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Implications of Australia's State Renewable Energy Targets for NEM's Future

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Abstract: *The document explores the impact of Australia's state-level renewable energy targets on the future of the National Electricity Market (NEM). It examines the renewable energy strategies of five major Australian states—New South Wales, Victoria, South Australia, Queensland, and Tasmania—highlighting their goals, progress, and challenges in transitioning to cleaner energy sources. The study analyses how these targets will influence NEM's capacity, the proportion of renewable energy, and electricity prices. It also delves into the broader implications for market dynamics, CO2 emission policies, and the reliability of the energy supply, emphasizing the interconnectedness of environmental, economic, and technological factors in achieving a sustainable energy future for Australia.*

Keywords: *National Electricity Market (NEM), Renewable energy targets, Energy transition, Electricity price impacts*

1. Introduction

The National Electricity Market (NEM) in Australia is undergoing a profound transformation driven by ambitious renewable energy targets set by various states. As the world confronts the urgency of climate change, Australian states are taking proactive measures to transition from traditional fossil fuels to cleaner and sustainable energy sources. This paper explores the renewable energy strategies and targets of five major Australian states - New South Wales, Victoria, South Australia, Queensland, and Tasmania and analyzes their potential impact on the NEM's capacity, the proportion of renewable energy, and electricity prices.

The pursuit of renewable energy targets demonstrates a commitment to both environmental preservation and economic growth. Each state is uniquely positioned to harness its abundant natural resources, such as wind, solar, hydro, and more, to contribute to the NEM's energy transition. These targets not only align with global climate goals but also promise substantial economic benefits and enhanced energy security.

This paper delves into the specific renewable energy goals of each state, highlighting their plans to increase renewable energy capacity, boost the proportion of renewable energy in their energy mix, and ultimately reduce greenhouse gas emissions. By examining the measures taken by state governments to encourage renewable energy adoption, including financial incentives and public awareness campaigns, this study emphasizes the collective effort required to achieve these targets.

Furthermore, the paper explores the potential impact of renewable energy integration on the NEM's wholesale electricity prices. It discusses the intricate relationship between renewable energy adoption, CO2 emission policies, and the cost dynamics of electricity generation. By analyzing historical and projected wholesale prices, the paper aims to shed light on the potential shifts in the energy market landscape.

In conclusion, this paper underscores the significance of the renewable energy targets set by Australian states in shaping the future of the National Electricity Market. It emphasizes the interconnectedness of environmental, economic, and technological factors in achieving a cleaner and more sustainable energy future. By examining the strategies and targets of individual states and their collective impact on the NEM, this study provides valuable insights into the ongoing energy transition in Australia and its potential implications for other regions facing similar challenges.

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2. Literature Review

The shift toward renewable energy is vital in addressing climate change and reducing greenhouse gas emissions. In Australia, state-level renewable energy targets play a key role, with the National Electricity Market (NEM) at the center of this transformation. Paul highlights that global climate change awareness has driven renewable energy investments [1]. Cludius discusses Australia's Renewable Energy Target (RET), which aimed for 9500 GWh of new renewable energy by 2010 and 20% of electricity from renewable sources by 2020. This policy boosted investments in renewables like biomass, hydro, solar, and wind, though it also introduced complexities in electricity pricing [2]. Cludius also points out that renewable energy can help stabilize electricity prices, which is crucial for the NEM's long-term affordability [2].

Csereklyei shows that the growth of wind and solar energy in the NEM mirrors global trends, significantly influencing price dynamics and energy policy [3]. Meanwhile, Rey-Costa's study suggests that surplus energy generation could lower production costs and stabilize prices, benefiting the NEM as states work towards renewable energy targets [4]. De Atholia highlights that the planned retirement of coal-fired plants, which make up 63% of capacity, underscores the need for new renewable generation to avoid price hikes and ensure grid stability [5].

The literature review highlights the multifaceted impact of Australian state renewable energy targets on the future of the national electricity market. As states set ambitious goals to increase the share of renewable energy, the national electricity market is poised for significant changes in capacity, pricing dynamics, economic development, and energy security. The findings highlight the need for proactive planning to ensure a smooth and successful transition to a renewable energy future in new energy markets. In summary, state renewable energy targets will reshape the NEM, affecting capacity, pricing, and energy security. Careful planning is essential to ensure a smooth transition to a renewable energy future.

3. Various state target

3.1 New South Wales

New South Wales (NSW) has been actively pursuing its Renewable Energy Development Strategy, working towards a cleaner, sustainable and cost-effective energy system. In the face of the enormous challenge of global climate change, NSW's renewable energy targets demonstrate the state's strong commitment to balancing environmental protection with economic growth. NSW was one of the first Australian jurisdictions to commit to net zero emissions by 2050, they also have an objective to reduce emissions by 70% by 2035 compared to 2005 levels, helping us ensure we track our progress to 2050 [6]. So far (2023), the total capacity of NSW is 10,614MV.

Firstly, NSW has a clear target to reduce carbon emissions over a future timeframe. The state plans for renewable energy to make up a large part of its electricity supply by 2030. This means the state will need to invest more in wind, solar and other renewable energy sources to ensure that their share of the overall energy mix grows each year. Figure 1 is a map of renewable energy plants in NSW so far, based on data provided by the Clean Energy Council.

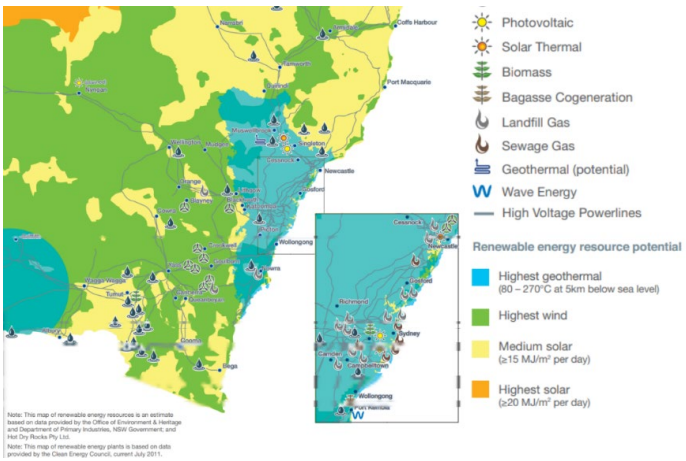

Figure 1: Map of Renewable Energy Power Plants in NSW [7]

ISSN 2522-3488 Vol. 8, Issue 5: 1-8, DOI: 10.25236/IJNDES.2024.080501

In addition, NSW is committed to expanding energy storage technologies, particularly battery storage, to stabilize renewable energy supply and improve grid efficiency. This ensures consistent power delivery, even during low wind and sunlight periods.

To support this, the NSW government has introduced financial incentives to encourage investment in renewable energy projects. These schemes aim to attract businesses and individuals by providing financial and tax benefits. However, government support alone isn't enough; public participation is essential. NSW also collaborates with other state governments, research institutions, and private companies to advance renewable energy technologies. This cooperation accelerates the development and application of new technologies, supporting the state's renewable energy goals.

In conclusion, NSW's renewable energy commitment is a community effort, reflecting a proactive approach to climate change and a shared goal of sustainable development and environmental protection.

3.2 Victoria

Victoria's coal-rich Latrobe Valley made it an energy powerhouse but also posed challenges in transitioning to renewables. Recognizing the ecological and economic implications of continued dependence on fossil fuels, Victoria initiated its transition to greener energy alternatives. By 2020, Victoria aimed to derive 25% of its electricity from renewable sources, an ambitious yet crucial benchmark. However, this was only the beginning. The state has set more aggressive targets for the years to come. By 2025, it intends to generate 40% of its electricity from renewable resources, culminating in a massive 50% by 2030, they have recently announced an intention to legislate updated targets of: 65% by 2030; 95% by 2035 [8].

This transition aims not only to reduce greenhouse gas emissions but also to boost the economy by creating jobs and providing more reliable, cost-effective power. Although wind energy started late in Australia, it benefits from the experience and technological advances in Europe [9]. Studies show that Victoria will need an additional 4,000 MW of generating capacity between 2025 and 2030, and by 2031-2040, the state will need another 18,300 MW, including storage and renewable energy integration.

In summary, Victoria's strategy combines compliance and ambition, relying on innovation and diversification, especially through investments in renewable energy, to drive economic growth and technological progress.

3.3 South Australia

South Australia is at the vanguard of the global energy transition, having transformed its energy system from 1% to over 70% renewable energy in just over 16 years. South Australia's objective is both commendable and ambitious: South Australia's aspiration is to achieve 100% net renewables by 2030 [10]. The strides made in this direction are evident in the wind farms dotting its landscape and the increasing number of households turning to solar panels.

One of the main driving forces behind South Australia's initiative is its geography. With vast expanses of land and abundant sunlight, the state is naturally predisposed to generate solar energy. Rooftop PV is a big part of South Australia's identity. More than 32% of South Australian dwellings now have rooftop PV systems installed, the second highest level of penetration in Australia [11]. The consistent coastal winds further bolster its potential for wind energy generation. Given these natural advantages and the ongoing global shift towards sustainable energy. There were 16 wind farms operating across the state with an installed capacity of 1,473MV of power in 2014 [12]. South Australia's goal, though ambitious, seems within reach.

However, transitioning to renewable energy is not without its challenges. The intermittent nature of solar and wind energy necessitates efficient storage solutions. Both Victoria and South Australia have to invest in infrastructure, like battery storage systems, to ensure uninterrupted power supply.

3.4 Queensland

With some of the world's best solar and wind resources, Australia is a prime market for solar and wind energy [13]. And Queensland is a major Australian state whose rich natural resources and geographic location provide favorable conditions for renewable energy. The Queensland Government has developed a range of renewable energy targets and strategies to address global climate change and ensure the sustainability of energy supplies.

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The Queensland renewable energy target (QRET) requires that 50% of Queensland's electricity consumption is sourced from renewables by 2030 [14]. Queensland is rapidly advancing towards its goal of 50% renewable energy. Currently, there are moments when the state's renewable production surpasses half of its energy consumption. Nonetheless, the availability and dispatchability of resources, be it renewable or non-renewable, can fluctuate. Queensland is accelerating towards its renewable energy targets and now boasts 52 large-scale renewable energy projects (operating, under construction or financially committed) [15].

The Queensland Energy and Jobs Plan outlines how the Queensland Government will achieve our renewable energy targets and ensure a sustainable and affordable energy future for Queenslanders:50% renewable energy target by 2030,70% renewable energy target by 2032, 80% renewable energy target by 2035 [17]. The total capacity of renewable energy in Queensland is currently 4,840MV and is expected to reach 7,500MV in 10 years.

In summary, Queensland's commitment to renewable energy is not only about environmental protection, but also about economic development and energy security. As technology advances and the economy grows, Queensland is expected to become a reference for renewable energy in other Australian states, providing experience and a model for other states and territories.

3.5 Tasmanian

Tasmanian have already met their 2022 target of 100 per cent self-sufficiency in renewable electricity generation, making us one of only a handful of places around the world to have achieved this [18]. And they want to double renewable energy production by 2024. Tasmania currently has approximately 25,000 GWh of potential renewable energy projects seeking approval and scheduled to begin operations by 2030 [19].

Tasmania's renewable energy industry is rapidly developing, with key projects like Project Marinus and Battery of the Nation advancing, and increased wind farm investments. The Tasmanian Government has launched various renewable energy programs to enhance resource use, combat climate change, and ensure long-term energy security. Hydropower plays a central role, with plans to expand its capacity, leveraging Tasmania's abundant rivers and lakes. Wind energy is also growing, particularly in the north and west, with more wind farms planned. While solar energy is less abundant, rooftop solar installations are helping supplement power generation.

Overall, Tasmania's efforts showcase its commitment to sustainability, contributing to both national energy security and global climate change initiatives.

4. NEM future impact

The National Electricity Market (NEM) is currently undergoing a once-in-a-century transformation, supporting the evolution of power generation and consumption in Australia's eastern and southeastern regions. This transformation entails the replacement of traditional assets with low-cost renewable energy sources, increased adoption of energy storage and other innovative support mechanisms, as well as a reconfiguration of the power grid to facilitate bidirectional energy flow. Several coal-fired power plants have already planned their exit from the market, while offshore wind energy generation is receiving greater support, and investors are placing more emphasis on climate, environmental, social, and governance considerations [20].

As Australia's states push forward with renewable energy targets, the NEM is set to encounter a series of significant changes and challenges in the future. These renewable energy targets will have far-reaching implications for the electricity market and the entire energy system. This chapter will analyze the impact of each state on the future of the NEM from the following perspectives: capacity, the proportion of renewable energy, and electricity prices (wholesale price).

4.1 Capacity

All states in Australia have set ambitious targets to increase the capacity of renewable energy in the future, particularly from sources like wind and solar power. As new renewable energy projects are developed, the capacity for renewable energy generation is expected to grow, potentially leading to a decrease in market share for traditional energy sources such as coal and natural gas. However, the addition of new renewable energy capacity may also impact the supply-demand balance in the NEM

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market. The intermittency of renewable energy sources like wind and solar means that they cannot operate at high-capacity factors consistently [21]. Therefore, it is essential to consider effective energy storage and flexibility measures to ensure the stability and reliability of energy supply. Furthermore, the introduction of more renewable energy capacity may influence electricity prices.

State governments will formulate new energy development plans to increase the capacity of new energy technologies and consequently enhance the generation of renewable energy. As evident from the Figure 2 most states have plans to double their newly built renewable energy capacity over the past decade. Additionally, as discussed in previous chapters, states are also planning to develop these areas in the next 20 or 30 years to reach the government's target of achieving 100% renewable energy share by 2050.

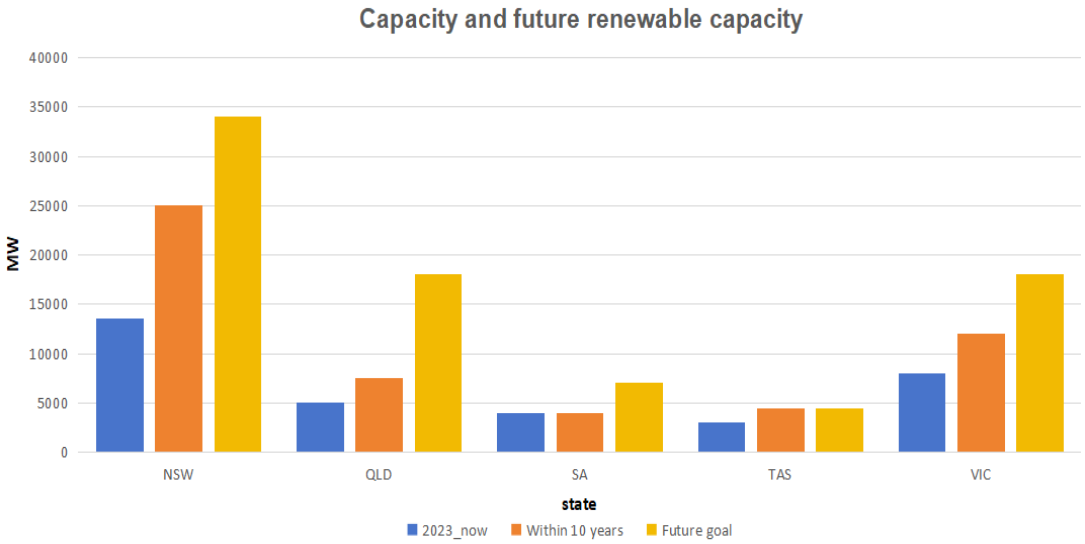

Figure 2: Capacity and future renewable capacity

4.2 Renewable shares of annual

Australia's NEM market is set to witness continued robust growth in renewable energy in the future. As global attention towards climate change and sustainable development intensifies, state governments will continue to set more stringent renewable energy targets to foster the development of additional new energy projects [22]. As detailed in Chapter 2, the policies of each state have been outlined, and Table 1 provides a summary of the current and future target percentages for renewable energy generation in recent years. These measures are aimed at accelerating the adoption of renewable energy and facilitating a sustainable and environmentally conscious energy landscape in Australia's NEM market.

Table 1: Summary of the current and future target set by various states

Date	NSW	QLD	SA	TAS	VIC	Progress change	Step change	Slow change
2017	8.5	5.5	40	86.5	16	/	/	/
2018	11	7	48.5	98.5	18	/	/	/
2019	13	12	53	96.5	21	/	/	/
2020	16.5	16	58	100.5	25	/	/	/
2021	21	18.5	61	98	32	/	/	/
2022	26	21	66	97.5	37	/	/	/
2023	29	25	69	95	40	40	40	40
2030	50	50	100	150	65	65	80	70
2035	70	80	100	200	95	80	90	75

The data presented in the graph for each state's renewable energy shares from 2017 to 2022 (to date) is sourced from OpenNEM. The renewable energy technologies considered include solar, wind, hydro,

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and bioenergy. The data is processed by calculating the annual proportion sum and averaging it based on monthly data for each year. The projections for the years 2023, 2030, and 2035 are based on the targets outlined in Chapter 2 for each state.

According to the NEM 2022 report [20], three curve analyses have been proposed: Step Change, Progressive Change, and Slow Change. These curves represent different scenarios and the pace of energy transition. For each of these change scenarios, the renewable shares for the years 2023, 2030, and 2035 are extracted. The resulting data is then used to create the "Renewable Shares of Annual" graph, as shown in Figure 3, showcasing the expected renewable energy shares for each state in the years 2023, 2030, and 2035 under different change scenarios.

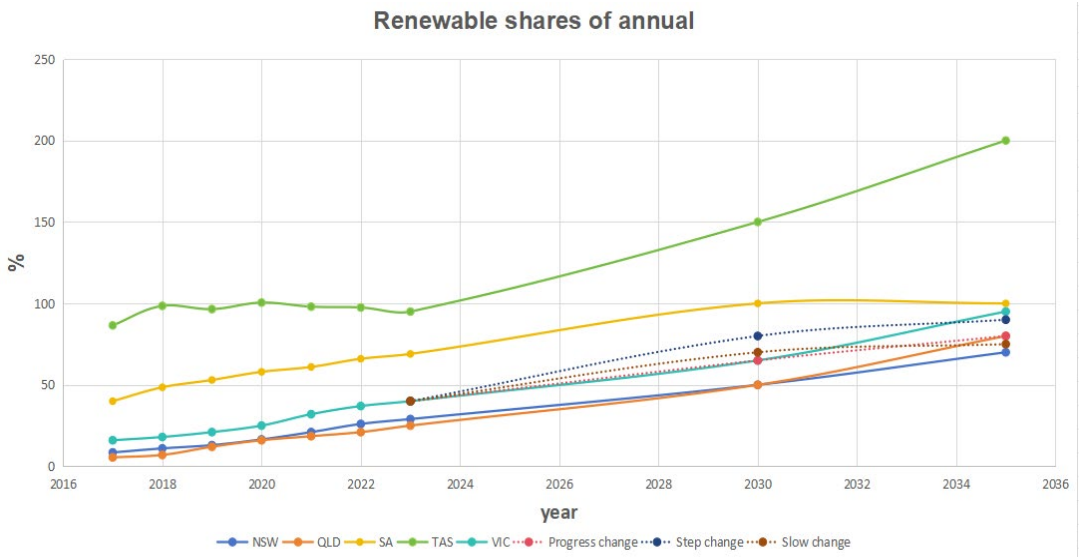

Figure 3: Renewable shares of annual

Based on the analysis from the above graph, under the future major trend of the NEM, all states are projected to achieve a renewable energy share of at least 50% by the year 2025. Furthermore, by 2035, the targets for most states are expected to be close to or reach 100%, particularly states like TAS, VIC, and SA. NSW and QLD, being the largest markets in the NEM, are projected to achieve an 80% renewable energy share. These two states, given their significant reliance on traditional energy sources, demonstrate a relatively slower increase in the proportion of renewable energy, as indicated by the 60% share of electricity generation from coal plants in NSW in 2023.

However, states with relatively lower total energy generation and less reliance on traditional energy sources, such as TAS or SA, are expected to have a higher proportion of renewable energy and experience a faster rate of increase in the future. Finally, it is anticipated that after 2035, the share of renewable energy will continue to rise steadily in all states, eventually achieving the government's target of 100% renewable energy share by 2050.

4.3 Electricity Prices

Electricity in Australia's eastern and southern regions is traded through the National Electricity Market (NEM). Power generators provide offers to sell electricity in the market, and the Australian Energy Market Operator (AEMO) dispatches power plants based on the lowest prices to meet demand. Real-time matching of electricity supply and demand is required [23]. The increasing share of renewable energy in the future may have various impacts on the wholesale prices in the electricity market, but this will depend on multiple factors.

Among these factors, one of the most crucial is the price of CO2 emissions. In line with the global trend, environmental conservation has become a primary consideration, leading to high CO2 emission prices in the future. A report by ACIL Allen Consulting in 2013 [24], analyzed the wholesale prices of electricity in different states, considering scenarios with and without CO2 policies, and made price predictions. Additionally, using data from AEMO, we obtained market prices for each year from 2017 to 2023, and combining this with research from VIC state, we formulated future price forecasts. The graph of Future Market Wholesale Price Forecast is proposed, as shown Figure 4, based on our analysis and data modeling.

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From Figure 4 comparing the solid lines (without considering CO2) to the dashed lines (considering CO2 policies) for each state from 2023 to 2035, it is evident that there is a significant difference in wholesale prices. Among the various influencing factors, we specifically analyzed the impact of considering or not considering CO2 emissions and compared it with historical annual prices for the past years to observe future trends. However, in reality, price forecasting is a highly complex task, as there are several other factors that can also influence prices.

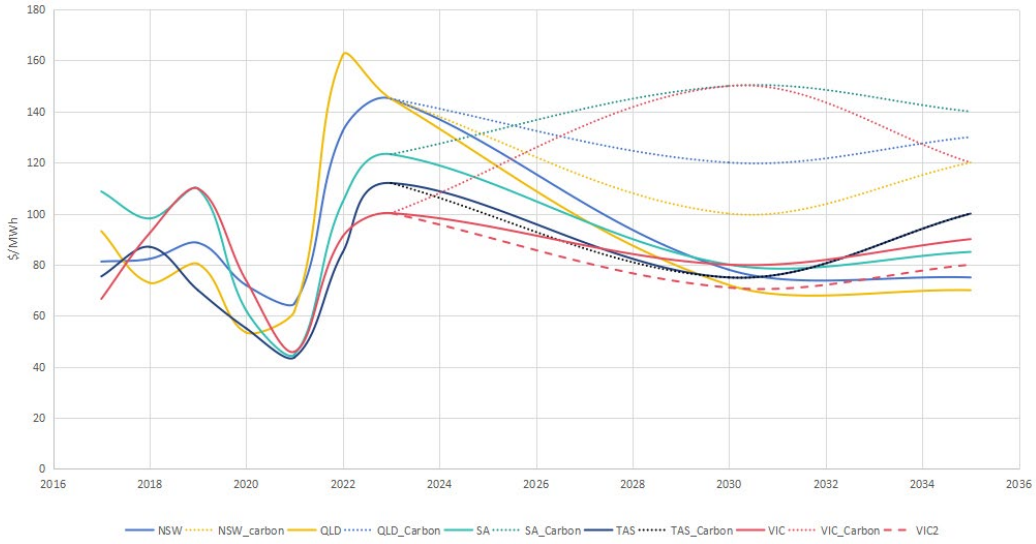

Figure 4: Future Market Wholesale Price Forecast

Moreover, during the period of large-scale replacement of traditional energy sources with new renewable energy, and the exit of coal plants from the electricity market, the analysis and patterns of pricing can become even more complex.

5. Conclusion

In conclusion, the renewable energy targets set by various Australian states will have a significant impact on the future of the National Electricity Market (NEM). Each state government is actively striving to increase the capacity of renewable energy, with a primary focus on raising the proportion of renewables in their electricity generation mix in the coming years. The federal government has set a renewable electricity target of 82 per cent by 2030 [25]. This collective effort aims to achieve the NEM's overarching goals of reaching 50% renewable energy by 2035 and ultimately achieving 100% by 2050.

As the capacity of renewable energy increases across the states, the National Electricity Market (NEM) will undergo significant changes. The growing share of renewable energy year by year will gradually replace traditional energy sources, driving market transformation. CO2 policies play a key role in shaping state government targets and wholesale prices, with future CO2 emission prices expected to remain high, thereby impacting wholesale prices. However, this energy market shift raises concerns about the reliability of power supply. As traditional coal-fired power plants close, the increased reliance on weather-dependent energy sources introduces greater volatility, posing new challenges to the power system.

In summary, the renewable energy targets set by Australian states will drive the energy market towards a cleaner future. Although achieving these goals is not easy, it is an important step toward sustainable development.

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