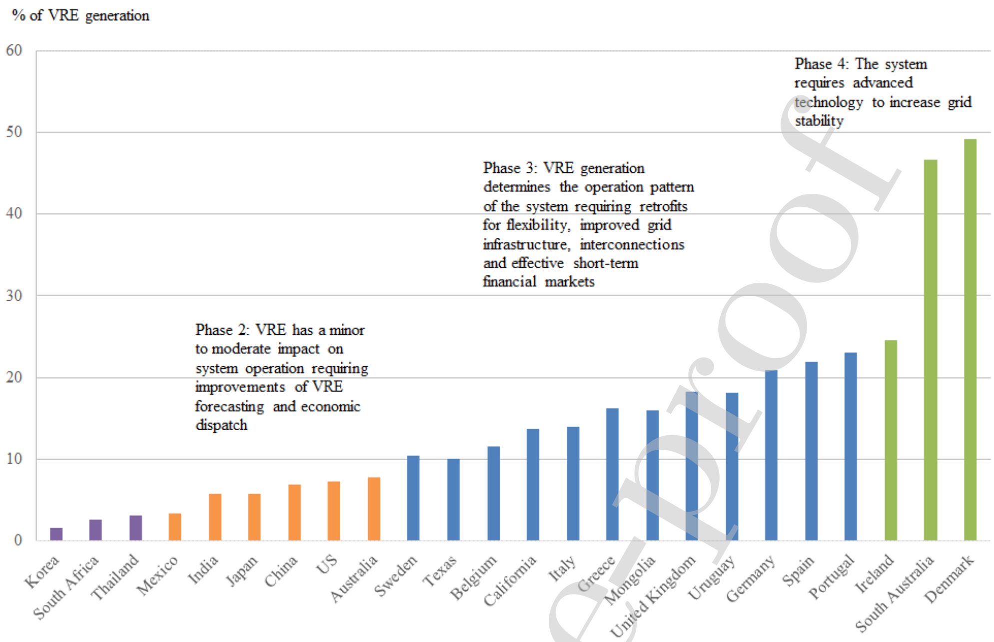
PFiTs have been used extensively in Australia to drive investment in residential solar PV. In some states, around one-quarter of detached housing residences now operate their own embedded solar PV system due to both the previous use of PFits and the significant reductions in cost of solar PV. Nelson, Simshauser and Kelley (2011) and Nelson, Simshauser and Nelson (2012) demonstrate that FiTs act as a regressive form of taxation.

It is particularly important that Australian policy makers recognise the limits of production subsidies as a means of reducing greenhouse gas emissions. The South Australian electricity market is one of only three systems recognised by the International Energy Agency as being in the fourth and final phase of renewable energy integration. With around one in four households embracing distributed solar PV and more than 1,500 MW of large-scale wind in a system with peak demand of around only 3,000 MW, South Australia has the second highest penetration of renewables in the world. The IEA (2019) has stated that the South Australian system 'requires advanced technology to increase grid stability' (see Figure 1).

[7] Incorporating the carbon farming initiative, which commenced in 2011.

[8] See https://www.environment.gov.au/climate-change/government/emissions-reduction-fund/publications/factsheet-safeguard-mechanism-initial-baselines

Figure 1: Stage of renewable energy integration by market



Source: IEA (2019)

To be clear, it is highly likely that renewable technologies will continue to be deployed irrespective of the policy mechanisms deployed to meet Australia's greenhouse gas abatement obligations. Renewable energy has declined materially in cost over the past decade. While it is true that the lowest cost form of new generation is renewable energy, it will be required to compete with existing thermal generators whose economic fixed costs are sunk. As such, some form of policy will be required to reduce emissions where the carbon budget requires economic substitution of existing plant with new renewables.

3. The economics of electricity generation in the NEM

At noted in the previous Section, policy-makers have focused climate policy instruments on the use of production subsidies, despite their well-known limitations in the literature. The use of these subsidies, primarily the LRET, has led to increased use of non-derivative alternative contract arrangements. Over the preceding decade, around 5,000 MW of dispatchable generation (coal and gas) has been retired from the NEM while approximately 18,000 MW of non-dispatchable generation (wind, solar etc.) has been, or is in the process of being, commissioned. Put another way, generation that has traditionally provided derivative contracts (i.e., risk management products) has been retired and replaced with generation that is variable in nature and largely contracted in a manner that does not allow for wholesale price risk to be managed. This Section unpacks why this phenomenon is problematic for the ongoing efficient operation of Australia's NEM.

The NEM is a gross pool with a uniform clearing price. Generators are paid only for the energy they produce, not the capacity they make available. At times of surplus capacity, pricing outcomes tend to trend towards short-run marginal cost (SRMC), which may be below long-run average cost (LRAC). When there is an expectation of scarcity of capacity, prices can rise significantly above LRAC. Over the business cycle, generators expect to recover their average total costs (ATC) given an efficient or 'optimal' level of investment (see Nelson et al., 2018).

A critical characteristic that underpins the market's operation is the ability of generators to *choose* when to be scheduled (as distinct from dispatch). Relatively heavy fixed cost generators, such as coal-fired plants, are designed to operate at high capacity factors. They are best suited to meeting 'baseload demand'. Relatively lower fixed cost generators, such as gas-fired plants, are better suited to meeting 'intermediate demand' and 'peak demand'. These plants have the ability to quickly ramp their production and are generally able to start relatively quickly. As variable renewable generators cannot *choose* when to operate, they simply operate as long as the price is greater than their opportunity cost of operation (Nelson et al, 2015).

To provide for the most efficient dispatch within the wholesale market, the NEM allows for significant pricing volatility. Prices can vary from negative $1,000 per megawatt hour (MWh) to $14,700 per MWh. Generators and retailers manage this risk through the use of financial derivative products. Entering into wholesale hedging contracts increases the certainty of generators' revenue streams, and this allows them to get funding for their business operations from banks or other financial institutions. This is particularly important for generation companies seeking funding to build new power stations – which are generally expensive, long term investments.

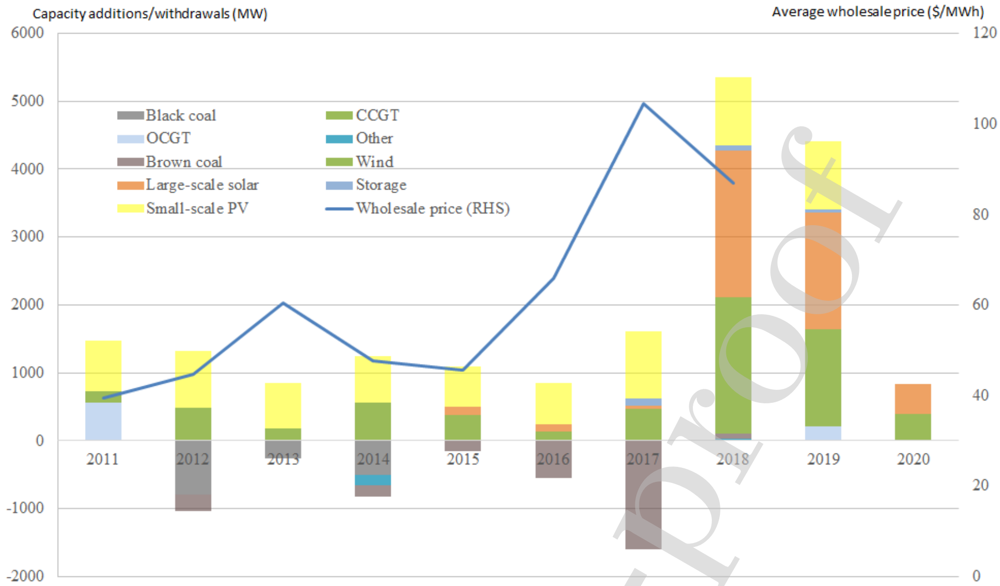
Generators are incentivised to ensure their financial position in the contract market is consistent with the physical needs of the electricity system. If they have forward sold energy through derivative contracts but unable to generate, they can be materially impacted financially. The financial penalty relates to the difference between the contract price and the spot price. The higher the spot price, the higher the financial penalty. Because of this penalty, generators typically hold a certain amount of generating capacity in reserve to make sure they can deliver their contract quantities. In this way, power should be available when demand is greater than expected. The spot and contract markets work together to deliver the required amount of power on a day-to-day basis and also over the longer term.

Wholesale contract prices are broadly based on expectations of average future spot prices. Difference types of contracts provide insights into future spot prices for different types of demand.[9] If supply of electricity is expected to be tighter in the future to meet average demand, spot prices are likely to rise and this will be signalled through rising contract prices. Different types of contract prices therefore provide important signals to the market about how much generation needs to be available, of what type, and where it needs to be located. For example, following the closure of a large power station, there may be sustained higher spot prices if there is a subsequent tight match of supply and demand, which are then reflected in higher contract prices. These higher prices provide an incentive to build new generation or demand response capability that will fill the supply gap.[10]

Figure 2: Entry and exit of power generation and average wholesale electricity prices

[9] Swap and cap contracts are the most obvious examples of derivative contracts for hedging risk for very different types of electricity demand. Swap contracts are generally used to hedge against 'average' spot prices. Cap contracts provide a hedge against 'peak demand' and very high spot prices.

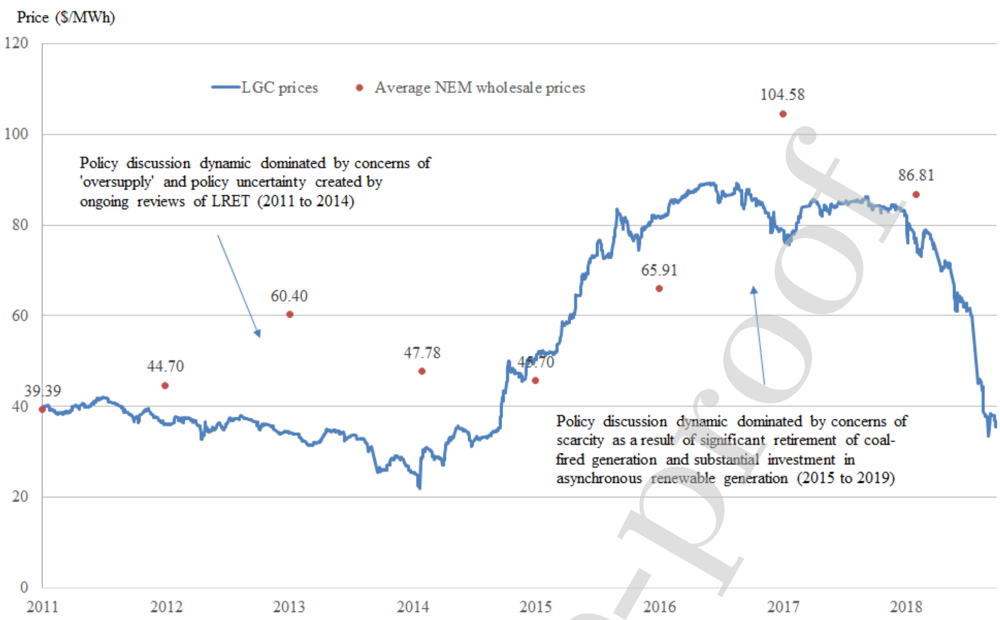
[10] It should be noted that not all exit of power stations will drive a significant shift in pricing. In an already oversupplied market, power station exits may not have a material impact on price at all (e.g. Swanbank B in Qld, Redbank in NSW).



Source: AEMO data

At first glance, the NEM has provided pricing signals that reflect the oversupply or scarcity of generation relative to demand. Figure 2 shows the entry and exit of different categories of generation technology since 2011 (LHS) and the average wholesale price (RHS). Given declining demand, and significant uptake of subsidised embedded small-scale PV and large-scale renewable generation, there was an oversupply of capacity with prices well below the cost of new-entry until 2015 (see Nelson et al., 2015). This sustained low pricing resulted in several incumbent ageing coal-fired generators retiring over several years with the most capacity being retired in 2017. In most cases, less than a year's notice was provided of the generator closure. With such little time available to participants to replace the capacity being withdrawn, wholesale prices increased markedly in 2017. A preliminary conclusion could be drawn that the market has worked as intended with more than 8,000 MW of new capacity under construction or at financial closure at the time of writing.

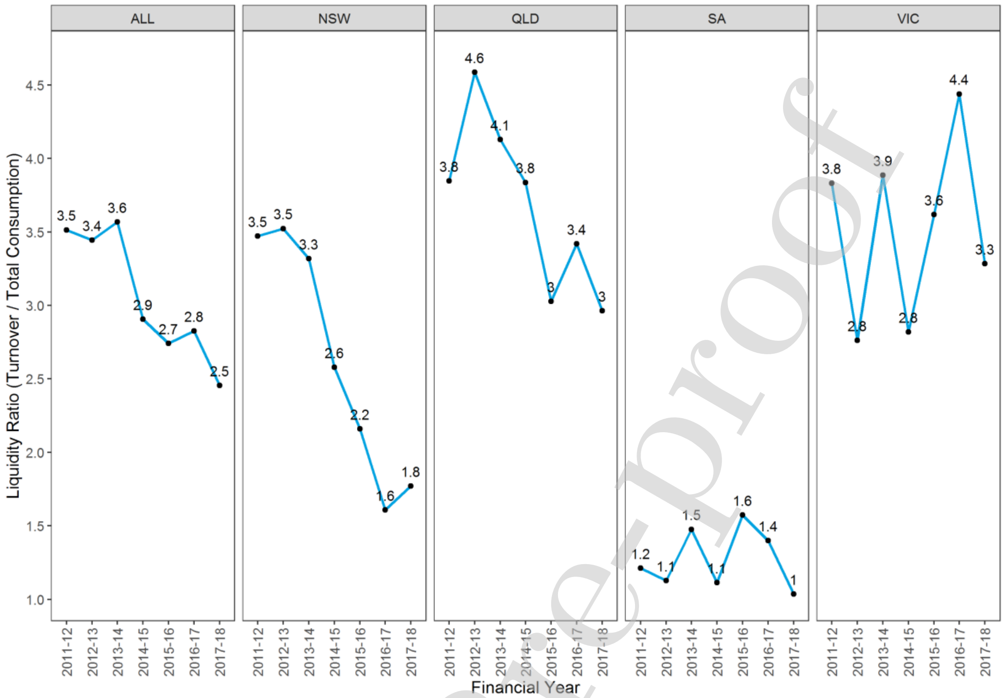
Figure 3: Large-scale generation (LGC) certificate and wholesale prices



Source: AEMO data

Figure 3 shows the correlation between wholesale electricity pricing and LGC pricing outcomes from 2011 to 2019. The provision of a subsidy means there is less incentive to generate at times when the electricity system requires more electricity. A consequence of the use of production subsidies has been the increased adoption of renewable Power Purchase Agreements (PPAs). A PPA is a long-term agreement between a generator and a purchaser (a retailer or a consumer) for the sale and supply of energy. Wind and solar farms often use PPAs. Typically, this involves the wind or solar farm selling renewable energy certificates to the purchaser at a fixed price. Unlike financial derivative contracts, PPAs reward the seller for generating as much electricity as possible at any time. There is no incentive for the seller to generate more or less electricity when the power system needs it - that is, when spot prices are high or low. As noted in Section 2, PPAs break the link between financial incentives and the physical needs of the system (see Simshauser, 2019). A consequence of this, and other developments such as increased vertical integration of energy companies, has been reduced risk management product liquidity. This is shown in Figure 4.

Figure 4: Liquidity ratios in the NEM



Source: Industry data

The use of production subsidies for variable renewable energy technologies not only results in a break between the physical needs of the system and financial outcomes, it results in a sub-optimal deployment of these technologies. Variable renewable energy technologies suffer from the 'coincident production problem'. As a result of only producing when fuel is immediately available and not stored (i.e. the sun is shining and the wind is blowing), there is often an 'oversupply' of energy from these coincidentally producing technologies. To demonstrate this, we have constructed the price received by variable renewable generators and the 'firming' price required to either meet demand or offer a flat swap derivative style contract. The first of these analyses is shown in Table 1.

Table 1: NSW region large-scale solar PV price, 'firm' complementary price and 'swap' price

Year	Solar PV dispatch-weighted price	Average price of 'firming' profile	Time-weighted average 'swap' price
2016	$60.0	$58.6	$59.0
2017	$103.0	$92.7	$95.5
2018	$78.6	$83.8	$82.3

Table 1 shows the dispatch-weighted price received by solar PV, other 'firming' generators and the combined 'swap' style price that a blend of the two produces for the NSW region. It should be noted that NSW had relatively low levels of large-scale solar PV penetration over this particular period of time so the spread between the price received by variable renewables and other generators is relatively low. But as more variable renewable generation enters the system, it is evident that a production based subsidy results in new variable renewable generation 'cannibalising' the wholesale electricity prices of other variable renewables due to the existence of an out-of-the-market production subsidy. This is most evident in South Australia where around half of the energy consumed is now sourced from variable renewables. The same economic analysis for South Australia is presented in Table 2.

Table 2: SA region large-scale wind price, 'firm' complementary price and 'swap' price

Year	Wind dispatch-weighted price	Average price of 'firming' profile	Time-weighted average 'swap' price	Ratio of wind to average price (by weighted volume)
2010	31.5	44.2	41.1	0.75
2011	26.8	41.0	36.1	0.84
2012	40.0	45.5	43.4	0.54
2013	59.0	87.3	76.5	0.87
2014	39.2	49.9	46.3	0.93
2015	38.0	55.6	49.5	0.57
2016	59.2	86.8	76.8	0.48
2017	83.6	111.9	102.1	0.77
2018	78.0	111.7	98.5	0.61

Table 2 shows the gap between the price received by variable renewables and the average time-weighted 'swap' price. In 2010, the spread was around $10 per MWh but by 2018 it had grown to around $20 per MWh. In other words, the inability of wind to choose when to generate results in pricing outcomes below that of a generator that is able to sell and physically back a swap product. This phenomenon is even more pronounced when the ratio of wind to average prices is assessed. In some years, wind generators are only receiving half of the average price in the South Australian region. So in the absence of policy reform, the continued use of production subsidies will not result in an optimal investment mix. Participants will be incentivised by maximising production at any time rather than investing in an optimal mix of investments that lowers the overall cost of reducing greenhouse gas emissions (see Simshauser, 2018).

Our analysis provides three important conclusions that build upon the literature in Section 2. Firstly, reliance upon a production subsidy mechanism such as the LRET or SRES results in a more disorderly transition towards meeting Australia's emission reduction commitments. Secondly, the variable production nature of the capacity being added results in an inability to provide traditional risk management contracts, thereby breaking the link between the physical needs of the system and financial outcomes. And thirdly, the use of production subsidies for coincident renewables is unsustainable financially in the absence of technologies such as energy storage. These insights are used to guide our assessment of an optimal policy response in Section 4.

4. Evaluation of policy options against assessment framework

As discussed above, Australia has had broad experience with several varieties of emission reduction policies. Each of these policies, and others that have not been implemented in Australia, vary in both their efficiency of reducing emissions and broader impact on the economy. Therefore developing an assessment framework that encompasses these broader impacts is important.

Several assessment frameworks and criteria appear in the academic literature. Betz and Macgill (2005) use the criteria of environmental performance, economic efficiency, dynamic incentives, technical administration and practicality, equity aspects, and competitive impacts to assess emissions trading policies in Australia. Blechinger and Shah (2011) employed the criteria of environmental performance, political acceptability and feasibility of implementation. Verbruggen and Lauber (2012) used a similar framework of efficacy, efficiency, equity and institutional feasibility to assess renewable support instruments.

The assessment framework used in this paper builds on these, and emphasises three main categories, namely: cost effectiveness, environmental effectiveness, and efficacy of implementation. Table 3 below provides a high level description of the specific criteria in each category, and a fuller explanation is presented in Appendix 1.

Table 3: High level description of assessment criteria

Category	Code	Criteria	Details
Cost effectiveness	CE1	Incentivise new low emission capacity	Does the policy incentivise new low emission generation capacity to be installed?
	CE2	Remove high emissions capacity	Does the policy incentivise the removal of high emission generation capacity?
	CE3	Incentivise lower emission generation	Does the policy incentivise increased generation from existing lower emission capacity?
	CE4	Incentivise efficiency improvements in existing plant	Does the policy incentivise existing generators to make efficiency improvements?
	CE5	Reduce electricity demand	Does the policy reduce demand?
	CE6	Fungibility with other carbon units	Does the policy allow the use of domestic or international carbon offset units?
Environmental effectiveness	EE1	Surety of emission reductions	Will the emissions reductions actually occur?
	EE2	Additionality of abatement	Would the emissions reductions incentivised by the policy, have occurred in the absence of the policy?

	EE3	Scalability of policy outcomes	Can the policy be adjusted to meet a change in emission reduction targets? Are there limits to the maximum emission reductions achievable under the policy?
Efficacy of implementation	EI1	Scalability of policy implementation	Can the policy be implemented across the NEM while allowing for different regional targets?
	EI2	Synergy with risk management tools	Does the policy distort or support financial markets?
	EI3	Support of reliability objectives	Does the policy distort or support existing mechanisms that aim to incentivise enough generation to meet demand?
	EI4	Equity impacts	Does the policy affect all stakeholders equally or does it target one specific group?

The assessment framework in Table 3 has been used to perform an indicative desktop evaluation of the merits of eight key policies that have been utilised or suggested by policy makers in Australia. Each policy was assessed as if it were the primary emission reduction policy for the electricity sector (noting that there may be value in a subsidiary role for certain policies despite ranking lower than the primary policy). Each policy was rated on a 'yes – neutral – no' scale for each criterion, based on whether the policy is thought to largely meet the criterion or not. The relative value of each criterion has not been assessed or weighted, and thus care must be taken when interpreting the results. The authors opted not to weight these criteria, as any weighting would be subjective based on the specific policy design, policy goals and operating environment at the time of the assessment.

The key policies assessed are: an emissions trading scheme (ETS)[11]; a carbon tax[12]; an emissions intensity scheme[13]; a baseline and credit scheme[14]; a monopsony government auction for abatement (ERF)[15]; a certificate based renewables production subsidy (CET/RET)[16]; a contract for difference framework for new technologies[17]; and a coal plant closure mechanism[18].

Our results, presented in Table 4, indicate that a tax or trading scheme would be the most efficient, environmentally effective and efficacious policy to implement. Specifically, an emissions trading scheme or emissions intensity scheme (such as the most recent National Energy Guarantee) is deemed to achieve almost all of the policy objectives. At the other end of the spectrum, technology specific policies score poorly in relation to cost effectiveness and efficacy of implementation, as well as environmental effectiveness.

A trading scheme would facilitate a restoration of the link between financial incentives in the electricity market and the physical needs of the system (criterion EI2 in the assessment framework presented in Table 3). By pricing the externality of greenhouse emissions, there is a signal for efficient entry *and* exit of electricity generation. The relative economic merits of different electricity generation technologies would be priced through energy *and* greenhouse externality markets. This would provide for a more stable and orderly substitution of the capital stock, through the development of integrated forward energy and carbon markets, and ensure that greenhouse emission reductions occur where they are most cost effective and efficient within the electricity system. Financial contracts would be able to reflect the value of energy to the system and the greenhouse abatement achieved (or not).

[11] The Commonwealth Government's Clean Energy Future package adopted in 2012 was designed to transition to an emissions trading scheme before being repealed in 2014.
[12] The Clean Energy Future package commenced with an initial carbon tax of $23 per tonne.
[13] The proposed National Energy Guarantee was designed to operate as an emissions intensity scheme.
[14] The New South Wales Greenhouse Gas Abatement Scheme (GGAS), introduced in 2003 and repealed when the Clean Energy Future package was adopted, was a baseline and credit scheme.
[15] The Emissions Reduction Fund (ERF) is a key component of the current 'Direct Action' framework.
[16] Both the SRES and LRET are certificate based production subsidies.
[17] The Queensland, Victorian and ACT governments have all implemented contract for difference (CFD) policies to incentivise new renewables.
[18] Nelson et al (2015) and Jotzo and Masouz (2015) both proposed policy frameworks for the staged exit of coal plants.

Table 4: Results of application of assessment framework on key policies

Policy		Cost effectiveness - lowest cost abatement						Environmental effectiveness			Effi
		CE1	CE2	CE3	CE4	CE5	CE6	EE1	EE2	EE3	EI1
Tax and trading schemes	ETS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	EIS	Yes	Yes	Yes	Yes	Neutral	Neutral	Neutral	Yes	Yes	Yes
	Carbon tax	Yes	Yes	Yes	Yes	Yes	Neutral	Neutral	Yes	Yes	No
	Baseline and credit	Yes	Neutral	Yes	Yes	Neutral	Yes	Neutral	No	Neutral	Neutral
Subsidy schemes	ERF	Yes	Yes	Neutral	Yes	Neutral	No	No	No	No	Yes
	RET/ CET	Yes	No	Neutral	No	No	No	No	Neutral	Neutral	Yes
	CFD	Yes	No	Yes	No	No	No	No	Neutral	Neutral	Yes
Direct regulation	Coal closure	No	Yes	No	No	Yes	No	Neutral	Neutral	Neutral	Yes

5. Concluding remarks

This article has considered the various options for introducing a stable, long-term climate change policy that integrates efficiently with electricity policy objectives. Australia has struggled to properly integrate an emissions framework within the east-coast Australian NEM. Over the preceding two decades, this has led to a proliferation of second-best policy options. In particular, the use of production subsidies for renewable energy has resulted in three perverse outcomes: a more disorderly transition with no explicit financial signal to existing generators to exit; the variable production nature of the capacity being added results in an inability to provide traditional risk management contracts, thereby breaking the link between the physical needs of the system and financial outcomes; and the use of production subsidies for coincident renewables is unsustainable financially in the absence of new technologies such as storage. The evolution of financial hedging arrangements that overcomes these issues within the NEM would be worthy of future research.

By applying a broad policy assessment framework, we are able to establish that an emissions trading or emissions intensity scheme (such as the National Energy Guarantee) aimed at achieving an independently set carbon budget (linked to Australia's long-term international emission reduction commitments) is the most efficient policy response. Importantly, such a mechanism could be developed nationally with specific targets for abatement set by the national government as a default, but with the option for individual states to choose to set more ambitious goals. This would facilitate the objectives of individual states such as Victoria and Queensland that have more stringent emissions reduction targets to meet.

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Appendix 1: Assessment framework for climate change policy

As noted in section 4, there are several possible frameworks that could be used to assess a climate change policy in the energy sector. In this paper, three broad categories of criteria were chosen, namely, cost effectiveness, environmental effectiveness and efficacy of implementation. This Appendix explores these criteria in greater detail. The relative weighting of these categories or specific criteria can be relatively subjective and dependent on the specific program design details and on the objectives to be achieved, and hence weighting is not explored.

A.1 Cost effectiveness

The cost effectiveness of the policy should be measured relative to a 'no action' scenario, which would illustrate the practical differences for implementing the policy. Any climate change policy that is implemented in the energy sector will have both direct and indirect impacts on total economic welfare. Indirect costs refer to the second order costs resulting from the introduction of any policy on the broader economy. For example, an indirect cost of a policy could include interactions with the tax system. Taxes can have a dampening effect on the level of activity across the economy. Therefore, in a scenario where revenue generated from an emissions trading scheme were to be directed into reducing distortionary taxes, it could improve levels of economic activity.

For the purposes of this article, the assessment framework will focus only on the different ways to reduce direct costs, relative to a 'no-action' scenario. Examples of direct costs would include:

- capital expenditure for any new generation, storage and network infrastructure installed as a result of the policy;
- the change in operational expenditure and fuel costs, relative to the reference scenario;
- any direct costs from emitting greenhouse gases (e.g., cost of emission permits under a cap and trade scheme);
- any costs associated with early retirement, write-downs and plant rehabilitation, relative to when they would have occurred under a reference scenario; and
- any costs associated with reduced demand that occur as a direct result of the policy relative to the reference case.

We have identified six main options for reducing emissions in the electricity sector, of which five are directly linked to changing behaviour of participants in the sector. These are outlined below. A policy that can better access the lowest cost abatement from each of these six avenues of emissions reduction would, by definition, be the policy that achieves emissions reductions at lowest cost, assuming administration and implementation costs are relatively similar between each policy type.[19] The five mechanisms directly linked to changing the behaviour of participants in the sector are shown stylistically in Figure 6.

Incentivise new low-emission capacity (CE1)

A policy that directly incentivises the build of new low emission capacity will increase the likelihood of that generation being dispatched, notionally displacing higher emission generation. For example, as shown in Figure 6, a renewable support scheme or tax subsidy would incentivise new renewable build, which would in turn displace higher marginal cost, higher emission generation in the merit order.

[19] This is not to say that a policy that can access all six means of achieving emissions reductions will necessarily be the lowest cost policy when implemented. However, if a policy can access more low-cost abatement opportunities on a marginal abatement cost curve, theoretically it could deliver cheaper outcomes overall.

Remove high emissions capacity (CE2)

A policy that removes high emission capacity would necessarily prevent that capacity from bidding into the merit order, and hence emitting greenhouse gases. As the respective emission intensity of the plant replacing the removed generation will directly influence the change in absolute emissions, this will change the quantity of absolute emission reductions achieved under the policy.

Incentivise lower emission generation (CE3)

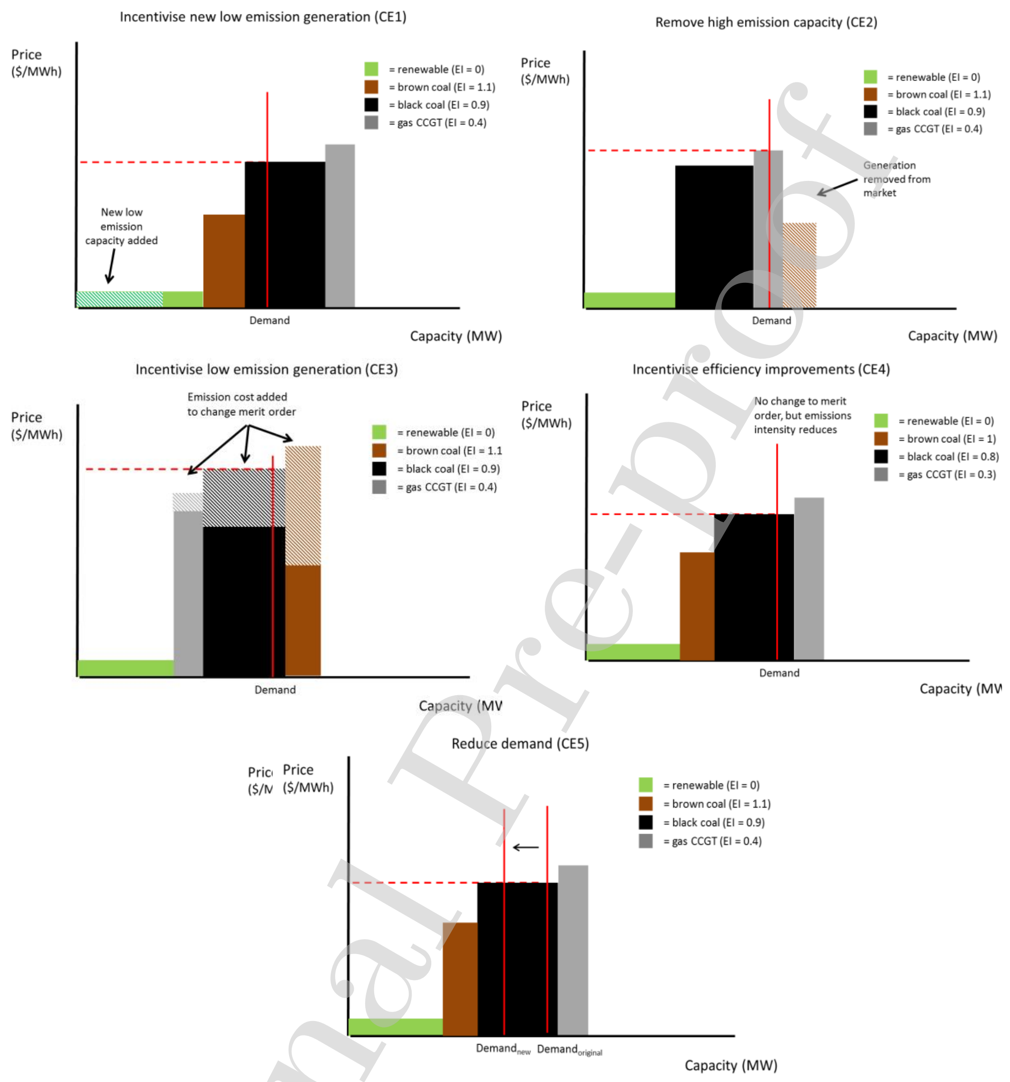
Policies that can incentivise generation from lower emission existing or new plant would also reduce overall emissions from the sector. For example, a policy that adds a carbon cost to emissions from generation could result in a shift in the merit order to favour the lower emission generation. In this instance, even if the carbon cost is not significant enough to affect the merit order and shift behaviours, it would still alter the underlying economics of a high emission plant, potentially leading to an earlier retirement than otherwise expected.[20]

Incentivise efficiency improvements in existing plant (CE4)

Policies can incentivise existing plant to improve their energy efficiency, reducing the emissions per unit of generation from that plant. For example, a thermal generator could receive a grant to install a more efficient turbine that generates more electricity per unit of coal burned, thereby reducing the emissions intensity of that plant. As noted earlier, there is the potential of perverse outcomes from each of these methods of emission reductions. For example, the emissions intensity of a plant is generally affected by how much it generates, and if a high emission plant is disincentivised from generating it could increase the emissions intensity of that plant.

[20] A point of distinction between CE1 and CE3 relates to generation from variable renewable energy sources. A policy that completely shields a renewable generator from the wholesale electricity price and does not rely on generation certificates may not result in the renewable generator actually being dispatched.

Figure A.1: Stylistic representation of methods to reduce emissions and effects on merit order



Reduce electricity demand (CE5)

Any reduction in demand for electricity should reduce absolute emissions for the sector. For example, energy efficiency schemes, which reduce demand for electricity whilst generally not affecting consumer behaviour will reduce energy consumption and maintain utility of consumers. Alternatively, the reduction in demand could arise from the closure of an electricity intensive manufacturing plant, which would affect overall demand and absolute emissions. A reduction in demand may also have a welfare cost associated with it, and this would need to be accounted for in assessing the overall cost of the policy.

Fungibility with other carbon units (CE6)

A policy that allows purchasing abatement from other sectors would enable access to lower cost abatement from outside the Australian electricity sector, reducing the overall cost of implementing the policy. Such a policy requires careful consideration as it could simply delay structural changes in the Australian electricity sector. This could increase costs in the long-term.

A.2 Environmental effectiveness

Any government policy that is introduced to reduce emissions in the sector must ensure those emission reductions actually occur. We have developed three criteria to assess this goal within our assessment framework.

Surety of emission reductions (EE1)

Each emissions reduction policy will have a different level of certainty that the targeted emission reductions actually occur. Policies with a hard cap on emissions will result in greater surety of emissions reductions. Emissions policies without a hard cap could have perverse outcomes if markets develop in an unexpected way, ultimately defeating the premise of implementing the policy.

Additionality of abatement (EE2)

Additionality is a term that refers to the likelihood that abatement that is incentivised/rewarded under the policy, would not have occurred in the absence of the policy being implemented. For example, a policy that offers a subsidy for a generator to replace a turbine with a more efficient (and hence lower emission intensity) turbine would be seen as non-additional if the turbine was due to be replaced anyway.

Scalability of policy outcomes (EE3)

There are two elements of this criteria:

- Firstly, the ease by which the policy can adjust to meet a change in emission reduction targets. For example, if the policy is calibrated to achieve a specific emission reduction goal, and the emission reduction goal shifts - up or down - how easily can the policy be recalibrated to meet that new emission reduction target.

- Secondly, consideration of the limits to the emissions reductions feasibly achievable under the policy.

A.3 Efficacy of implementation

While an emissions policy may be both low cost and environmentally effective, there are several implementation considerations that will affect the overall success of the policy.

Scalability of policy implementation (EI1)

The ability for a policy to be implemented within the context of the NEM's governance structure – the Council of Australian Governments Energy Council, comprised of energy ministers from the Commonwealth and each state and territory government – while allowing for the different levels of ambition of those governments will be key to the success of the policy. Constitutional limitations need to be recognised, for example that the Commonwealth Government has the right to legislate with respect to 'external affairs', including to implement international agreements such as those made through the UNFCCC, and thus has responsibility for a national emission reduction target.[21] The energy sector, however, is a state responsibility, and all state and territory governments, together with the Commonwealth Government, are involved in the governance of the NEM under the Australian Energy Market Agreement. The jurisdictions have expressed a range of preferences for emission reduction targets and measures, and the ability to accommodate different targets within a NEM-wide policy will be important.

Trading schemes such as an ETS could be implemented within the governance framework of the NEM while allowing for different targets to be set in different jurisdictions, provided that the target set by the Commonwealth Government is the floor (i.e. no state targets are lower than the Commonwealth one). This would ensure the national target can be met while providing state/territory flexibility.[22]

Synergy with risk management tools (EI2)

As noted earlier, the physical electricity market operates alongside a secondary financial market which allows participants to manage their risk appropriately. It is important that the policy facilitates (or at least does not distort) alignment of financial incentives with the physical needs of the electricity system.

Support of reliability objectives (EI3)

In a well-functioning electricity market there is enough physical generation to meet demand. An emission policy should not compromise electricity market reliability objectives. For example, a policy that improves the efficiency of plant may reduce any unexpected outages and hence improve the reliability of supply. Alternatively, if a policy solely promotes the removal of dispatchable generation, it may compromise reliability objectives.

Equity impacts (EI4)

Any policy that is implemented will affect specific workers, owners of capital and communities in different ways. Policies that facilitate some degree of redistribution to allow for equity impacts on these stakeholders will be preferable to those that do not.

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[21] Section 51(xxix) of the Constitution of Australia.

[22] However, there remains a risk (as with any emission reduction mechanism) that Commonwealth legislation would override state/territory legislation to the extent of any inconsistency, or could evince an intention to cover the field so as to exclude the operation of state/territory legislation.