Office of Energy and Climate Change

NSW Electricity Infrastructure Roadmap benefits modelling report

A method for estimating the consumer benefits of the NSW Electricity Infrastructure Investment Act 2020

June 2023

The Office of Energy and Climate Change is part of the **Treasury Cluster**

NSW GOVERNMENT

Acknowledgment of Country

We acknowledge that Aboriginal and Torres Strait Islander peoples are the First Peoples and Traditional Custodians of Australia, and the oldest continuing culture in human history.

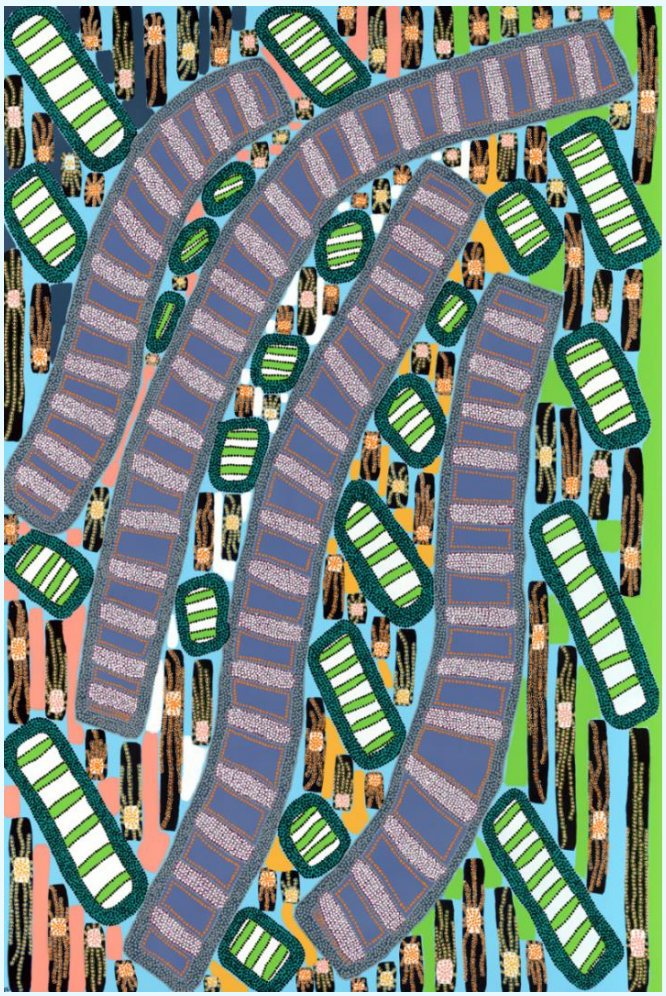
We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

We celebrate the deep and enduring connection of Aboriginal and Torres Strait Islander peoples to Country and acknowledge their continuing custodianship of the land, seas and sky.

We acknowledge the ongoing stewardship of Aboriginal and Torres Strait Islander peoples, and the important contribution they make to our communities and economies.

We reflect on the continuing impact of government policies and practices, and recognise our responsibility to work together with and for Aboriginal and Torres Strait Islander peoples, families and communities, towards improved economic, social and cultural outcomes.

Artwork:
Regeneration by Josie Rose



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Glossary

Acronym/Abbreviation	Definition
ASL	AEMO Services Limited
Aurora	Aurora Energy Research
AEMO	Australian Energy Market Operator
BtM	Behind-the-Meter
DSP	Demand Side Participation
EV	Electric Vehicle
EII Act or the Act	Electricity Infrastructure Investment Act 2020
EnergyCo	Energy Corporation of NSW
EST	Energy Security Target
GWh	Gigawatt hours
GW	Gigawatts
IIO	Infrastructure Investment Objectives
IASR	Inputs, Assumptions and Scenarios Report
ISP	Integrated System Plan
JKM	Japan/Korea Marker
LGC	Large-scale Generation Certificate
LRET	Large-scale Renewable Energy Target
LNG	Liquefied Natural Gas
LDS	Long Duration Storage
LTESA	Long-Term Energy Service Agreements
MW	Megawatts
NEM	National Energy Market
NPV	Net Present Value
NIS	Network Infrastructure Strategy
AEMO Services	NSW Consumer Trustee
DPIE	NSW Department of Planning and Environment
Roadmap	NSW Electricity Infrastructure Roadmap
PDRS	Peak Demand Reduction Scheme
PV	Photovoltaic
PTIP	Priority Transmission Infrastructure Project
PEC	Project Energy Connect
RIT-T	Regulatory Investment Test for Transmission
REZ	Renewable Energy Zone
TWh	Terawatt hours
TAF	Transmission Acceleration Facility
VRE	Variable Renewable Energy
VNI West	Victoria-NSW Interconnector West
WACC	Weighted Average Cost of Capital

Introduction

The NSW Electricity Infrastructure Roadmap (Roadmap) is a plan to deliver reliable, affordable, and clean electricity to NSW households and businesses. The NSW Consumer Trustee, AEMO Services Limited, publishes regular Infrastructure Investment Objectives (IIO) reports that inform the Roadmap implementation. NSW EnergyCo prepares the Network Infrastructure Strategy (NIS) that the transmission investment needed in NSW and serves as an input for consideration in the IIO. Both publications are informed by electricity market modelling activities undertaken by the NSW Consumer Trustee.

The NSW Office of Energy and Climate Change plans to use market modelling to project a scenario where the Roadmap is not implemented. The results from this scenario can then be compared against NSW Consumer Trustee modelling, where the Roadmap is implemented. The comparison will provide an estimate of how much consumers will save because of the Roadmap. This report outlines the reasons for updating the analysis and the modelling approach used for this purpose.

The report is structured as follows:

- Section 1 Background provides a summary of the Roadmap and the previous consumer impact analysis, discusses the rationale for revising the analysis, and explains the general approach to modelling consumer impacts.
- Section 2 Method and input assumptions describes the details of the modelling method and implementation.

1

Background

1 Background

1.1 About the Roadmap

In November 2020, the NSW Government released the Roadmap. The Roadmap is the State's bipartisan 20-year plan to transform our electricity system into one that is cheap, clean, and reliable. It aims to coordinate investment in transmission, generation, storage, and firming infrastructure as ageing coal-fired generation plants retire.

It sets objectives to deliver at least:

- The equivalent of 12 gigawatts of new renewable electricity generation
- 2 gigawatts of long-duration (8 or more hours) storage.

The Roadmap is enabled by the *Electricity Infrastructure Investment Act 2020* (the Act or EII Act), which passed into law with cross-party support in December 2020.

Taking action now to implement the Roadmap is critical. It took 30 years to plan and build the existing fleet of coal-fired generation plants in NSW. With Liddell Power Station having recently retired, we now need to replace three of the four remaining plants within the next decade.

The NSW economy and communities must also be positioned to capture the huge opportunities arising from the global growth in low-carbon industries.

Modernising our electricity system now is key to setting our economy up to be even more globally competitive and growing the sustainable prosperity of our communities over the coming decades.

1.2 Previous estimates of Roadmap consumer impacts

In November 2020, the NSW Government released a detailed report[1] for the Roadmap. This report outlined the various opportunities and benefits of the Roadmap, including benefits to electricity consumers, broader economic benefits, and benefits to regional communities.

Modelling of the forecast wholesale electricity market outcomes by Aurora Energy Research (Aurora) was a core component of this benefits analysis. Aurora found that the Roadmap would result in retail electricity price reductions of 8 per cent compared to no action, with total system costs around $12.4 billion lower in present value terms, translating to:

- Average annual household bill savings of $130 a year between 2023 and 2040
- Average annual small business savings of $430 a year between 2023 and 2040.

1.3 The need to update estimates of consumer benefits

The National Energy Market (NEM) has witnessed rapid and significant transformations since the Aurora modelling which was based on the inputs and assumptions for the draft central scenario of Australian Energy Market Operator's (AEMO's) 2020 Integrated System Plan (ISP). These assumptions are now outdated due to the market developments that have occurred since then and AEMO has updated its scenarios accordingly. The inputs and assumptions for the 2022 ISP 'Step Change' scenario were voted by stakeholders, in a Delphi Panel process, as the most likely trajectory for the future NEM.

The 2022 ISP Step Change scenario differs fundamentally from the Draft 2020 ISP Central scenario, projecting a swift transition to achieve Australia's net zero policy goals, as well as incorporating technology innovations, government aspirations and consumer preferences. In 2021, AEMO CEO, Daniel Westerman said that the significant changes already underway in the NEM have continued to accelerate in recent years, considerably exceeding forecasts in the 2020 ISP central scenario.[2]

The NSW Consumer Trustee (AEMO Services) regularly conducts modelling for the wholesale electricity market for the IIO report and NIS that includes the Roadmap and the current market context (the Roadmap scenario). However, the counterfactual to this scenario (the no-Roadmap scenario), which is essential to compare outcomes and estimate consumer impacts, has not been updated since 2020.

In 2022, the NSW Office of Energy and Climate Change committed to updating forecast consumer impacts by creating a modelling framework to allow periodic updates to the no-Roadmap scenario so that consumer outcomes can be calculated by comparison with the Roadmap scenario. This will enable the estimated benefits of the policy to be updated periodically and will inform the policy's evaluation as part of a statutory review in 2026/26.

This section explains the most important changes that justify the need to update consumer benefits modelling, including a rapid coal closure schedule, dramatic changes to demand forecasts, delays and scope changes for inter-regional transmission augmentations, and an unprecedented rise in commodity prices.

[1] NSW Dept of Planning, Industry and Environment, "NSW Electricity Infrastructure Roadmap," November 2020, https://www.energy.nsw.gov.au/sites/default/files/2022-08/NSW%20Electricity%20Infrastructure%20Roadmap%20-%20Detailed%20Report.pdf

[2] AEMO Media Release, "NEM prepares for Step Change," December 2021, https://aemo.com.au/newsroom/media-release/nem-prepares-for-step-change

1.3.1 Coal closure schedules and forecasts have accelerated

Since 2020, several coal-fired generators have decided to close earlier than planned, influenced by various factors. Moreover, the 2022 ISP Step Change scenario suggests that closures will need to accelerate further to achieve net zero by 2050 in line with a 1.8°C warming path.

Figure 1 compares the following forecast closure dates for NSW coal-fired power stations:

- Announced closure dates in AEMOs Generation information database as at November 2019 (equivalent to the Draft 2020 ISP Central scenario assumptions).
- Announced closure dates in AEMOs Generation information database as at February 2023.
- AEMO's 2022 ISP forecasts.

In 2020, Eraring Power Station was expected to operate until 2032 and Bayswater Power Station until 2035, but both coal-fired power stations have announced intended earlier closure dates. Origin Energy announced Eraring Power Station, which is Australia's largest power station with a capacity of 2,880 megawatts (MW), is expected to close as early as August 2025. AGL announced Bayswater Power Station, which has a capacity of 2,640 MW, is expected to close between 2030 and 2033. The 2022 ISP forecasts a more rapid closure of NSW's coal-fired power stations with the state forecast to lose 4.8 gigawatts (GW) of coal capacity by 2029 compared to what was expected when the Roadmap was released in 2020.

This significant change in coal generation availability will have major implications for the electricity system, which requires updating the 'no-Roadmap' scenario and reassessing consumer benefits.

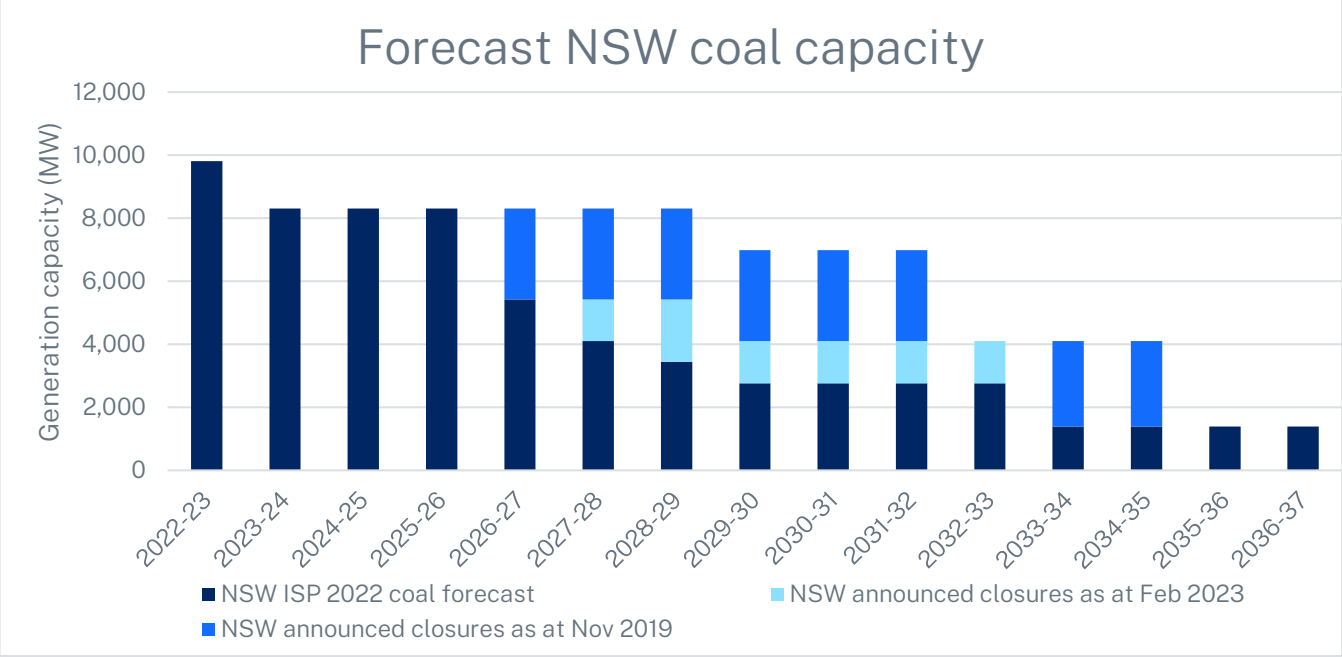

Figure 1: Announced and forecast coal closures based on AEMO Generation Information Nov 2019, AEMO Generation Information Feb 2023 and ISP 2022 (Step Change scenario)

1.3.2 Demand is expected to change faster than previously forecast

Forecast electricity demand for NSW has changed dramatically since 2020. The 2022 ISP Step Change scenario forecasts a significant increase in both consumption and maximum demand compared to the Draft 2020 ISP Central scenario, which assumed a more moderate pace of change. The main drivers of this change include the forecast growth of rooftop PV, behind-the-meter (BtM) battery storage, hydrogen production, electrification, and increasing uptake of electric vehicles in NSW.

The 2022 ISP Step Change scenario projects that electricity consumed by NSW from the grid will increase from 65 terawatt hours (TWh) in 2022 to 93 TWh in 2050, a near 50% increase (see Figure 2). This is mainly due to the higher demand from electric vehicles and hydrogen production, which more than offsets the reduction in grid consumption from rooftop PV generation and behind-the-meter storage. In contrast, the Draft 2020 ISP Central scenario assumed a more modest growth of these technologies and a lower impact on the electricity demand profile of NSW. This scenario forecast only a slight increase in grid electricity consumption, from 67 TWh in 2020 to 74 TWh in 2050.

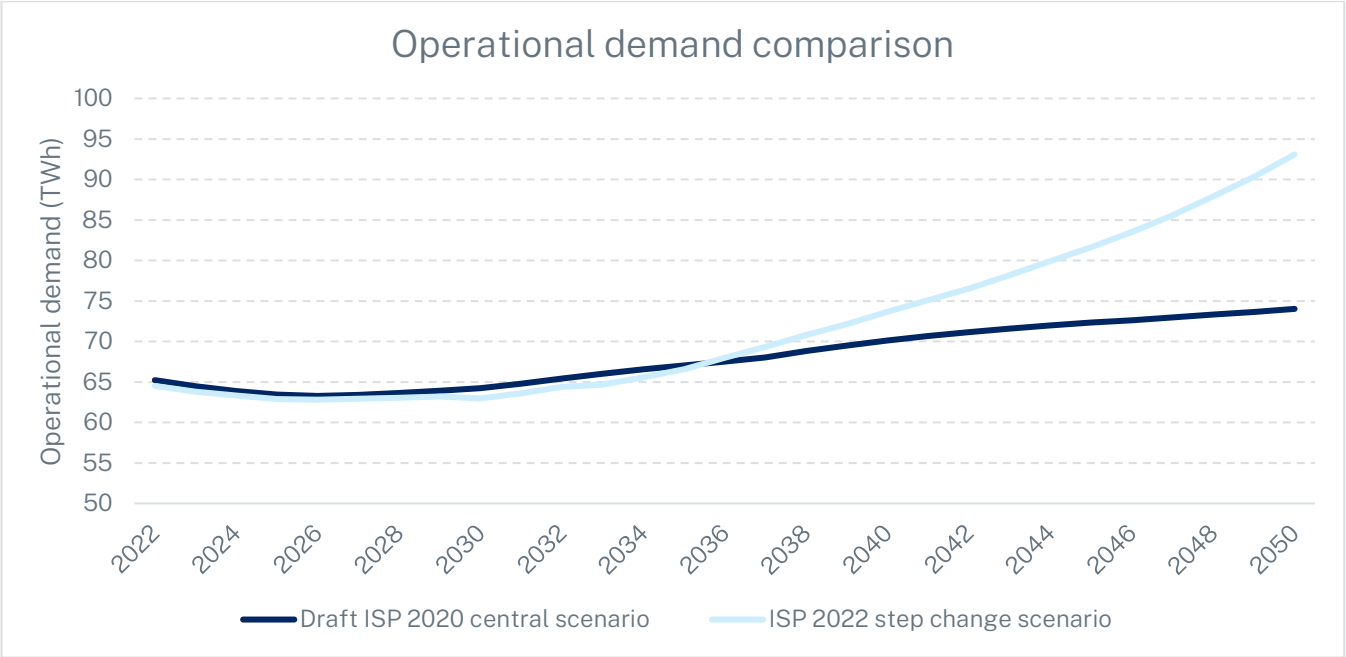

Figure 2: Comparison of the projected operational demand under the Draft 2020 ISP Central scenario and the 2022 ISP Step Change scenario

According to the 2022 ISP Step Change scenario, rooftop photovoltaic (PV) capacity in NSW is expected to increase from 5 GW in 2022 to 19 GW in 2050, while BtM battery storage capacity is expected to increase from 0.3 GW to 13 GW over the same period. In comparison, the Draft 2020 ISP Central scenario forecast rooftop PV capacity to increase from around 3 GW in 2022 to just under 9 GW by 2050, and the BtM battery storage capacity to increase from 0.2 GW to 1.8 GW over that period.

Green hydrogen production, which uses electricity from renewable sources to split water into hydrogen and oxygen, is also projected to grow significantly in the next decade. Consumption for hydrogen production is expected to pick up pace from 2032 onwards with a relatively low consumption of 60 gigawatt hours (GWh), growing steeply to over 9.5 TWh by 2050 under the 2022 ISP Step Change scenario. Hydrogen production did not feature in the Draft 2020 ISP Central scenario.

Electric vehicles (EVs) are another key factor that will increase electricity consumption and demand in NSW, as more consumers switch from fossil fuel vehicles to cleaner alternatives. The 2022 ISP Step Change scenario anticipates that battery EVs and plug-in hybrid EVs will add up to 8 million vehicles in NSW by 2050, which corresponds to almost 30 TWh of energy consumption, as opposed to just under 3.5 million vehicles in the Draft 2020 ISP Central scenario, equating to about 12 TWh of energy consumption.

Electrification of the residential, commercial, and industrial sectors rather than the transport sector also contributes strongly to increased operational demand in the 2022 ISP Step Change scenario, growing from 3.2 TWh in 2022 to 10.8 TWh in 2050. Electrification of these sectors was not identified as a distinct demand category in the Draft 2020 ISP Step Change scenario.

The maximum demand of NSW is also expected to change significantly, from just under 14 GW in the summer of 2022 to almost 19 GW in the summer of 2050 (at a 10% probability of exceedance). It is interesting to note that the 2020 ISP did not expect the winter maximum demand to increase much over the period, rising from just above 12 GW in 2019 to under 14 GW in 2049. However, the 2022 ISP expects a significant increase in the winter peak, rising from almost 13 GW in 2022 to 18 GW in 2050. The minimum demand of NSW is also expected to decline over time, as rooftop PV reduces daytime demand. In the Draft 2020 ISP Central scenario, the maximum demand was expected to increase from 13 GW to 17 GW throughout the summer period. The minimum demand was expected to remain relatively stable over time.

Charts comparing the two scenarios can be found in Appendix A.

1.3.3 Transmission augmentation timing and sizing has changed

The timeline and capacity of transmission system augmentations plays a crucial role in determining the build-out of renewable energy zones (REZs), generation infrastructure, and storage infrastructure. Therefore, any changes in the expected timing and capacity of major transmission infrastructure signals a need to update modelling that informs Roadmap consumer impacts.

Comparing the optimal development pathway of AEMO's Draft 2020 ISP with that of AEMO's 2022 ISP shows that Project Energy Connect (PEC), Humelink, and Victoria-NSW Interconnector West (VNI West) have all faced delays, specifically:

- **Project Energy Connect** – Commissioning has been delayed by two years from 2024-25 to 2026-27.
- **Humelink** – Commissioning has been delayed by a year from 2025-26 to 2026-27.
- **VNI West –** Timing has changed by four years from 2027-28 to 2031-32.

Figure 3 shows the change in timing (horizontal) and the relative capacity of the augmentation (size of the bubble). The magnitude of change in inter-regional augmentations is another factor supporting the need to re-model consumer impacts of the Roadmap.

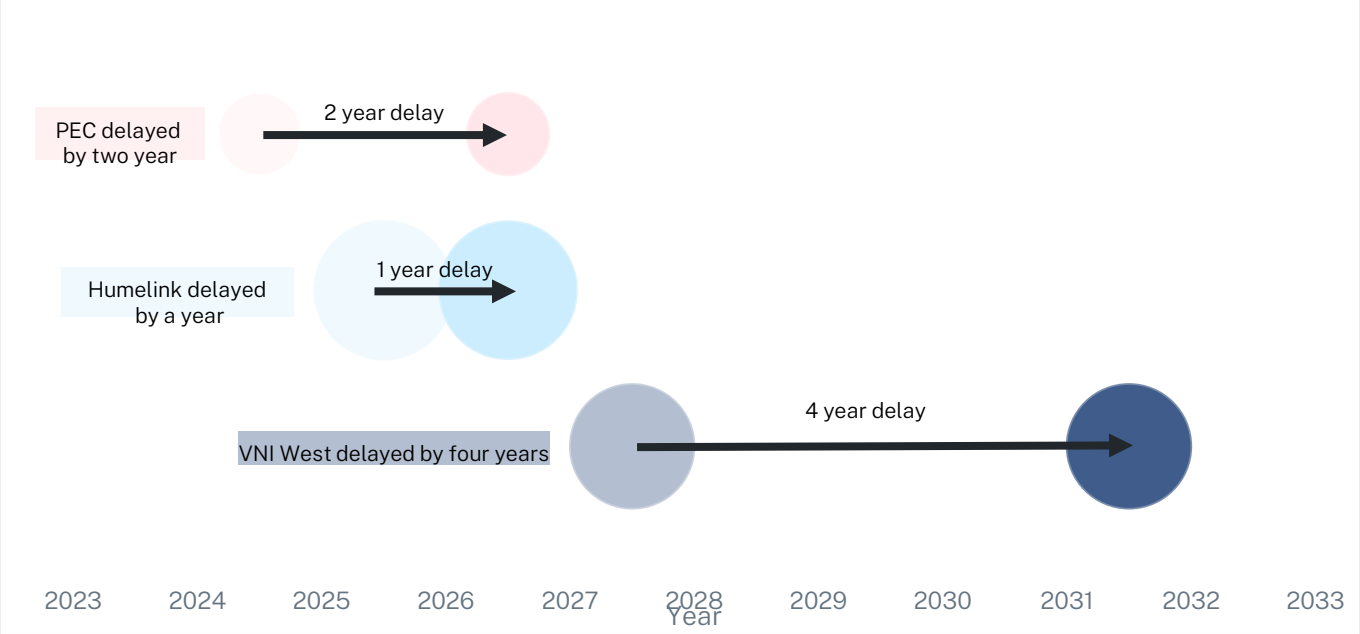

Figure 3: Inter-regional transmission augmentation timeline changes from Draft AEMO 2020 ISP Central scenario and AEMO 2022 ISP Step Change scenario

1.3.4 Commodity prices have been the most volatile in history

One of the main factors that influence the wholesale electricity price in NSW is the cost of fossil fuels, which still dominate the energy mix in the state despite the growth of renewables. The most recent twelve months of data shows that generation from fossil fuel power plants supplied about 64% of the operational demand in NSW, with black coal being the most prevalent source at 60%.[3] Therefore, any fluctuations in the prices of coal and gas have a direct impact on consumer energy bills.

The global energy crisis has caused a surge in the prices of Australian coal and gas. The Newcastle (6,000 kcal) thermal coal price, which reflects the quality of coal that Australia typically exports, reached around $600 per ton at the end of 2022. This is a fourfold increase from the average price seen 12 years ago. The Australian (5,500 kcal) thermal coal price, which reflects the quality of coal that Australia mainly uses for domestic electricity generation, rose to around $200 per ton at the end of 2022. This is more than double the average price seen 12 years ago. Similarly, the Japan/Korea marker (JKM) LNG price, which indicates the price of gas that Australia predominantly exports to its Asian customers, soared to about $44 per gigajoule at the end of 2022. This is almost triple the average price seen 8 years ago (the period since Australia began exporting Liquefied Natural Gas (LNG).

The higher fuel costs translate into higher marginal costs for the fossil fuel generators, which means that they bid higher price offers into the energy market. Since fossil fuel generation continues to be a frequent wholesale price setter, this has a flow on effect to consumer bills.

Figure 4 and Figure 5 show that the sudden spike in the fuel costs began around mid-2021, after the release of previous Roadmap consumer impact modelling, and that prices are not expected to return to historical levels in the near future. This drastic change in input costs for fossil fuel generators further points to the need to revisit Roadmap consumer impact modelling.

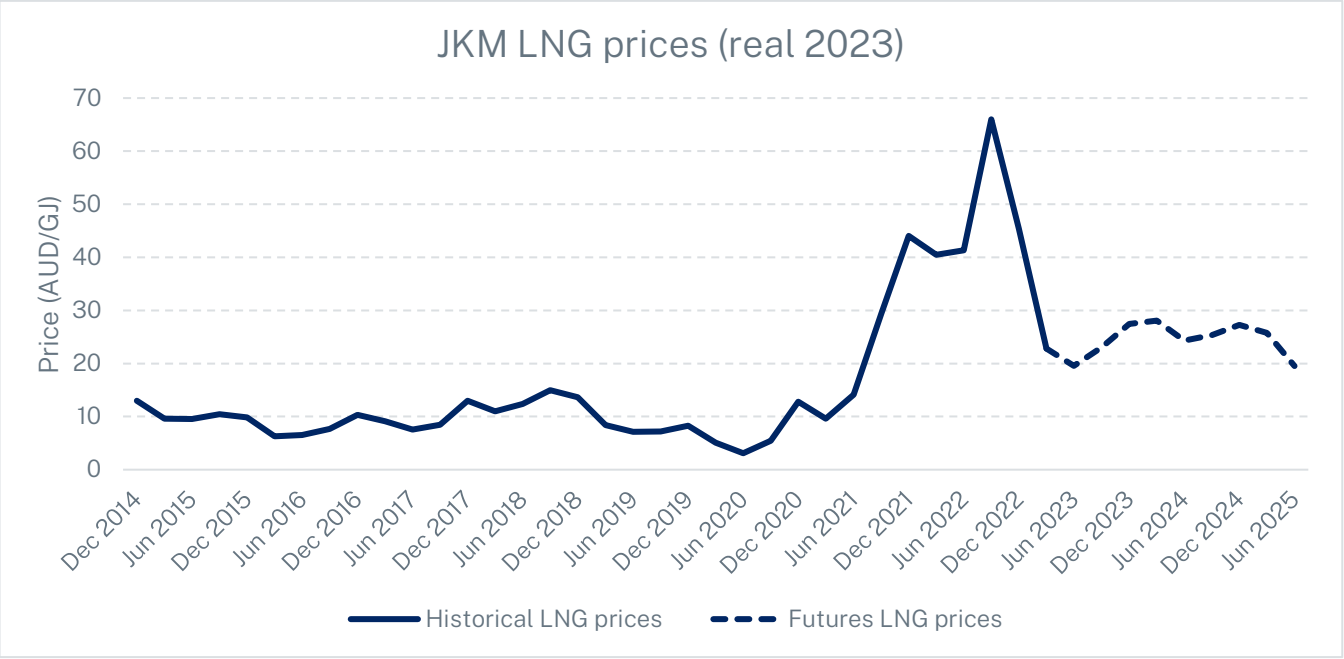

Figure 4: Historical and Futures prices of LNG in the Japan - Korea Marker. Sources: Investing.com; CME Group

[3] OpenNEM, "An Open Platform for National Electricity Market Data," Energy Consumption for New South Wales April 2022 - April 2023, https://opennem.org.au/energy/nsw1/?range=1y&interval=1w

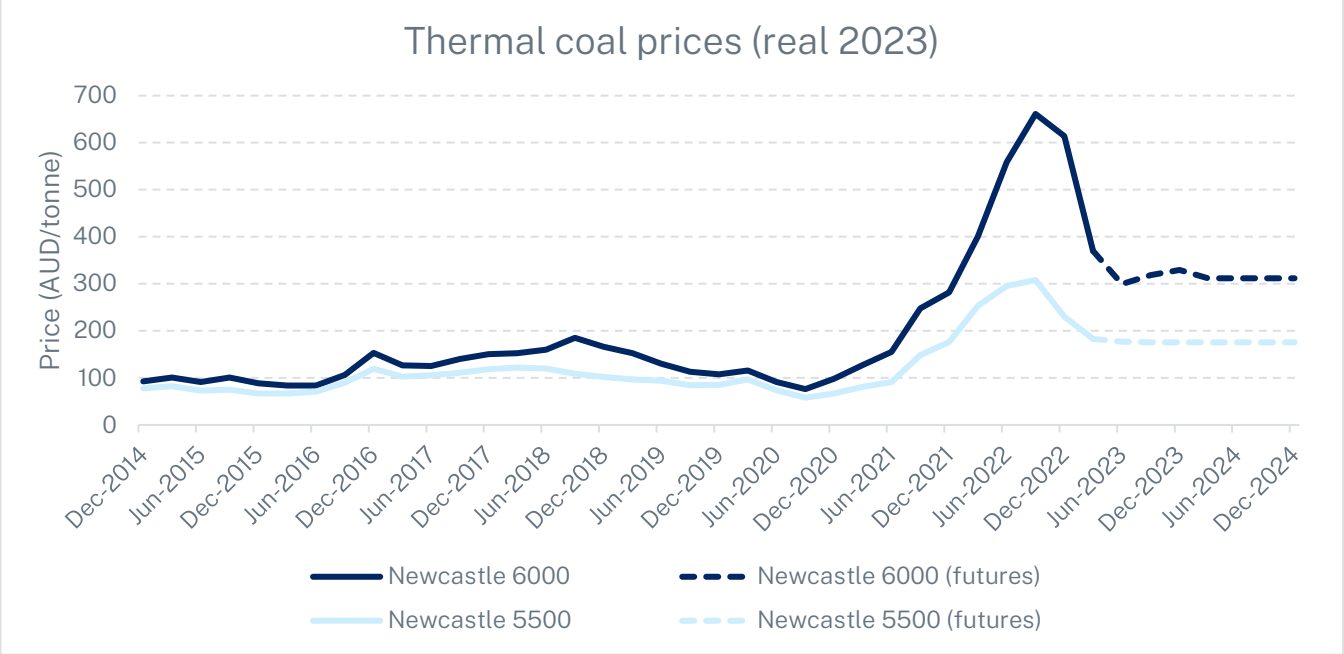

Figure 5: Historical and Futures prices of 6000kcal and 5500kcal coal. Source: OPIS by McCloskey

1.4 Approach

A set of assumptions and modelling methods used by the NSW Consumer Trustee, AEMO Services Limited (ASL), for Roadmap modelling underpins the no-Roadmap modelling. The assumptions diverge where required to reflect a world without the EII Act.

As per the Roadmap modelling, the no-Roadmap modelling involves finding an equilibrium generation, transmission and storage capacity mix across the NEM for a 20-year horizon. This is referred to as a 'capacity expansion'. The next step involves simulating how this capacity mix would dispatch power to meet consumer demand in half-hourly periods across a year and results in market outcomes including wholesale prices.

To calculate the updated estimates of Roadmap savings, and to measure the actual historical savings achieved, a forward-looking forecast model and a backward-looking backcast are both needed. Figure 6 shows a summary of this process. The following section explains the inputs, assumptions and methodologies that support the updated no-Roadmap forecast modelling, with the backcast process still under development.

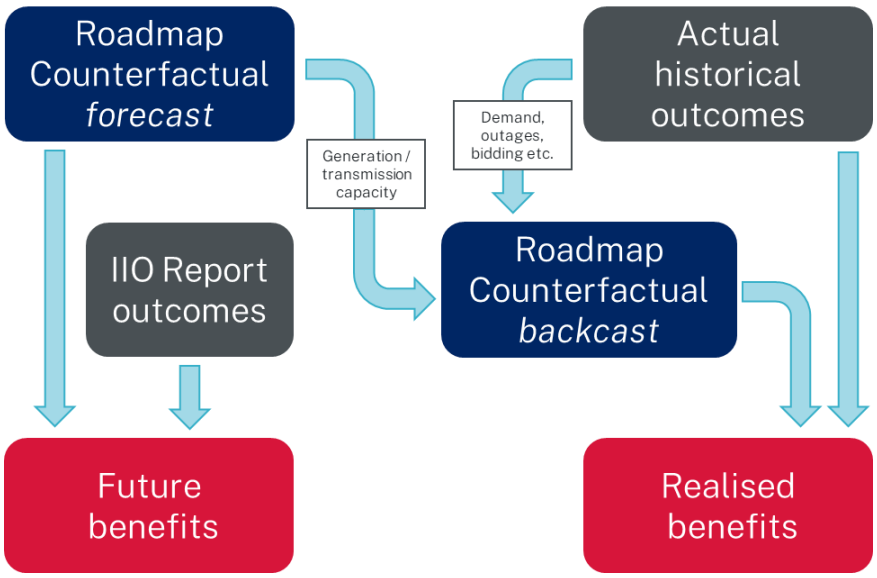

Figure 6: No-Roadmap modelling process

2

Modelling method and input assumptions

2 Method and input assumptions

The aim of the no-Roadmap model is to produce projections of the NSW wholesale electricity market in the absence of the EII Act. The NSW Consumer Trustee regularly publishes its IIO Report, which projects a rolling 20 year time horizon incorporating the latest policy and market developments. The IIO model is therefore an appropriate starting point from which to adjust the inputs, assumptions, and settings to reflect an NSW market without the EII Act for the purpose of the no-Roadmap model.

2.1 Model consistency

The NSW Consumer Trustee engages a dedicated AEMO modelling team to perform electricity market modelling on its behalf. The no-Roadmap model is based on this model and is operated by the same dedicated AEMO modelling team. This reduces the potential for discrepancies arising due to model setting and methodology differences, allowing for more directly comparable results between the Roadmap scenario and no-Roadmap scenario.

In addition, where possible and appropriate, AEMO aligns these methodologies with those employed for the ISP so that forecasting and planning outcomes at a national and state level are broadly consistent and readily comparable.

One important distinction between the modelling done by AEMO for the NSW Consumer Trustee and the modelling done by AEMO for the ISP is the **objective function**. The ISP model aims to minimise the total system costs for the National Electricity Market, while the NSW Consumer Trustee model aims to minimise the costs for NSW consumers, as required by the Electricity Infrastructure Investment Act 2020. The no-Roadmap scenario does not follow either of these approaches, as explained in Section 2.3.

2.2 Method

This section provides a high-level summary of the components and phases of AEMO's modelling process. AEMO's modelling methodology forms a dynamic and flexible approach, ensuring market modelling activities' quality, completeness, and robustness.

Figure 7 provides an overview of the integrated suite of forecasting models and assessments:

- The **fixed and modelled inputs** are the inputs, assumptions and scenarios selected for the modelling exercise and detailed in each relevant publication, leveraging information published in AEMO's *Inputs, Assumptions and Scenarios Report* (IASR) and other third party sources where current and appropriate.
- The **capacity outlook model** uses all the available inputs to develop projected generation expansion, transmission expansion, generation retirement, and (draft) dispatch outcomes for the no-Roadmap model. The aim when doing so is to minimise the objective function, which is the NEM total system cost.
- The **time-sequential model** then optimises electricity dispatch for every half-hourly interval. In so doing, it validates the outcomes of the capacity outlook model. The model is intended to reflect participant behaviour and network constraint limitations in a more granular, precise, and chronological manner than the capacity outlook model to produce final modelling outcomes including half-hourly wholesale prices. The wholesale price output for the no-Roadmap scenario, along with other consumer cost categories, can then be compared against the Roadmap scenario to estimate consumer benefits.

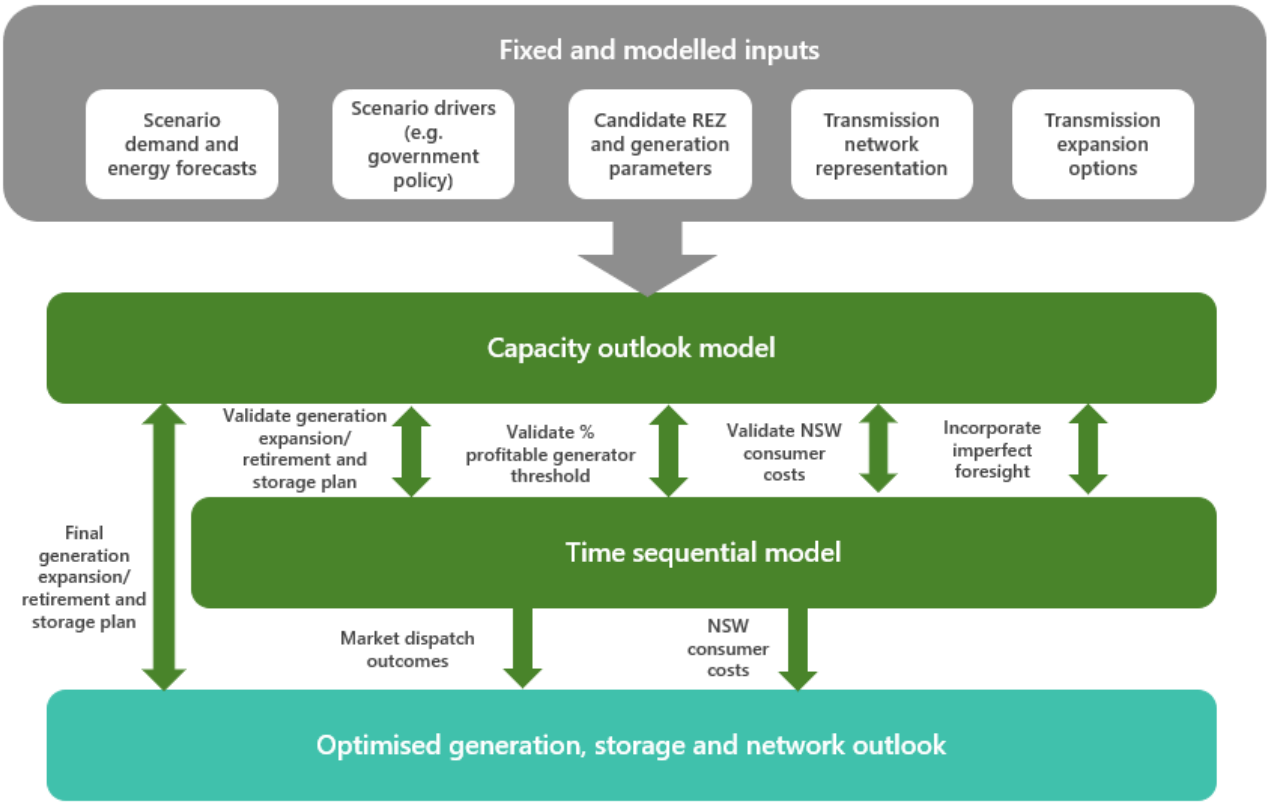

Figure 7: Overview of modelling methodology[4]

2.3 Framework and input assumptions

Table 1-5 presents a broad overview of various input assumptions and methodologies used for the no-Roadmap model, including where deviations are made from the Roadmap model to simulate a market devoid of the EII Act. This framework serves as a guideline for present and future modelling of the no-Roadmap scenario.

Table 1: No-Roadmap modelling framework – Modelling objectives

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
Minimise NSW customer costs	No	The objective of the Consumer Trustee's Roadmap modelling is to minimise New South Wales customer costs, reflecting the intent of the EII Act. Since the no-Roadmap scenario does not include this legislation, the objective function of the model is instead to minimise system costs while maintaining producer profitability.	This is implemented through iterations (in the time-sequential model) in which new entrants' profitability is assessed and the capacity mix adjusted. This ensures profitability is maintained – reflecting an environment where investment decisions are made without the objectives and incentives of the Roadmap.

[4] AEMO ISP Methodology August 2021, https://aemo.com.au/-/media/files/major-publications/isp/2021/2021-isp-methodology.pdf?la=en

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
Meet the New South Wales IIOs, and beyond	No	In the no-Roadmap scenario, no NSW Government policy objectives for renewable generation or storage capacity targets exist.	The Acts' key objectives of constructing 12 GW equivalent renewable energy, and 2 GW long-duration storage are removed as constraints from the capacity expansion model.
Meet the New South Wales Energy Security Target (EST).	No	The EST is legislated within the Act and is therefore not included in the no-Roadmap scenario.	No explicit post-modelling check is performed to assess whether the no-Roadmap scenario forecast meets the EST.
Meet the reliability standard.	Yes	Assumed to be independent of the Act.	To meet the reliability standard, unprofitable firming capacity may be built under the assumption of government intervention in the market. The 'missing money' required to make this firming capacity net present value (NPV) neutral is assumed to be recovered from NSW consumers over the life of the project.
Meet the Large-scale Renewable Energy Target (LRET).	Yes	Assumed to be independent of the Act.	The LRET has already been met and is therefore not represented in the model.
Meet non-NSW state-based renewable energy targets[5].	Yes	Assumed to be independent of the Act.	The Queensland Renewable Energy Target (QRET), 50% of Queensland electricity consumption to be provided by renewable generation by 2030, is implemented as a constraint in the model that linearly interpolates the required developments to meet the objective of the QRET between forecast levels of existing, committed and anticipated renewable energy (including forecast distributed PV) and the 2030 target. The Victorian Renewable Energy Target (VRET), 40% renewable energy generation as a percentage of total Victorian generation by 2025 and 50% by 2030, is implemented as a constraint in the model that linearly interpolates the required developments to meet the objective of the VRET between forecast levels of existing, committed and anticipated renewable energy (including

[5] Descriptions and implementation of state-based renewable energy targets are sourced from AEMO's 2022 Inputs and Assumptions workbook (released 30 June 2022)

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
			forecast distributed PV) and the 2030 target. The Tasmania Renewable Energy Target (TRET), 15.8 TWh from renewable sources by 31 December 2030 and 21 TWh from renewable sources by 31 December 2040 (including DER and non-scheduled generation), is implemented as a constraint in the model that linearly interpolates the required developments to meet the objective of the TRET between forecast levels of existing, committed and anticipated VRE (including forecast distributed PV) and the first interim target as well as between the interim and 2040 target.
Emissions reduction	Partial	As per the Roadmap scenario and the 2022 ISP Step Change scenario, a NEM-wide emissions budget, aligned with a 1.8°C warming trajectory, is applied as a constraint in the capacity outlook model. However, in the no-Roadmap model the carbon budget can be violated if required in the time-sequential model to meet the producer profitability modelling objective and/or the reliability standard.	The NEM-wide emissions budget is applied in the capacity outlook model, however there is no explicit post-modelling check to assess whether the NEM-wide emissions budget is violated following the producer profitability iterations in the time-sequential model.

Table 2: No-Roadmap modelling framework – Demand

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
Electricity demand	Yes	Assumed to be independent of the Act.	Demand traces from the AEMO 2022 ISP Step Change scenario are included in the model. A summary of this demand is provided in Section 1.3.2 and Appendix A.
Rooftop PV	Yes	Assumed to be independent of the Act.	Rooftop PV uptake is assumed to proceed as per the AEMO 2022 ISP Step Change scenario. A summary of this uptake is provided in Section 1.3.2 and Appendix A.

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
NSW Energy Security Safeguard	Partial	The recent expansion of the Energy Savings Scheme is included in the no-Roadmap scenario; however, the Peak Demand Reduction Scheme (PDRS) is not, consistent with the Roadmap Detailed Report[6].	This was reflected in the volume of Demand Side Participation (DSP) assumed in both the capacity outlook and time-sequential models.
Electric vehicle uptake	Yes	Assumed to be independent of the Act.	Electric vehicle uptake is assumed to proceed as per the AEMO 2022 ISP Step Change scenario. A summary of this uptake is provided in Section 1.3.2 and Appendix A.
Hydrogen production	Yes	Assumed to be independent of the Act.	Hydrogen production is assumed to proceed as per the AEMO 2022 ISP Step Change scenario. A summary of this uptake is provided in Section 1.3.2 and Appendix A.

Table 3: No-Roadmap modelling framework – Supply

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
New committed VRE & Long Duration Storage (LDS) capacity	No	VRE and LDS projects committed up to 24 months after 14 November 2019 or committed later if the project was considered 'anticipated' by 14 November 2019, are to be included in the no-Roadmap model. All projects not meeting this criterion are to be excluded.	Detailed in section 2.3.1.
Government supported capacity	Yes	Committed generation capacity developed directly by Federal, State, or Local Governments are included in the no-Roadmap scenario as these market interventions are anticipated to be motivated by factors additional to profit.	This capacity is assumed to enter the market irrespective of profitability.
Capacity expansion	No	Capacity expansion occurs on a lifetime NPV neutral/positive basis. No targets for generation or storage are enforced in this optimisation. The exception to the above is assets with lead times >4 years. While they must be profitable, they are assumed to enter with imperfect foresight.	A 'profitability check' has been applied to all new capacity added to the no-Roadmap model, in the form of a lifetime NPV calculation (including assumptions for non-wholesale market revenue). New capacity is only built if the lifetime NPV of the prospective project is positive, and other modelling constraints, such as REZ build limits and supply chain constraints, do not bind.

[6] https://www.energy.nsw.gov.au/sites/default/files/2022-08/NSW%20Electricity%20Infrastructure%20Roadmap%20-%20Detailed%20Report.pdf

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
Retirement dates for existing capacity	Partial	Retirement dates to align with the Roadmap model; however, this methodology may be adjusted in future years if evidence arises that additional retirements have been accelerated by the Roadmap.	Retirement dates in the current version of the no-Roadmap scenario are aligned with the Roadmap model, and therefore aligned with the AEMO ISP 2022 Step Change scenario. Coal-fired power station retirements are outlined in Section 1.3.1.
Technology cost assumptions	Partial	Most technology cost assumptions are assumed to be independent of the Act, apart from the weighted average cost of capital (WACC). A main benefit of Long-Term Energy Service Agreements (LTESA) and coordinated transmission at a system level is the reduction of investment risk resulting in lower cost of capital. This benefit would not be realised in the no-Roadmap scenario, and therefore WACCs are adjusted appropriately.	Detailed in section 2.3.2.
Commodity prices	Yes	Assumed to be independent of the Act.	Commodity prices are aligned with the Draft 2023 IIO report. These commodity prices were provided by a third-party following major market movements as outlined in Section 1.3.4.
Supply chain constraints	Yes	A supply chain constraint is applied to limit the amount of build that can occur in a single year, as per the IIO.	This is implemented as a constraint that limits the amount of new entrant capacity that can enter the NSW market in a single year, in terms of the amount of energy the capacity can generate. Refer to the Draft 2023 IIO report for details.

Table 4: No-Roadmap modelling framework – Transmission

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
Renewable Energy Zones (REZs)	No	REZ development options are aligned with the Roadmap model. However, REZs are developed reactively (with imperfect foresight); i.e., development will only begin once market signals arise (e.g., coal closures, grid congestion, high electricity prices).	Detailed in section 2.3.3.
Non-REZ network augmentation options	Yes	Non-REZ intra-regional augmentation options, such as the Hunter Transmission Project and Humelink, are aligned between the Roadmap scenario and the no-Roadmap scenario.	Refer to the Draft 2023 IIO report for details.

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
Non-REZ network augmentation timings	No	The absence of the Roadmap is unlikely to materially alter *which* augmentations would be necessary for secure system operation in the future, only the timing in which they are delivered. Therefore, as per the methodology for REZ development, non-REZ intra-regional network augmentations are built reactively (with imperfect foresight) in response to market signals.	Detailed in section 2.3.3.
Interconnector augmentations	Yes	Interconnector augmentations aligned with Roadmap model assumptions.	Refer to the Draft 2023 IIO report for details.

Table 5: No-Roadmap modelling framework – Model settings

Methodology / assumption	Aligned with Roadmap scenario	Description	Implementation
Time horizon	Yes	Modelling horizon aligned with the Roadmap model	
Bidding behaviour	Partial	As per the Roadmap model for most generator types, however bidding strategy for renewable generators in the no-Roadmap scenario (in the absence of LTESAs) is assumed to be different.	Bidding strategy for renewable generators has been updated to account for Large-scale Generation Certificates (LGCs), which are also included when estimating generator profitability. In the Roadmap scenario, renewable generators are assumed to bid with a zero-floor price due to this being a requirement when an LTESA is exercised.
Technology operating parameters	Yes	(e.g., ramp rates, heat rates, minimum stable levels, outage rates etc.) as per the Roadmap model.	Refer to the 2022 ISP Inputs, assumptions, and scenarios workbook for details.
Perfect foresight	No	Imperfect foresight is incorporated through delays to network augmentation development and generation assets with long lead times. This is counter to the Roadmap model which assumes perfect foresight, reflective of the high volume of detailed planning and policy incentives that reduce the risks of a reactive rather than proactive electricity market.	Detailed in section 2.3.3.

2.3.1 New committed capacity

Several generation projects have been committed in NSW as well as the broader NEM since November 2019. A key question for the no-Roadmap model is: how many of these projects were likely to have been committed regardless of the EII Act being legislated?

It is likely that many projects committed after November 2019 were in late-stage development, and the Roadmap was not a material factor in reaching a Final Investment Decision. Figure 8 provides a

simplified overview of the development process for a project, including milestones for when a project is typically classified as 'publicly announced', 'anticipated', or 'committed' by AEMO.[7] As indicated in this graphic, committed projects that were considered 'anticipated' as of November 2019 are included in the no-Roadmap scenario. Additionally, even if the project was not considered 'anticipated' as at November 2019, if it became committed within the 24 months following November 2019 then it is included in the no-Roadmap scenario under the assumption that it was likely sufficiently developed to not be materially influenced by the Roadmap legislation.

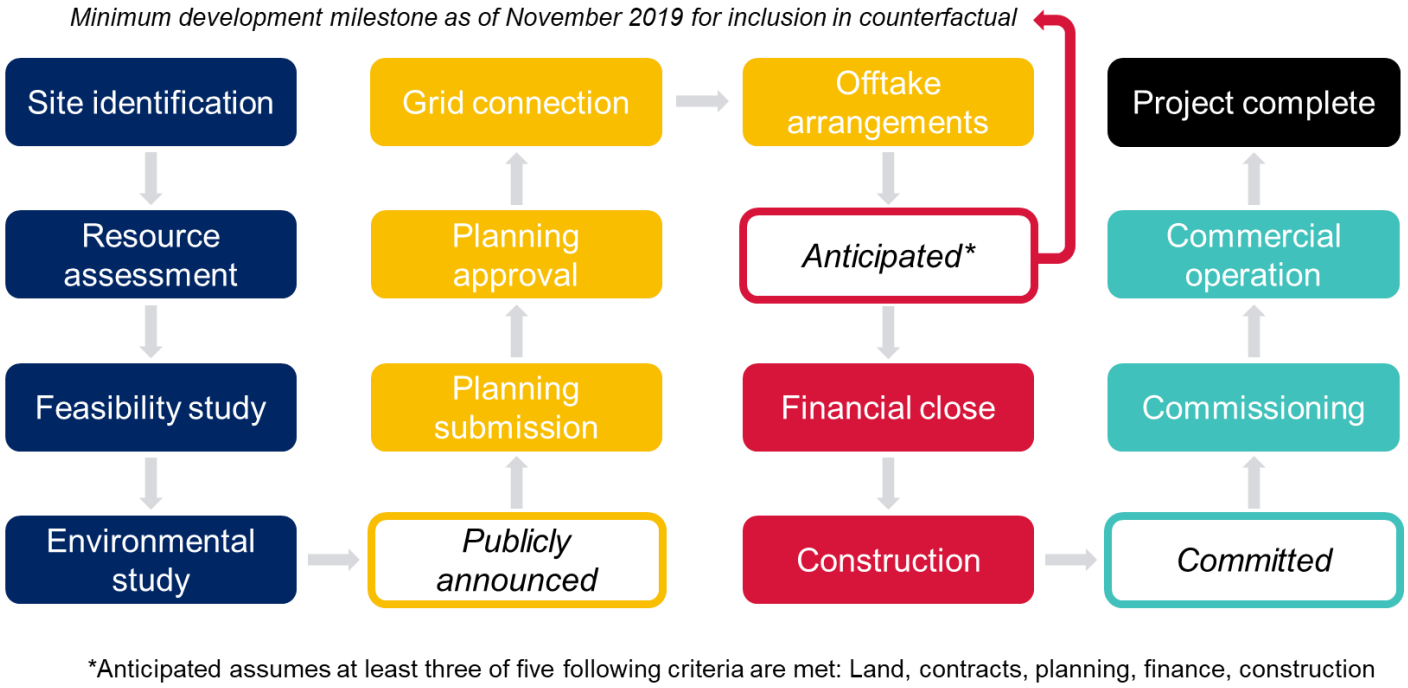

Figure 8: Simplified overview of development process for a VRE project

A list of projects that are excluded from the no-Roadmap scenario under this criterion is provided in Appendix B.

2.3.2 Technology cost assumptions

All technology cost assumptions, apart from the WACC, are aligned between the Roadmap model and the no-Roadmap model. The WACC for projects in New South Wales has been adjusted to reflect the impact of merchant financing without the Roadmap incentives including LTESAs and access rights.

Technology-specific WACCs for the Roadmap model are sourced from the November 2020 NAB NSW Electricity Infrastructure Roadmap Weighted Average Cost of Capital Report.[8,9] For the no-Roadmap model, these WACCs have been adjusted upwards based on the percentage point difference between 'wholesale revenue' WACCs and 'safeguard revenue' WACCs in the November

[7] AEMO NEM Generation Information Feb 2023, Background Information tab, https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information

[8] National Australia Bank, "NSW Electricity Infrastructure Roadmap Weighted Average Cost of Capital Report," November 2020, https://www.energy.nsw.gov.au/sites/default/files/2022-08/NSW%20Electricity%20Infrastructure%20Roadmap%20-%20WACC%20Report.pdf

[9] The WACC value assigned to long-duration storage was aligned with the AEMO 2021 IASR (5.5%) given the value produced in the 2020 NAB report was deemed unreasonably low.

2020 NSW Electricity Infrastructure Roadmap Detailed Report.[10] These WACCs were based on input provided to NSW Department of Planning and Environment (DPIE) by NAB and other major lenders.

Table 6 details the WACC assumptions applied in the Roadmap and no-Roadmap models.

Table 6: Technology-specific WACC assumptions in the Roadmap model and the no-Roadmap model

Technology	Roadmap model assumption	No-Roadmap model assumption
Wind	1.8%	5.0%
Solar PV	1.5%	5.2%
LDS	5.5%	7.9%
Firming	2.4%	4.8%

2.3.3 REZ and intraregional network augmentations

The Roadmap model optimises for the timing of all NSW REZ network augmentations based on augmentation options, earliest possible delivery times, and costs provided by EnergyCo. This optimisation is done with perfect foresight, reflecting the proactive nature of the Roadmap including the detailed planning functions and funding for early works.

The no-Roadmap scenario seeks to represent the status quo for network augmentations, which currently relies on the Regulatory Investment Test for Transmission (RIT-T) cost recovery framework. It would be highly complex to perfectly reflect the RIT-T process in a long-term forecast model, so the no-Roadmap model adopts a simplified approach. This takes the form of a delay to REZ and intraregional augmentations, reflecting the reactive (rather than proactive) nature of the current process.

The applied delay is based on the clearest market signal for new transmission, the notice of closure of coal capacity. A coal power station announcing its withdrawal clearly signals to the market that building new generation, and likely new transmission capacity, will be required to fill both the energy and capacity gap left by the withdrawn power station. A transmission investment case, or a government intervention, is easier to build with a signal this strong as opposed to forecast demand growth or forecast future congestion.

Since the current National Electricity Rules require power station operators to provide 42 months (3.5 years) of notice before withdrawal,[11] it is assumed that REZ and intraregional augmentations, with a lead time of approximately 7.5 years, would occur at least 4 years later than the optimal timing. The lead time of 7.5 years is based on the lesser of the lead times for PEC and Central-West Orana, which are the only comparable large-scale network augmentations that have sufficiently progressed in recent times.

Figure 9 provides an example. When a coal-fired power station provides notice (the market signal) 3.5 years prior to retirement, in the absence of Roadmap-enabled proactive forward planning and additional development funding, the augmentation development would only commence once that market signal arises. This leads to the augmentation being energised 4 years later than what would have been the optimal outcome (energisation at the same time as the retirement of the power

[10] NSW Dept of Planning, Industry and Environment, "NSW Electricity Infrastructure Roadmap," November 2020, https://www.energy.nsw.gov.au/sites/default/files/2022-08/NSW%20Electricity%20Infrastructure%20Roadmap%20-%20Detailed%20Report.pdf

[11] National Electricity Rules, Clause 2.10.1(c2)

station). In this example, this 'imperfect foresight' coupled with long development times creates a four-year delay to the commissioning date of a network augmentation compared to the Roadmap scenario.

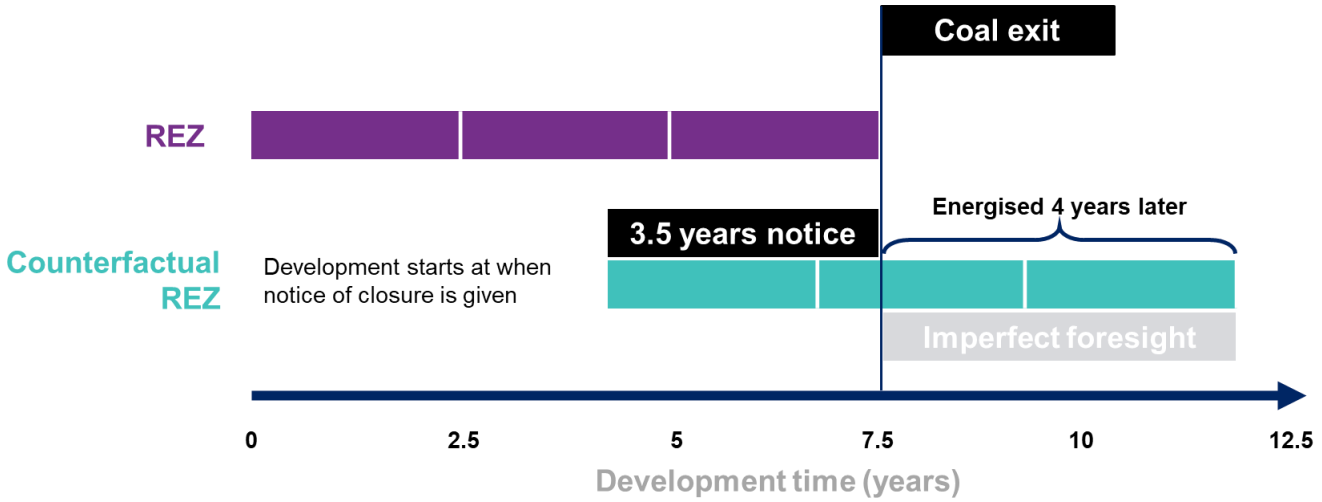

Figure 9: Example no-Roadmap scenario REZ augmentation delay

Given that the market signal of the Eraring Power Station retirement occurred in the first quarter of 2022, a shorter delay of two years is assumed for projects with an optimal development timing earlier than 2029. This is a conservative assumption that reduces the length of time between the closure of Eraring Power Station and the operational date of transmission augmentations that assist in providing replacement capacity and energy.

Table 7 lists the key intra-regional network augmentations and the delay applied in the no-Roadmap model relative to the optimal timing. It is also noted that the Waratah Super Battery (a 'virtual' transmission solution) is excluded from the no-Roadmap model since it is a project specifically conceptualised as a Roadmap-driven NSW Government response to the anticipated closure of Eraring.

Table 7: Comparison of REZ and intraregional network augmentation timings between the Roadmap scenario and the no-Roadmap scenario

Augmentation	No-Roadmap scenario (delay relative to optimal timing)
Hunter Transmission Project	Two years
Humelink	No delay due to Commonwealth support and development pre-dating Roadmap legislation
Central West Orana REZ	Stage 1 delayed two years, further development not identified in the no-Roadmap development pathway
Hunter Central Coast REZ	Delayed two years
South West NSW REZ	No augmentation identified in the no-Roadmap scenario development pathway to increase transfer capacity above that provided by PEC, VNI West and Humelink
New England REZ	Both augmentation stages delayed four years
Waratah Super Battery	Excluded from the no-Roadmap scenario

2.4 Consumer costs

Consumer costs are calculated for the no-Roadmap scenario and compared against the Roadmap scenario to estimate the Roadmap's consumer impact. Consumer costs in the no-Roadmap scenario consists of three categories: wholesale costs, transmission network infrastructure costs and firming infrastructure costs. These cost categories are passed through to consumers using the following methods:

1. **Wholesale costs** – The wholesale electricity purchase costs to NSW customers (assuming that spot prices reflect contract prices). This is passed through directly to consumers on an annual basis.
2. **Transmission network infrastructure costs** - The annualised capital costs (reported for 20 years only) of new NSW network infrastructure projects (excluding Humelink and inter-regional augmentations). The capital costs are annualised over their economic lifetime[12] using a 3.83%[13] rate of return, noting that we only consider costs over a 20-year period.
3. **Firming infrastructure costs -** Unprofitable firming capacity may be built in the no-Roadmap scenario under the assumption of government intervention in the market. The 'missing money' required to make this firming capacity NPV neutral is assumed to be recovered from NSW consumers over the life of the project.

Other consumer cost categories including distribution network costs, environmental policy charges, metering, retailer costs and retailer margin are not considered in the comparison. The Roadmap's net consumer impact is then calculated as the difference between consumer costs in the Roadmap scenario and the no-Roadmap scenario.

[12] Assumed to be 50 years in line with AEMO's assumptions in the ISP.

[13] Aligned with the 2022-23 update of AER's transmission determination for TransGrid.

Appendix A:

Changes in demand forecasts between Draft 2020 ISP Central scenario and 2022 ISP Step Change scenario

The figures below show the difference in the forecasted demand in NSW's energy sector under the Draft 2020 ISP Central scenario and the 2022 ISP Step Change scenario that have been described in section 1.3.2.

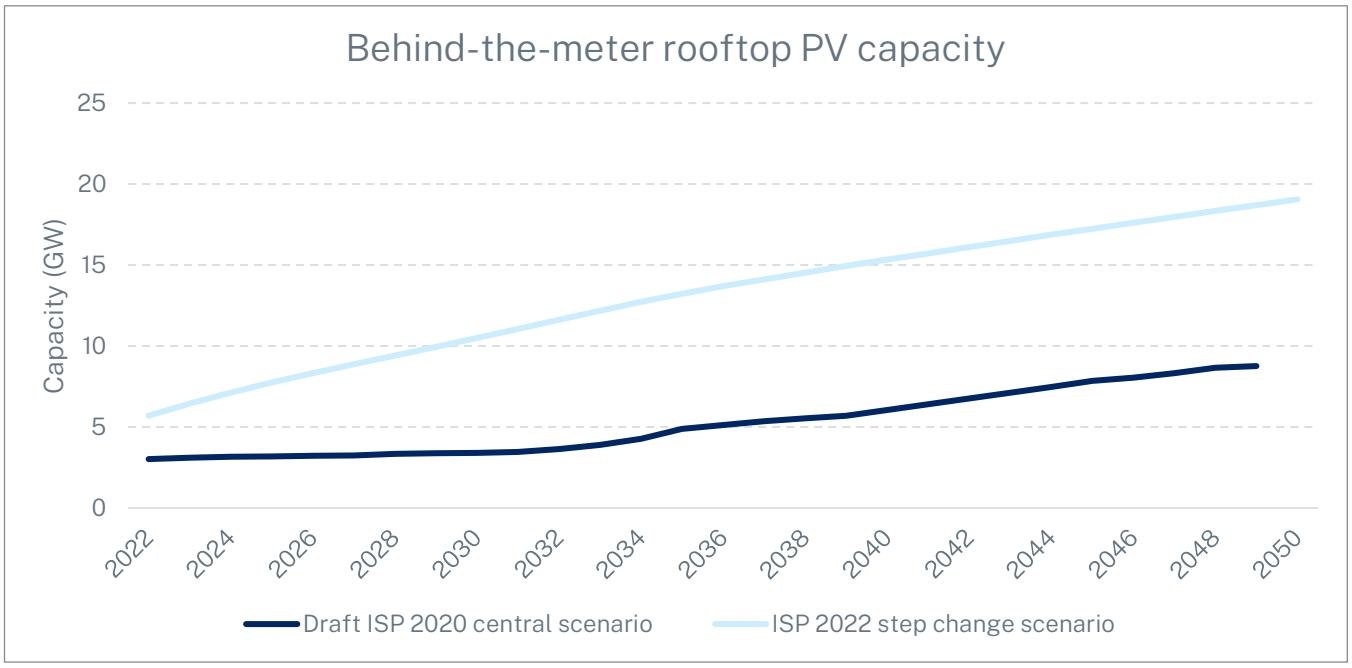

Figure 10: Comparison of growth in rooftop PV capacity under the Draft 2020 ISP Central scenario and the 2022 ISP Step Change scenario

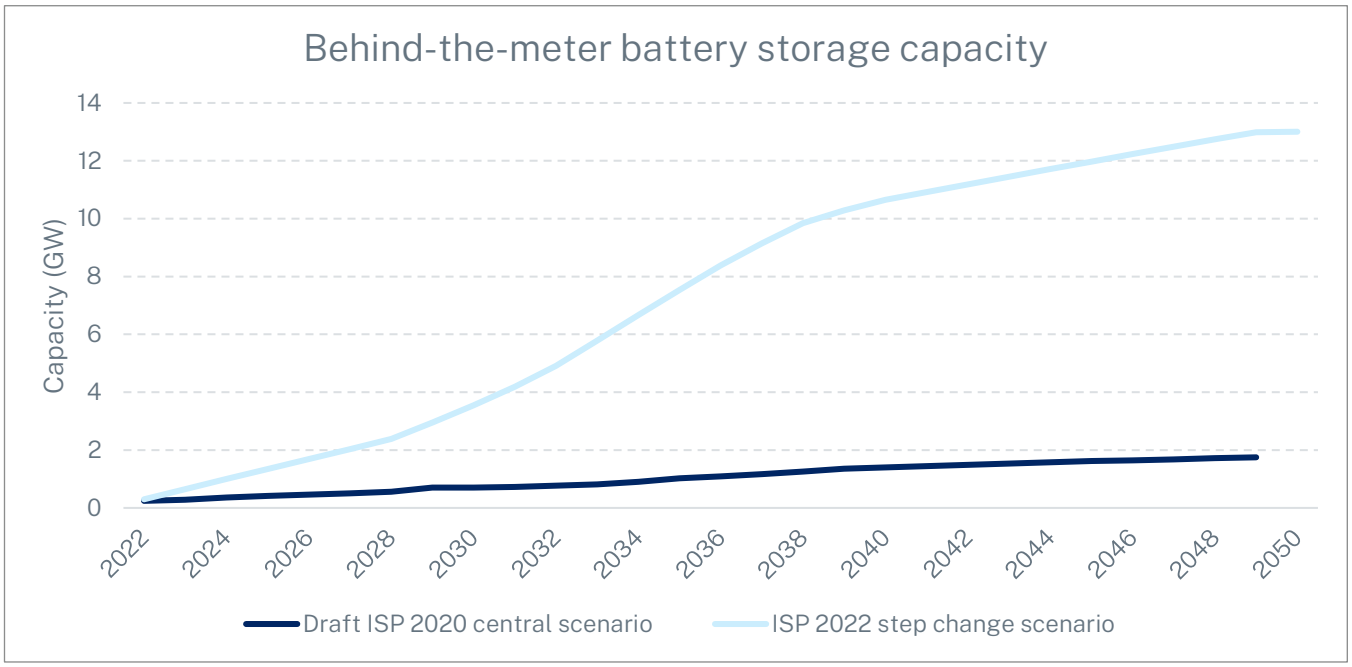

Figure 11: Comparison of growth in Behind-the-Meter battery storage capacity under Draft 2020 ISP Central scenario and the 2022 ISP Step Change scenario

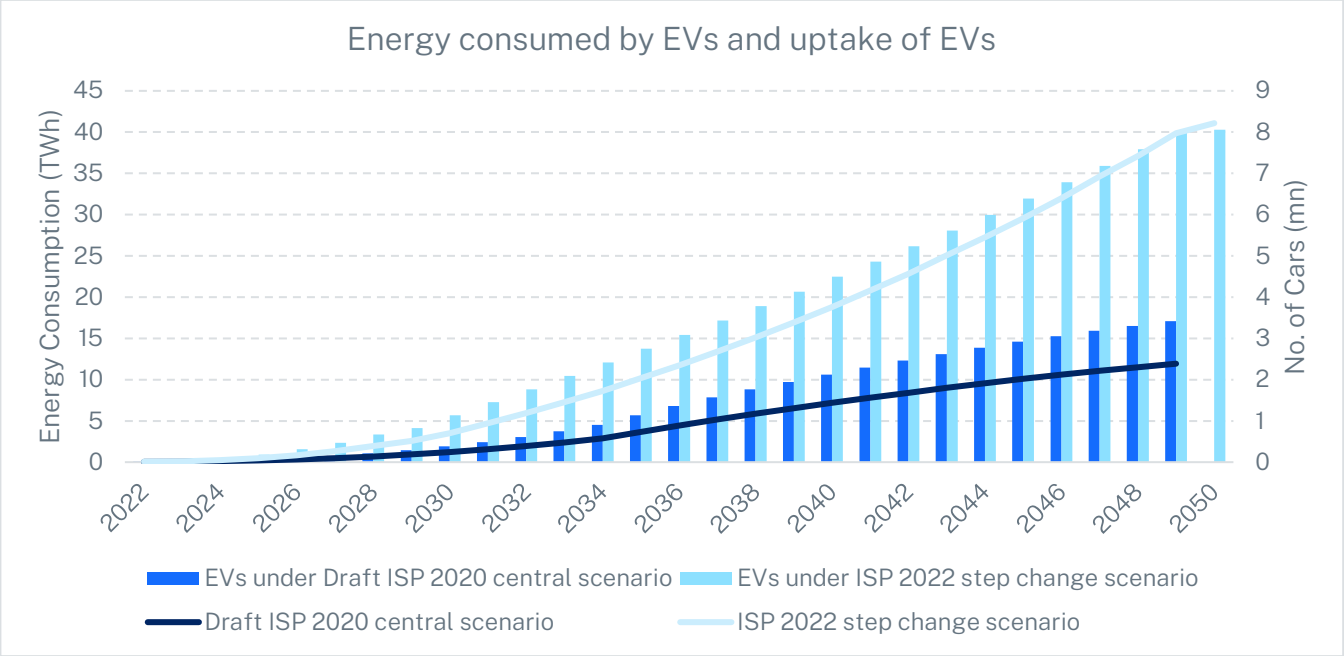

Figure 12: Comparison of EV uptake and energy consumption under the Draft 2020 ISP Central scenario and the 2022 ISP Step Change scenario

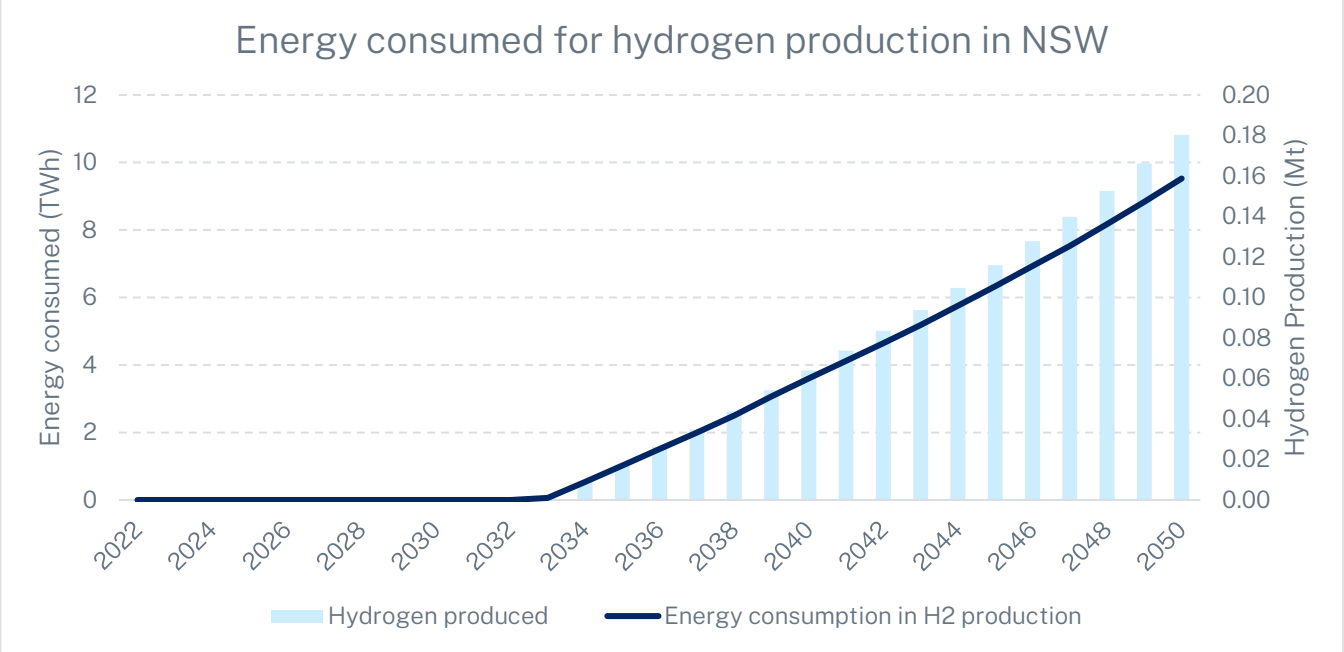

Figure 13: Projection of the energy consumed for domestic hydrogen production in NSW under 2022 ISP Step Change Scenario

Appendix B:

Projects excluded from the no-Roadmap scenario

Table 8 shows a list of projects that do not meet the criterion outlined in Section 2.3.1. These projects are included in the Roadmap scenario but have been excluded from the no-Roadmap scenario.

Table 8: List of projects that are included in the Roadmap scenario but excluded from the no-Roadmap scenario

Project name	Capacity (MW)
Avonlie Solar Farm	254.1
Darlington Point Energy Storage System	25 (50 MWh)
Orana BESS	407.1 (1600 MWh)
Riverina Energy Storage System 1	60 (120 MWh)
Riverina Energy Storage System 2	65 (130 MWh)
West Wyalong Solar Farm	105.2
Wollar Solar Farm	280
Wyalong Solar Farm	62.32

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