

When a climate crisis meets an energy crisis — lessons from the Australian National Electricity Market

Dylan McConnell ^{*1,2} and Iain MacGill^{1,3}

¹Collaboration on Energy and Environmental Markets, UNSW Sydney

²School of Photovoltaic and Renewable Energy, UNSW Sydney

³School of Electrical Engineering and Telecommunications, UNSW Sydney

May 2023

This is a post-print of an article published in the May 2023 issue of the Oxford Energy Forum's quarterly energy journal, published by the Oxford Institute for Energy Studies. The issue was titled "Electricity market design during the energy transition and the energy crisis", and the preferred citation is:

Dylan McConnell & Iain Macgill. (2023). "When a climate crisis meets an energy crisis—Lessons from the Australian National Electricity Market". In Rahmat Poudineh (Ed.), *Electricity market design during the energy transition and the energy crisis* (136th ed., pp. 49–55). *Oxford Institute for Energy Studies*. <https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/05/OEF-136-Electricity-market-design-during-the-energy-trasition.pdf>

1 Introduction

Australia is one of the world's largest coal and liquefied natural gas (LNG) exporters, and has a power system dominated by fossil fuels. It was also an early and enthusiastic adopter of electricity market restructuring. While it remains one of the world's most emissions-intensive electricity sectors, the Australian National Electricity Market (NEM) has also seen some of the world's highest growth in wind and solar generation.

In June 2022, the NEM was subject to an unprecedented market suspension that lasted nine days. This occurred against a backdrop of extremely high electricity prices, a largely uncoordinated energy transition, and long-running discussions on significantly reforming the structure of the market itself. This paper briefly outlines the experience of the NEM during the unfolding energy transition and the energy crisis, with a view to illuminating useful lessons and insights into the more general questions of market design and energy transition facing electricity industries around the world.

2 The Australian National Electricity Market

The NEM is the power system that connects the eastern states of Australia. It delivers power to approximately 10 million customers, and supplies approximately 80 per cent of Australia's electricity consumption^[1], across one of the longest grids in the world. Each year roughly 200 TWh of energy is generated across the NEM, predominately from approximately 300 large centralized generation facilities. Peak demand is around 35 GW, and the installed capacity (including distributed rooftop solar generation) is approximately 70 GW.

As of calendar year 2022, coal generation still dominated the energy mix, contributing 58 per cent of supply^[2]. However an impressive expansion of wind and solar has seen renewable energy providing an ever-increasing contribution. Renewable generation contributed 35 per cent over 2022, and almost 43 per cent in Q4 of 2022^[2, 3].

Prior to the 1990s, the electricity sector was owned and operated by vertically integrated state-based utility commissions, which were established by acts of state governments. As in some other parts of the world, Australia began restructuring the electricity sector in the 1990s, motivated by the efficiency and productivity

*Corresponding author: dylan.mcconnell@unsw.edu.au

gains promised by the introduction of competition¹. An intricate national framework for energy markets was established, which emerged from a need to unify disparate state approaches and responsibilities[5].

These reforms centred on the introduction of a regional wholesale spot market, to introduce competition in the wholesale electricity sector and decentralize operational and investment decisions—ideally to private firms, or failing that, to competitively driven state-owned corporations. A competitive wholesale spot market is still central to the current design of the NEM. The market is an energy-only gross pool market, with all electricity supply offered into a central regional five-minute spot market operated by the Australian Energy Market Operator. The NEM is one of the more pure implementations of an energy-only market and the principles of marginal cost pricing. There is currently no formal or explicit capacity market, and market revenue is primarily based only on energy delivered.

In theory, of course, generation is typically offered into the market at the short-run cost of production. This results in optimal electricity pricing, both maximizing profit for the generator and simultaneously minimizing total system costs. This short-run marginal cost is generally sensitive to and dominated by fuel costs. In practice, generator offers also reflect unit commitment needs, derivative contract positions and, typically, some opportunistic high price bids for additional generation near their rated capacity.

Prices also rise to extreme values during periods where reserves are scarce, as is necessary in energy-only markets. Such scarcity pricing is intended to play a key role in signalling the need for new investment in generation capacity. The high prices, or the risk of them, is critical to driving short- and longer-term derivative contracting that supports operational scheduling and investment.

In practice, questions remain about the suitability of this approach. Indeed, the debates about the resource adequacy implications of energy-market design can be traced back decades². These doubts are even greater when facing the need to rapidly drive profound increases in clean generation investment. Whether or not the NEM will (or in fact has) driven sufficient capacity to ensure resource adequacy continues to be the subject of debate in Australia[8]. While the NEM has seen considerable generation investment over its now 23 years of operation, it can be difficult to separate purely market-driven investment from the impacts of external policy-setting, including renewable energy targets, carbon pricing, and even state government ownership of some large participants.

In the NEM, wholesale prices are currently capped at AUD \$15,500/MWh. For comparison, annual volume weighted prices were typically historically AUD \$50-100/MWh. Some mechanisms exist to protect participants from prolonged extreme pricing. One such mechanism inadvertently contributed to the crisis and market suspensions, which is discussed further in the next section.

These features all contributed to the unprecedented crisis and market suspension in 2022. A system with generation and pricing still dominated by traded commodities was susceptible to international price shocks. Scarcity pricing resulting from unexpected generator unavailability and inadequate capacity contributed to extreme pricing. A key protection measure acted to exacerbate existing dynamics and worsen the situation. In isolation, the existing market design may well have persevered without significant problems. The combination proved too challenging, however, ultimately resulting in the temporary suspension of the market.

3 The makings of a crisis

3.1 The NEM pre-2022

In addition to facilitating the efficient dispatch of electricity in real time and ensuring system demands are met at lowest cost, the spot market was intended to provide price signals to market participants to drive investments. This function was questionable and debated prior to the crisis and has arguably been further eroded since. There were signs of stress in the NEM well before 2022.

An extraordinary rise in wholesale electricity prices from 2016, alongside a black system event in South Australia, sharpened political interest in and focus on the electricity sector. The system black and high electricity prices triggered multiple reviews and inquiries, most notably a review from the competition regulator and the chief scientist[9, 10]. The linking of the Australian east coast gas market to international LNG

¹For further details on the restructuring, see Haines, F., and McConnell, D. (2016), ‘*Environmental norms and electricity supply: an analysis of normative change and household solar PV in Australia*’[4]

²For example, see Cramton, P., & Stoft, S. (2006). *The Convergence of Market Designs for Adequate Generating Capacity*[6] and Cramton, P. (2017). *Electricity market design*[7]

markets through export facilities that came on line in 2016, and unexpected coal plant exits, were certainly factors[11]. A lack of flexible dispatchable generation investment to match these exits as well as growing renewable deployment were also argued to be key factors. These triggered several processes to reform the market to ensure it was fit for purpose. Most notably, these reforms included a proposal that essentially introduced a formal capacity market to the NEM.

However, frustrated governments (both state and federal) increasingly and simultaneously took matters into their own hands. In the immediate aftermath to the system black, the South Australian government significantly reinserted itself into the energy supply system, after years of their energy generation asset being fully privatised. This ultimately included direct support for a big battery energy storage system (the largest in the world at the time), and a state-owned gas peaking plant, among other actions[12]. The state government also legislated to give the state’s energy minister powers to direct the market. Shortly afterwards, the federal government announced and initiated the development of a 2 GW pumped hydro scheme (called Snowy 2.0). This was progressed via a government-owned entity (Snowy Hydro), which drew on equity from the state.

Since then, direct involvement from various governments of all persuasions has only increased, including other states passing legislation which allows them to work around and beyond the existing NEM frameworks and market structures. This includes the ambitious New South Wales (NSW) Electricity Infrastructure Act[13], which allows the NSW government to use long-term energy service agreements to underpin 12 GW of new renewable generation across three new Renewable Energy Zones. Victoria also introduced its own legislation, and its own renewable energy target (50 per cent by 2030)[14] and auctions to support that target. Through the government-owned Snowy Hydro, the previous federal government also later supported the construction of a new 750 MW gas turbine in NSW[15].

A new federal government was also elected on the promise to significantly modernize the electricity grid, through a \$20 billion ‘re-wiring the nation’ fund[16]. The details of this program are not fully finalized. However, it is expected that concessional financing will expedite the development of transmission infrastructure separately from or parallel to the existing arrangements funding transmission (and the checks and balances that entails).

In the lead-up to the market suspension, it was clear that both politicians and market institutions were not confident in the ability of the current market arrangements to deliver the necessary new investment. Processes were underway to significantly reform the market, but governments and other decision-makers had largely already made up their minds and were involving themselves more directly and purposefully in the provision of power once again.

3.2 Immediate lead up to the crisis

In early 2022, the war in Ukraine and the associated international turmoil sent both coal and gas prices to record levels, creating a global energy crisis. Australia was in no way isolated from these effects, with its domestic markets—particularly the gas market—strongly linked to international markets and pricing. Even where NEM participants have longer-term coal and gas contracts, some may have been able to reroute these towards exports rather than using locally[11].

Gas prices across the eastern seaboard states surged to over five times historical averages. This alone would have been sufficient to drive significant increases in prices in the Australian electricity market. While gas generation contributes a relatively modest share to annual electricity supply (6–9 per cent in recent years), it has a considerable impact on price setting in the market[11]. The relationship between electricity prices and gas prices can be seen in the figure 1 below.

The high gas (and coal) prices combined unfavourably with some planned and unplanned coal outages (see figure 2 below). Both NSW and Queensland had relatively high levels of planned outages at the black coal plants in 2022. Unplanned outages peaked in the period leading up to market suspension at 4.6 GW out of total installed capacity of 22 GW[17].

Combined with a relatively cold winter, these conditions and the market design drove spot and forward prices to high levels, placing some energy customers under a great deal of financial pressure. Several small electricity retailers also went into voluntary administration during this period. The impact of these wholesale prices is still flowing through to energy consumers today[18].

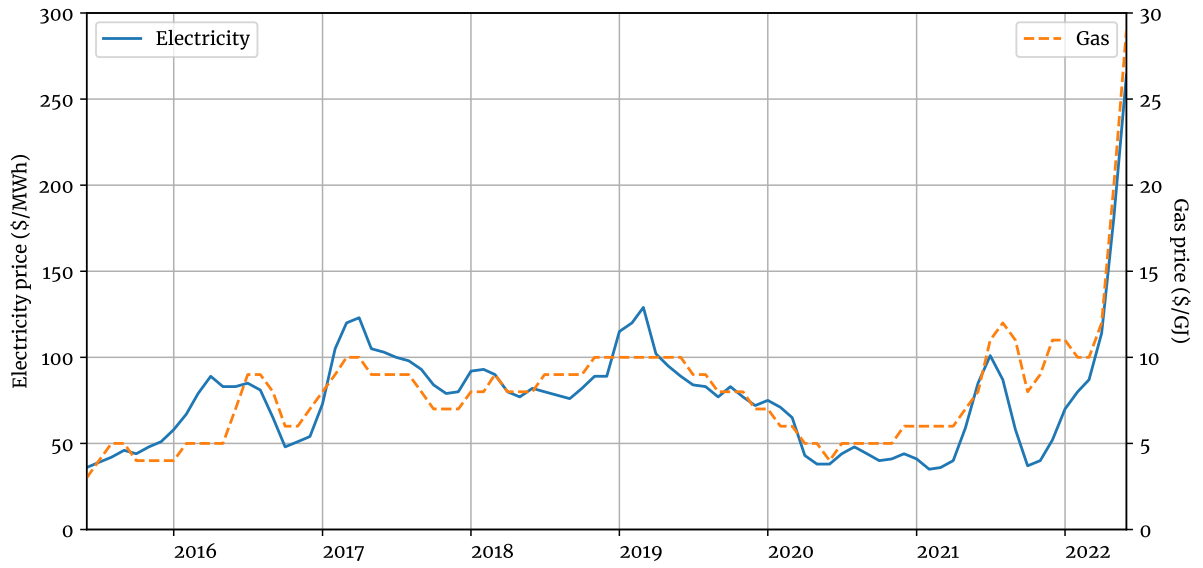


Figure 1: Gas and electricity prices across the National Electricity Prices. Prices in the electricity market increased steeply in step with increases in gas prices from April 2022 [data source: AEMO [17]]

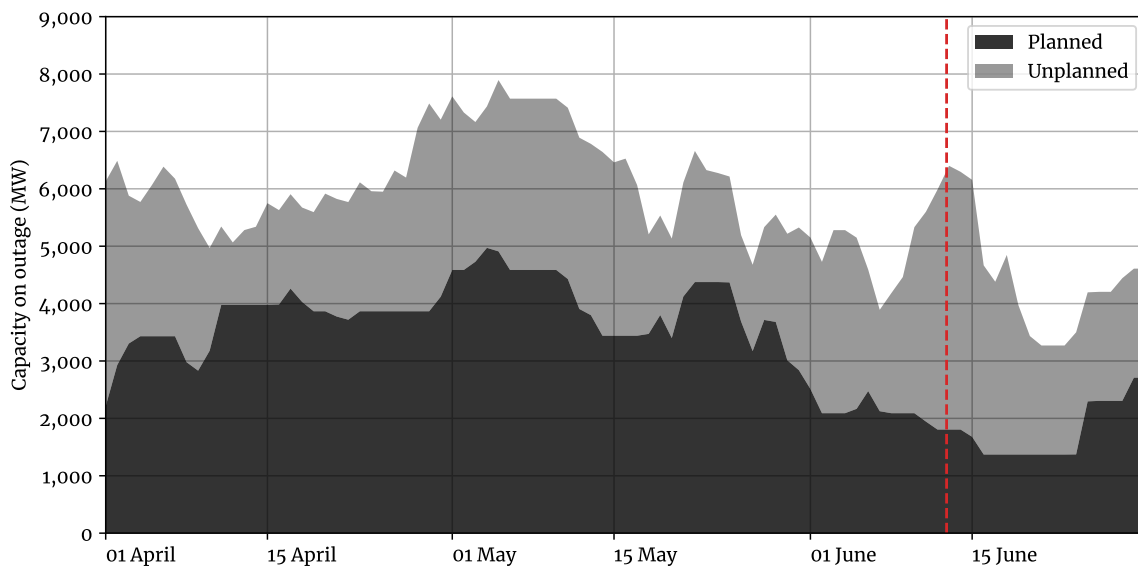


Figure 2: Planned and unplanned coal outage during the lead up to the market suspension. The dashed line indicates when the administered pricing first began [data source: AEMO [17]]

3.3 Price caps and unintended consequences

The high market price cap in energy-only markets represents a significant financial risk to market participants. Prolonged periods of pricing at the market price cap would generate windfall profits for some generators, well above the appropriate recovery of fixed costs, while bankrupting retailers or other large energy consumers.

To limit this risk, policymakers had decided early in the NEM design process to place a cap on market revenues equivalent to 7.5 hours of pricing at the market price cap during extreme periods[19]. This protection is implemented via the ‘cumulative price’, which is calculated as the rolling sum of prices over a period of a week. Once this sum exceeds a threshold (equivalent to the market price cap applied for 7.5 hours), administered pricing is applied. Administered pricing was set at \$300/MWh. This level was considered sufficient to allow all generators to at least recover their short-run marginal costs.

These arrangements were deemed to allow sufficient incentives and signals for financing new capacity while protecting consumers and other participants from onerous risks and costs. Significant recovery of fixed cost could occur at 7.5 hours at the market price cap (currently \$15,500/MWh), and beyond that short run costs could still be recovered, and generators would still have incentives to generate.

These market settings were initially established over two decades previously and were ill-equipped for the conditions that materialized in June 2022. The high marginal cost of generation due to the coal and gas price rally had significant impacts on this arrangement. Firstly, the high underlying marginal cost meant that the cumulative price was already a high level, even without scarcity pricing. Phrased alternatively, significantly less than the 7.5 hours of pricing at the market price cap was required for the threshold to be hit.

Secondly, and perhaps more significantly, the administered pricing was well below the marginal cost of thermal generation at export gas and coal prices. As such, some generators were in fact not able to recover their short-run marginal cost, as was envisaged in the initial design of this scheme, or were responding to the opportunity cost related to export opportunities. The consequence is that there is a disincentive for generators to offer their capacity to the market and continue generating. As administered pricing was applied, this is exactly what happened. Generators withdrew capacity, which further exacerbated the supply shortfall and pushed prices up and to the market price cap for longer (see figure 3 below).

In order to manage the dispatch process, the Australian Energy Market Operator began to issue dispatch instructions to withdrawn generation via their directions powers[20]. There were several complications associated with this. It was unclear how much capacity was actually unavailable rather than just bid as

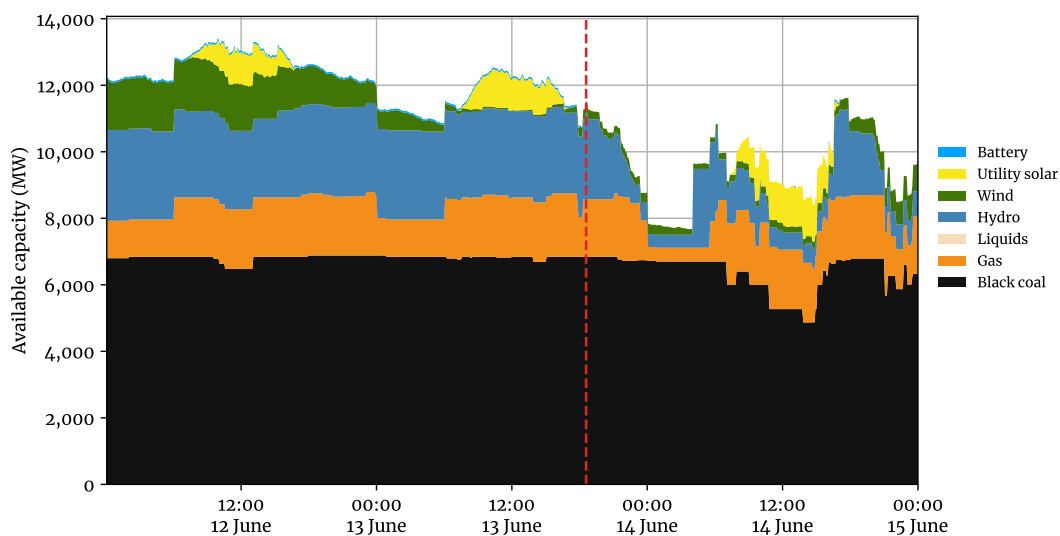


Figure 3: Availability of generation significantly declined following the imposition of an administered price cap of \$300/MWh [data source: AEMO [17]]

unavailable, and the dispatch engine was unable to find feasible solutions without violating constraints. The uncapped prices also remained at the market price cap, meaning that the cumulative price simply climbed ever higher with no prospect of it falling below the threshold.

After several days of administered pricing, the operator took the unprecedented step of suspending the entire market. The market-based dispatch process was essentially replaced with manual central decision-making by the market operator. The suspension was lifted nine days later, a point after which the cumulative price fell below the threshold, and the scheduling function of the market could resume, albeit at still high prices by historical standards.

4 Discussion and conclusions

The penultimate cause of the June 2022 market suspensions was arguably the presence of dated market settings that were not suitable for the conditions that materialized. The Australian NEM is hardly alone in this regard, given the electricity market turmoil seen elsewhere in the world. However it is the case that at least one of the conditions that materialized, namely insufficient supply, is very likely reflective of longer-term underlying challenges. It's clear that prior to the suspension, governments and other decision-makers had doubts about the ability of the market to deliver sufficient investment and were already moving beyond the existing NEM frameworks and market structures. Indeed, the more than 33 GW renewable capacity added to the NEM over the past 15 years—which has been the vast majority of new capacity—has largely been underwritten by ‘out of electricity market’ policy drivers[21].

Since the market suspension and wider energy price crisis, we have seen further moves away from a laissez-faire market approach. The federal government (with support from the states) moved to cap the domestic price of both gas and coal late in 2022, illustrating the political intractability of high domestic prices, particularly while coal and gas exporters reap record profits.

The political difficulty of potentially high and volatile energy prices—essential for a functional and complete energy-only market—does not sit well with the significant investment that the energy transition demands.

State-based policy initiatives have also continued to develop. The Victorian government was re-elected in late 2022 with a commitment to re-introduce the State Electricity Commission of Victoria (or at least a new state-owner participant in the Victorian region of the electricity market), alongside significant commitments to support an offshore wind industry. The Queensland government recently announced a new \$62 billion jobs and energy plan that would see the state reach 80 per cent renewable energy by 2035, which would remain majority owned by the people of Queensland[22]. A newly elected NSW government has just committed to a new state-owned entity, the Energy Security Corporation of NSW, and the potential re-nationalization of a coal plant has not been ruled out[23].

Meanwhile, the results of processes to formally reform the market and institutions have been lacklustre. After almost five years of development and consultations led by the Energy Security Board (formed specifically to address perceived gaps in governance after the South Australian blackout), the plan to introduce a formal capacity mechanism has been terminated. This has been replaced by a yet-to-be-designed mechanism that would see the federal government underwrite new capacity, potentially through reverse auctions. In its annual report, the Energy Security Board has acknowledged that recent events have set back the development of open and competitive markets [24].

Implicitly, these developments reflect a loss of faith in, if not outright rejection of, the energy market design. Irrespective of the theoretical appeal of the design, and the potential risks of moving away from this approach, Australian governments and decision-makers have seemingly made up their minds. The increasing role of out-of-market government action, or even risk of action, in turn undermines truly market-driven responses. Such developments need to be better acknowledged by Australia's energy rule-makers and regulators, and reflected in its institutional and governance arrangements, to ensure that the Australian energy transition is not delayed or even derailed over the coming decade and beyond.

References

- [1] AER. State of the energy market 2022. Technical report, Australian Energy Regulator, Melbourne, Australia, September 2022. URL <https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2022>.
- [2] openNEM. openNEM - An open platform for National Electricity Market data, March 2023. URL <https://opennem.org.au>.
- [3] AEMO. Quarterly Energy Dynamics Q4 2022. Technical report, Australian Energy Market Operator, Melbourne, Australia, January 2023. URL <https://aemo.com.au/-/media/files/major-publications/qed/2022/qed-q4-2022.pdf>.
- [4] Fiona Haines and Dylan McConnell. Environmental norms and electricity supply: an analysis of normative change and household solar PV in Australia. *Environmental Sociology*, pages 1–11, May 2016. ISSN 2325-1042. doi: 10.1080/23251042.2016.1155690. URL <http://www.tandfonline.com/doi/full/10.1080/23251042.2016.1155690>.
- [5] Anne Kallies. The Australian Energy Transition as a Federalism Challenge: (Un)cooperative Energy Federalism? *Transnational Environmental Law*, 10(2):211–235, July 2021. ISSN 2047-1025, 2047-1033. doi: 10.1017/S204710252000045X. URL https://www.cambridge.org/core/product/identifier/S204710252000045X/type/journal_article.
- [6] Peter Cramton and Steven Stoft. The Convergence of Market Designs for Adequate Generating Capacity. White Paper for the Electricity Oversight Board. *Center for Energy and Environmental Policy Research, MIT, Cambridge, MA*, 2006. URL <http://hdl.handle.net/1903/7056>.
- [7] Peter Cramton. Electricity market design. *Oxford Review of Economic Policy*, 33(4):589–612, November 2017. ISSN 0266-903X, 1460-2121. doi: 10.1093/oxrep/grx041. URL <http://academic.oup.com/oxrep/article/33/4/589/4587939>.
- [8] ESB. Capacity Mechanism High-level Discussion Paper. Technical report, Energy Security Board, June 2022. URL <https://www.energy.gov.au/sites/default/files/2022-06/Capacity%20mechanism%20high-level%20design%20consultation%20paper.pdf>.
- [9] ACCC. *Retail Electricity Pricing Inquiry - Final Report*. Number 06/18-1361. Australian Competition and Consumer Commission, Canberra, ACT, June 2018. ISBN 978 1 920702 34 2.
- [10] Alan Finkel. Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future. Technical report, Commonwealth of Australia, June 2017. URL <http://www.environment.gov.au/energy/publications/electricity-market-final-report>.
- [11] Dylan McConnell and Mike Sandiford. Impacts of LNG Export and Market Power on Australian Electricity Market Dynamics, 2016–2019. *Current Sustainable/Renewable Energy Reports*, November 2020. ISSN 2196-3010. doi: 10.1007/s40518-020-00164-2. URL <http://link.springer.com/10.1007/s40518-020-00164-2>.
- [12] Government of South Australia. Our Energy Plan South Australian power for South Australians, March 2017. URL <http://ourenergyplan.sa.gov.au/>.
- [13] NSW Legislative Council. Electricity Infrastructure Investment Act 2020, December 2020. URL <https://legislation.nsw.gov.au/view/html/inforce/current/act-2020-044>.
- [14] Victorian Government. Victorian renewable energy and storage targets, February 2023. URL <https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets>.
- [15] Australian Government. New gas power plant for Hunter Valley, May 2021. URL <https://www.energy.gov.au/news-media/news/new-gas-power-plant-hunter-valley>.
- [16] Parliamentary Budget Office. Powering Australia - Rewiring the Nation - Australian Labor Party, 2022. URL <https://www.aph.gov.au/-/media/OE6625101815437D8D883CB3DC6C515F.ashx>.
- [17] AEMO. Quarterly Energy Dynamics Q2 2022. Technical report, Australian Energy Market Operator, Melbourne, Australia, July 2022. URL <https://aemo.com.au/-/media/files/major-publications/qed/2022/qed-q2-2022.pdf>.

- [18] AER. Draft determination - Default market offer prices 2023-24. Technical report, Australian Energy Regulator, March 2023. URL https://www.aer.gov.au/system/files/AER%20-%20Draft%20determination%20-%20Default%20market%20offer%20prices%202023-24%20-%2015%20March%202023_1.pdf.
- [19] ACCC. Applications for Authorisation: VoLL, Capacity Mechanisms and Price Floor. Technical report, Australian Competition and Consumer Commission, December 2000. URL <https://www.accc.gov.au/system/files/public-registers/documents/D03%2B38328.pdf>.
- [20] AEMO. NEM market suspension and operational challenges in June 2022. Technical report, Australian Energy Market Operator, Melbourne, Australia, August 2022. URL https://www.aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/market_event_reports/2022/nem-market-suspension-and-operational-challenges-in-june-2022.pdf.
- [21] Tim Nelson, Tahlia Nolan, and Joel Gilmore. What's next for the Renewable Energy Target – resolving Australia's integration of energy and climate change policy?*. *Australian Journal of Agricultural and Resource Economics*, 66(1):136–163, January 2022. ISSN 1364-985X, 1467-8489. doi: 10.1111/1467-8489.12457. URL <https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12457>.
- [22] Queensland Government. Queensland energy and jobs plan. Technical report, September 2022. URL https://www.epw.qld.gov.au/__data/assets/pdf_file/0031/32989/queensland-energy-and-jobs-plan-overview.pdf.
- [23] Samantha Hutchinson. NSW Labor floats buying back Eraring power station, March 2023. URL <https://www.afr.com/politics/nsw-labor-floats-buying-back-eraring-power-station-20230306-p5cpt>. Section: politics.
- [24] ESB. Health of the National Electricity Market 2022. Technical report, Energy Security Board, September 2022. URL <https://esb-post2025-market-design.aemc.gov.au/health-of-the-nem>.