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Department of Mines, Industry Regulation and Safety
Energy Policy WA

BRCP Reference Technology Review

Consultation Paper

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Working together for a brighter energy future.

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Abbreviations

Term	Definition
BESS	Battery Energy Storage System
BRCP	Benchmark Reserve Capacity Price
CCGT	Combined Cycle Gas Turbine
CONE	Cost of New Entry
DSM	Demand Side Management
DSOC	Declared Sent Out Capacity
DWER	Department of Water and Environmental Regulation
EIA	Energy Information Administration (USA)
EPWA	Energy Policy WA
ERA	Economic Regulation Authority
ESOO	Electricity Statement of Opportunities
ESR	Electric Storage Resource
ESS	Essential System Services
FOM, Fixed O&M	Fixed Operating and Maintenance costs
FCESS	Frequency Co-Optimised Essential System Services
HEGT	High Efficiency Gas Turbine
LDC	Load Duration Curve
LP	Linear Programme
MIP	Mixed Integer Programme
NOx	Nitrogen Oxides
OCGT	Open Cycle Gas Turbine
OTSG	Once Through Steam Generator
PV	Photovoltaic
RCM	Reserve Capacity Mechanism

Term	Definition
SG	Steam Generator
SRMC	Short-Run Marginal Cost
tCO2e	Tonnes Carbon Dioxide Equivalent
TRT	Transmission Reference Tariff
WACC	Weighted Average Cost of Capital
WEM	Wholesale Electricity Market
WEMSIM	Wholesale Electricity Market Simulation

Executive Summary

Review Outcome 9 of the RCM Review[1] provided for the introduction of a provision in the Wholesale Electricity Market (WEM) Rules that will require the Coordinator of Energy to review the reference technologies for the Benchmark Reserve Capacity Price (BRCP).

This review is implemented in proposed new WEM Rule 4.16.11 as set out in the Exposure Draft of the amended WEM Rules[2].

The first review of the BRCP reference technologies must be conducted to set the reference technologies before the Economic Regulation Authority reviews the BRCP Methodology and to enable the implementation of the Flexible Capacity product.

The BRCP Reference Technology Review aims to ensure that the WEM Rules provide sufficient incentives for investment in new capacity to maintain system security and reliability at efficient cost to consumers.

The objective of the review is to determine the reference technologies for the Peak and Flexible BRCP.

The Market Advisory Committee (MAC) supported the analysis conducted in this review and discussed the following at its meeting on 12 October 2023:

- the approach to shortlisting technologies for each capacity product and shortlist determined through this approach;
- product requirement assumptions, including the need to review the BRCP technologies at regular intervals;
- the economic life and treatment of major overhauls, including the treatment of battery cell replacement as a variable cost;
- upfront capital costs and other fixed costs; and
- the results of the analysis indicating that the BRCP technology for both the Peak and Flexibility products should be a 200MW/800MWh lithium battery energy storage system (BESS).

This report outlines Energy Policy WA's proposals on the BRCP reference technology types for the Peak and Flexible products and the approach to Cost Of New Entry. These proposals are summarised in Table 1.

[1] https://www.wa.gov.au/system/files/2023-08/reserve_capacity_mechanism_review_-_information_paper_stage_2.pdf

[2] https://www.wa.gov.au/system/files/2023-09/reserve_capacity_review_wem_amending_rules_exposure_draft.pdf

Table 1: BRCP Reference Technology Review Proposals

Proposals	Rationale
Proposal A: The proposed efficient new entrants for the Peak and Flex services on a gross basis are: Peak Service: • Lithium BESS. • 200 MW / 800 MWh. • Connected at 330 kV. Flex Service • Lithium BESS. • 200 MW / 800 MWh. • Connected at 330 kV.	The 200 MW/800 MWh BESS has the lowest capital cost and fixed operations and maintenance cost per MW per annum for both the Peak and the Flex product. As the economic lives are assumed to be the same across the options, the 200 MW/800 MWh BESS is the lowest cost new entrant on a gross basis. This technology is capable of meeting the requirements of both the Peak and the Flex services as defined.
Proposal B: The BRCP reference technology should be reviewed every 3 years.	Rapid advancements in technology and market dynamics mean that the selection of reference technology should be reviewed frequently.
Proposal C: Retaining a gross Cost Of New Entry approach is recommended.	While Net Cost Of New Entry may result in lower costs to consumers, the amount of reduction is highly sensitive to other factors. Implementing Net Cost of New Entry adds significant complexity and uncertainty to the BRCP determination procedure. The resulting uncertainty may deter investment, undermining cost efficiency and reliability.

Call for Submissions

Stakeholder feedback is invited on the proposals and analysis of BRCP Reference Technology Review, as outlined in Parts 2-3 of this paper.

Submissions can be emailed to energymarkets@dmirs.wa.gov.au. Any submissions received will be made publicly available on www.energy.wa.gov.au, unless requested otherwise.

The consultation period closes at **5:00pm WST on Thursday 30 November 2023**. Late submissions may not be considered.

1. Introduction

Review Outcome 9 of the RCM Review[3] provided for the introduction of a provision in the Wholesale Electricity Market (WEM) Rules that will require the Coordinator of Energy (Coordinator) to review the Benchmark Reserve Capacity Price (BRCP) reference technologies.

This review is implemented in proposed new WEM Rule 4.16.11 as set out in the Exposure Draft of the amended WEM Rules[4]. The first review of the BRCP reference technologies must be conducted to set the reference technologies before the Economic Regulation Authority (ERA) reviews the BRCP Methodology and to enable the implementation of the Flexible Capacity product.

The BRCP Reference Technology Review aims to ensure that the WEM Rules provide sufficient incentives for investment in new capacity to maintain system security and reliability at efficient cost to consumers.

The objective of the review is to determine the reference technologies for the Peak and Flexible BRCP.

1.1 Background

1.1.1 Relevant Outcomes from RCM review

The Reserve Capacity Mechanism (RCM) Review established high level design changes to the RCM. Some of the relevant outcomes that impact the choice of the Peak and the Flexible Capacity product are as follows:

- Review Outcome 2 of Stage 1 of the RCM Review confirmed that the current Peak Capacity product should remain.
- Review Outcome 3 of Stage 1 of the Review requires the introduction of a new Flexible Capacity product and a Flexible Benchmark Reserve Capacity Price.
- Review Outcome 6 of Stage 1 of the RCM Review establishes that the Reserve Capacity Price for the Peak Capacity product and the Flexible Capacity product can be based on different Benchmark Reserve Capacity Prices.
- Under Review Outcome 9 of Stage 2 of the RCM Review the Coordinator of Energy Coordinator will have to review the appropriateness of the reference technologies for the Peak Capacity product and the Flexible Capacity product at least every five years.

1.1.2 Scope of the BRCP Reference Technology Review

The objective of this review is to determine the reference technologies for the Peak and Flexible BRCP which:

- provide efficient investment signals to ensure system security and reliability; and
- ensure that customers do not overpay for the desired system security and reliability by selecting the most efficient new entry technology.

[3] https://www.wa.gov.au/system/files/2023-08/reserve_capacity_mechanism_review_-_information_paper_stage_2.pdf

[4] https://www.wa.gov.au/system/files/2023-09/reserve_capacity_review_wem_amending_rules_exposure_draft.pdf

The following aspects related to the BRCP are out of scope for this review:

- the methods for setting the BRCPs; and
- the Reserve Capacity Price regime.

The BRCP Reference Technology Review will consist of the two key items:

1. Peak BRCP:
    a. review of the reference technology for the Peak Capacity product and assess whether the current reference technology is still appropriate or if a different reference technology should be selected to represent the most efficient new entry.
    b. review whether gross Costs Of New Entry (CONE) or net CONE should apply to the Peak BRCP.
2. Flexible BRCP
    a. Review of the Reference Technology for the Flexible Capacity product; and
    b. Review whether gross CONE or net CONE should apply to the Flexible BRCP.

1.2 Approach to analysis

The following analysis has been undertaken for the BRCP Technology Review:

1. Establish a long list of potential technologies.
2. Define the requirements that must be met to provide Peak Capacity and Flexible Capacity.
3. Establish a list of candidate technologies for the Peak and Flexible Capacity product.
4. Identify cost data (based on the existing BRCP determination approach) for each of the technologies when delivering each capacity service.
5. Identify additional data for determination of net Cost Of New Entrant (CONE) assessment.
6. Market modelling to inform proposals on gross/net CONE.
7. Develop reference technology and gross/net CONE proposals.

1.3 Call for Submissions

Stakeholder feedback is invited on the proposals and analysis of the BRCP Reference Technology Review, as outlined in Parts 2-3 of this paper.

Submissions can be emailed to energymarkets@dmirs.wa.gov.au. Any submissions received will be made publicly available on www.energy.wa.gov.au, unless requested otherwise.

The consultation period closes at **5:00pm WST on Thursday 30 November 2023**. Late submissions may not be considered.

2. Reference technology analysis

2.1 Long list of potential technologies

The long list of capacity technologies was developed with consideration of the following factors:

- The technology must have a mechanism to be able to be certified for the provision of Reserve Capacity under the existing WEM Rules, as amended by the WEM Amending Rules implementing the outcomes of the RCM Review.
- The technology must be viable in the capacity range of up to 400 MW. Unit sizes bigger than this are not considered technically viable for operation in the WEM.
- The technology must have the potential to meet the emission threshold requirements proposed under the WEM Investment Certainty Review. This requirement excluded generation based on certain fuels.
- The technology must work with existing infrastructure in the WEM for the provision of fuel and the removal of waste. This requirement reflected the fact that an efficient new entrant is most likely to be an incremental development of existing technologies. It is unlikely that an efficient new entrant would be establishing supporting infrastructure from scratch. Amongst other things, this requirement excluded nuclear technologies from the long list.

Table 2. Generation technology long list

Generation Technologies	
OCGT (Heavy Duty)	Lithium Based BESS
OCGT (Aeroderivative)	Vanadium Based BESS
High Efficiency Gas Turbine (HEGT)	Pumped storage
Reciprocating Engine	Solar thermal
CCGT Once Through Steam Generator (OTSG)	Solar PV
CCGT Drum SG	Wind
Fuel Cell	

Table 3. Fuels/energy sources considered for the long list

Fuels/Energy Sources
Liquid
Natural Gas
Solar
Wind
Hydrogen

2.2 Capacity service requirements

Definitions of the requirements of the Peak and Flex Services were necessary to evaluate the long list of reference technologies. The requirements for these Services will ultimately be defined by either the WEM Rules or AEMO to reflect the specific requirements of the system over time. For the purpose of the reference technology evaluations, EPWA has proposed the technologies' service definition shown in Table 4, Table 5 and Table 6.

Table 4. Peak Service – Other than Storage

Parameter	Setting	Comments	Impact on Short List
Operational Duration	14 hours with 3-day recharge		Liquid storage size Requirement for gas transport contract / line pack
Operating Temperature	41° Celsius	Existing	Rated capacity
NOx emissions	150 mg/m^3	DWER approval at Kwinana	Requirement for Dry Low NOx or water NOx control
Carbon emissions intensity	0.55 tCO_2e/MWh	Based on latest proposal for emissions thresholds	Excludes diesel fuels and heavy duty gas turbines
Capacity factor	10%	Based on demand side programmes (DSPs) meeting the last tranche of peak demand, and this facility meeting the next portion of the Load Duration Curve (LDC)	Operational life considerations

Table 5. Peak Service – Storage

Parameter	Setting	Comments	Impact on Short List
Operational Duration	4 hours	Match existing requirements on Electric Storage Resource technology	Battery storage duration
Operating Temperature	41° Celsius	Existing	Rated capacity
NOx emissions	None	Not required	Emissions accounted for at generation, not at charge
Carbon emissions intensity	None	Not required	Emissions accounted for generation, not charging
Capacity factor	10%	Based on DSP meeting the last tranche of peak demand, and this facility meeting the next portion of the LDC.	Operational life considerations

Table 6. Flex Service

Parameter	Setting	Comments	Impact on Short List
Must meet all Peak Service Requirements			
Ramp rate	100% capacity in 30 min	Estimated requirement after ESS support short term ramps	Excludes some CCGT
Start time	30 minutes	Start time within ESS response	Excludes CCGT
Minimum online generation	25%	Not technically required but minimizes market impact, no worse than ESS requirements	Excludes CCGT
Capacity factor	Daily operation	Flex service required daily	Shortens BESS economic life

Pumped storage meets the requirements of Table 5 and can meet the requirements of Table 6 with appropriate design. It has been excluded from the short list due to the need for scale significantly higher than the 200MW reference scale discussed in section 2.4.1 and the significantly higher capital cost per unit of capacity, which makes it significantly more expensive than the other options.

2.3 Technology short list

The short list of technologies (Table 7) has been established based on the column “Impact on the short list” in Table 4, Table 5, and Table 6.

Table 7. Technology short list

Peak Service	Flex Service
Super Aero GT (HEGT) on gas	Super Aero GT (HEGT) on gas
Reciprocating engines (15MW) on gas	Reciprocating engines (15MW) on gas
Lithium BESS	Lithium BESS
Vanadium BESS	Vanadium BESS
CCGT with OTSG	Aero GT (e.g., LM6000) on gas

2.4 Assumptions for assessment of technology costs

2.4.1 Scale of reference technology

In developing a new relevant project there are a range of costs that do not change with the scale (MW) of the project. These costs include project development costs, owners' engineer costs, approvals and financing. Consequently, the cost efficiency of a new entrant improves with scale within the capacity of the connection to the grid.

The capacity of the connection to the grid is defined by the connection voltage. Each voltage represents a step change in cost with the most efficient new entrant using the full transfer capacity provided by that connection voltage. Table 8 provides the maximum capacity for each connection voltage adopted in the assessment of reference technologies.

Table 8. Scale of reference technology

Voltage	Maximum Scale
22kV	15MW
132kV	100-150MW
220kV	150-200MW
330kV	200-500MW

Natural gas supply is most economically delivered by proximity to existing pipelines. There are a range of locations that have 132 kV and 330 kV transmission infrastructure in close proximity to the Dampier-Bunbury Pipeline including Kwinana, Pinjar, and the 330 kV transmission line north to Three Springs. For these reasons, only 132 kV and 330 kV connections were considered further.

Market intelligence suggests there is limited capacity to connect new generation to the 132 kV network, particularly in the locations close to the Dampier-Bunbury Pipeline. For this reason, the 132 kV connection has been excluded.

At the 330 kV connection voltage, scale becomes limited by the requirement to provide Contingency Reserve services for a new technology. Under the runway model for recovery of Contingency Reserve Raise, larger facilities contribute a more significant proportion of the cost. NewGen Kwinana has the highest Certified Reserve Capacity at 327 MW. For this BRCP Reference Technology Review, a reference scale of 200 MW connecting at 330 kV has been adopted. The actual capacity under each technology will vary slightly from this reference size.

BESS Efficient Size

BESS does not require connection to the natural gas pipeline and has a lower economy of scale than other technologies (cost per MW does not decrease significantly as size increases). Consideration was given to the connection of lithium BESS at zone substations using existing 22 kV circuits used for capacitor banks. Under this proposal, the lithium BESS would provide the following services:

1. Reactive power supply.
2. Active power supply to reduce the peak load on the zone substation transformers and therefore defer or remove the need for capital upgrades.
3. Active power for the Peak services.
4. Active power for the Flex service.

5. Reserve for ESS markers.
6. Provision of energy.

Under the existing framework, items 1 and 2 above are network control services procured by Western Power, and items 3 to 6 are procured or managed by the AEMO under the WEM Rules.

If the economic value of providing services 1 and 2 were realised, it is most likely that 15 MW BESS connected in this manner would be the most efficient new entrant. In a centrally planned system this would be the most efficient new investment for the provision of capacity.

However, the structure and operation of the WEM Rules do not provide a basis on which to forecast the value of the Network Control Services of items 1 and 2. Without a value for items 1 and 2, items 3 to 5 can more efficiently be delivered under the 200 MW 330 kV connection. The contribution items 5 and 6 make to the efficient new entrant are considered in the net CONE versus gross CONE analysis.

Connection at an existing wind or solar site

Connection costs are ultimately a matter for the ERA's BRCP Methodology, but this review needs to make some assumptions to determine the appropriate technology.

Some recent proposed projects do not involve a new connection, but rather installing new equipment at an existing High Voltage connected site to make better use of existing Declared Sent Out Capacity (DSOC). Capacity connected in this way would have lower connection costs than a new standalone facility but relies upon development by an existing participant at an existing site.

This assumption may be considered further by the ERA. However, the analysis in this assessment has assumed a new 330 kV connection for all technologies.

2.4.2 Economic life

Table 9 specifies the assumed economic life for each shortlisted technology.

Table 9. Assumed economic life

Technology	Economic Life
Peak Service (10% capacity factor during small number of peak intervals)	
Super Aero GT (HEGT) on gas	25 years
Reciprocating engines (15MW) on gas	25 years
Lithium BESS	25 years
Vanadium BESS	25 years
CCGT with OTSG	25 years
Flex Service (daily cycling)	
Super Aero GT (HEGT) on gas	25 years
Reciprocating engines (15MW) on gas	25 years

Lithium BESS	25 years
Vanadium BESS	25 years
Aero GT (e.g. LM6000) on gas	25 years

Economic life assumptions

While assumed economic life is a matter for the ERA's BRCP Methodology, this review requires assumptions to support the economic modelling.

The current BRCP procedure uses a 50-year life but, given the move to net zero emissions by 2050, this review has assumed gas generation has an economic life of 25 years. It may be possible to extend life beyond 25 years by using green fuels (hydrogen/biogas), but the availability and cost of doing so is currently uncertain.

In the early stages of the assessment, different economic lives were established for each of the technologies and they varied between the Peak and the Flex Services. However, it was recognised that major overhauls were equivalent to the cell replacement for lithium BESS and that major overhauls were typically modelled as a variable cost component, as discussed further below. The result of including cell replacements as a major overhaul cost was that the same economic life was adopted for all technologies for all services.

Major overhauls as a variable cost component

Flexible Capacity providers will incur greater maintenance costs than Peak providers. These costs include reducing the time between major overhauls and cell replacement. Under the current practice in the WEM, these maintenance costs are recovered from the energy market as variable costs.

The analysis assumes that the costs of all major overhauls and end of cell life replacements are recovered though energy market offers (including through the BESS buy/sell spread). These costs are excluded from capital costs and will be considered in the economic analysis.

2.5 Technology Cost Results

In this section, we provide comparisons of the relative costs of each of the shortlisted technologies (and also the existing reference technology for comparison). These have been calculated based on the assumptions specified in section 2.4.

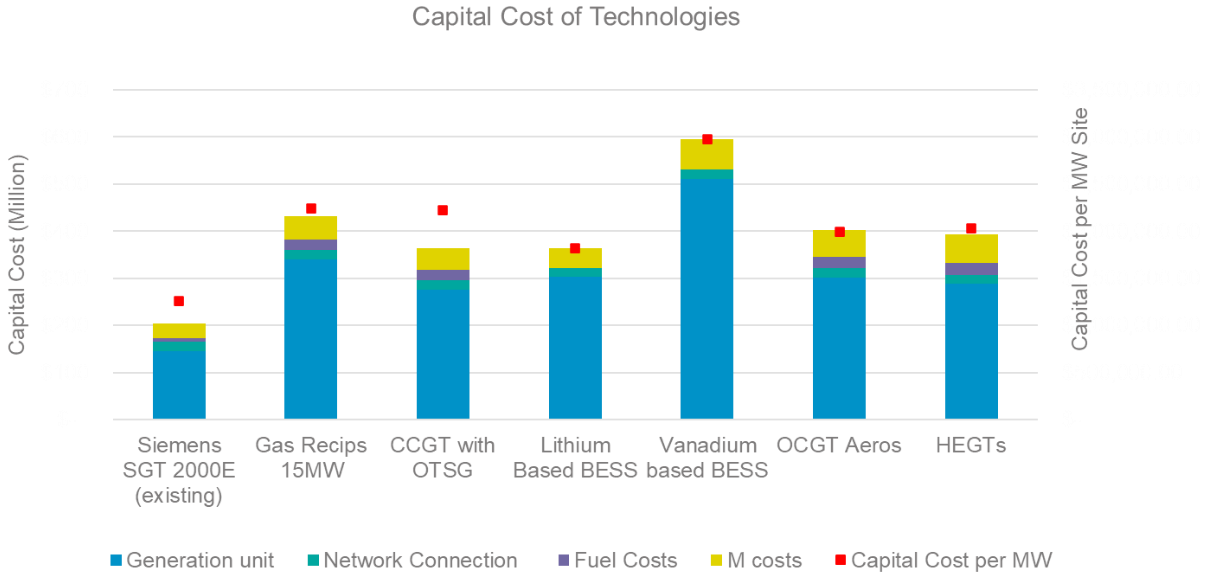


Figure 1. Capital costs of shortlist technologies

Figure 1 compares the components of the total capital cost of each technology type. The red dot provides the capital cost per MW, as the total MW delivered under each technology vary around the 200 MW reference due to unit size. Capital costs per MW is calculated using capacity at the site conditions (temperature, humidity, wind). The capital costs are based on data from the CSIRO cross checked against recent projects in Western Australia.

The Siemens SGT2000E (OCGT running on liquid fuel) is not in the short list but is the existing refence technology and is provided as a basis for comparison.

The purple component provides for the gas lateral. For both aeroderivative gas turbine technologies and HEGTs, a compressor station is also included. The size (diameter) of the gas lateral has been scaled to provide storage for 14 hours supply for gas-fired technologies.

Figure 1 demonstrates that the 200 MW/800 MWh Lithium BESS has the lowest capital cost per MW.

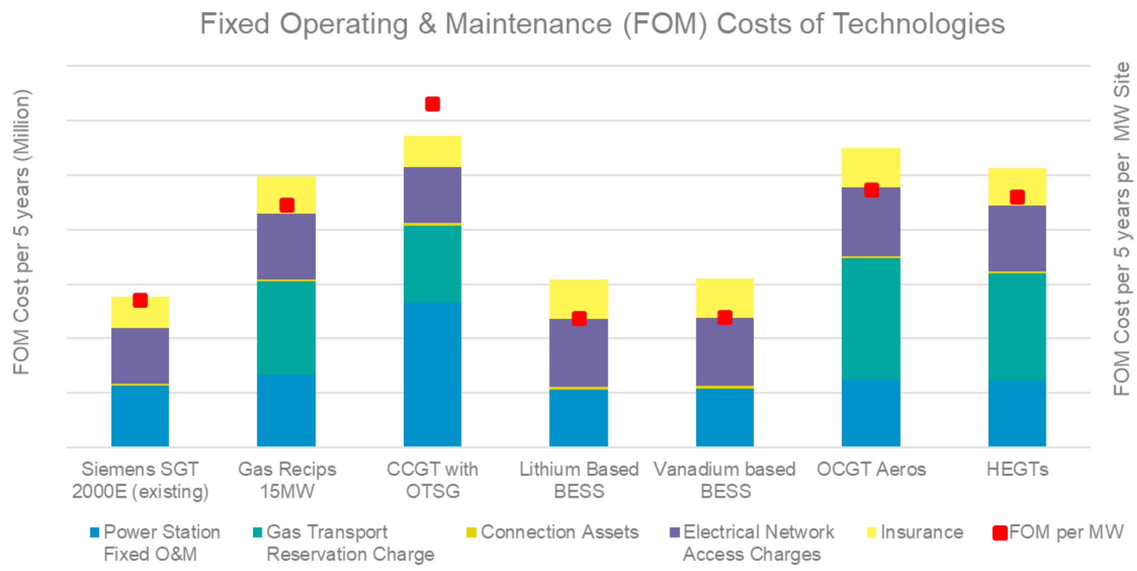


Figure 2. Fixed operating and maintenance costs of shortlist technologies

Figure 2 provides the components of the annual fixed O&M for each option. Again, the red dot provides the total fixed O&M per MW per annum as the total MW delivered under each technology vary around the 200 MW reference due to the unit size.

The gas transport reservation charge (shown in teal) allows for sufficient gas for ~4 h/day, or 14 h on one day then two days to replenish the lateral line pack.

Electrical network access charges are for Western Power's storage TRT3 (Bidirectional for Storage) adopted with price as TRT2 (Entry Service).

2.5.1 Changes in costs relative to the existing reference technology

As shown above, the lithium-based BESS is the lowest cost shortlisted reference technology. This is more expensive than the current reference technology in terms of capital cost and less expensive in terms of fixed operating costs. This section provides a breakdown of the components of these cost changes relative to the current reference technology.

Capital Costs

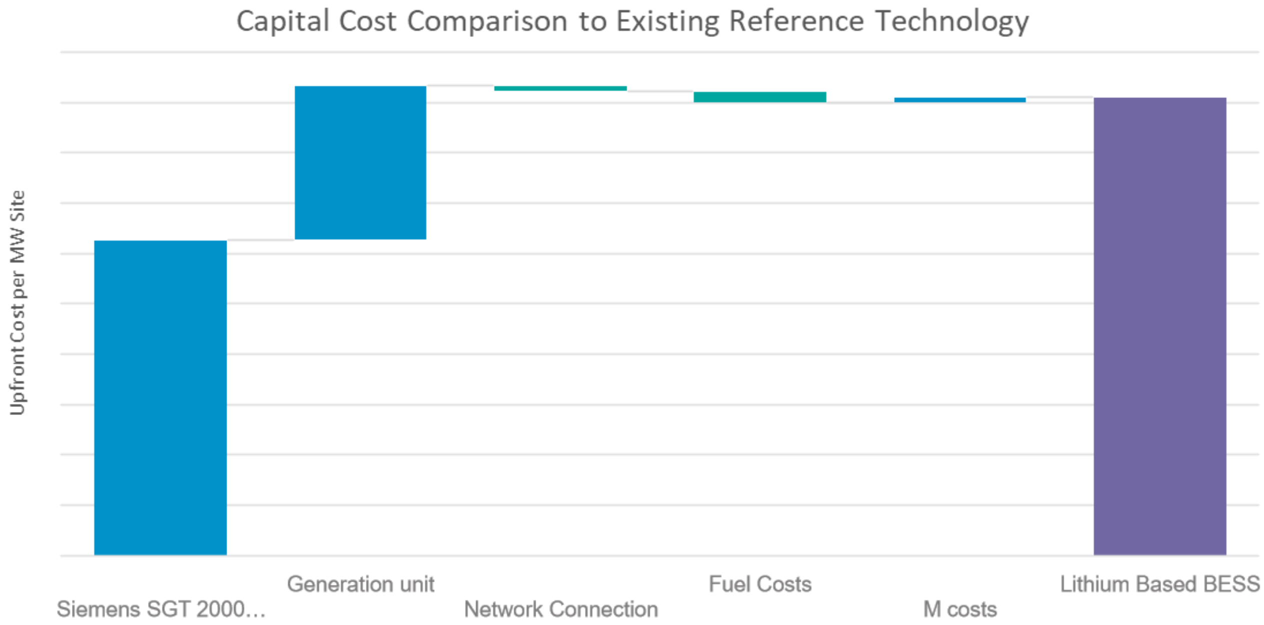


Figure 3. Components of capital cost change

Figure 3 demonstrates how the components of the capital cost change against the existing reference technology.

- Generation Unit: The capital cost of a 200 MW/800 MWh BESS is higher than that of the OCGT SGT 2000.
- Network Connection: The costs of the network connection are the same but the 200 MW BESS delivers more capacity within that cost.
- Fuel Costs (cost of storage): The 200 MW/800 MWh BESS does not require the 14 hours liquid storage that the existing reference technology does.
- M Costs (M-factor): The 200 MW/800 MWh BESS avoids some environmental approvals costs but has higher insurance costs as a result of the higher unit capital.

Fixed Operating Costs

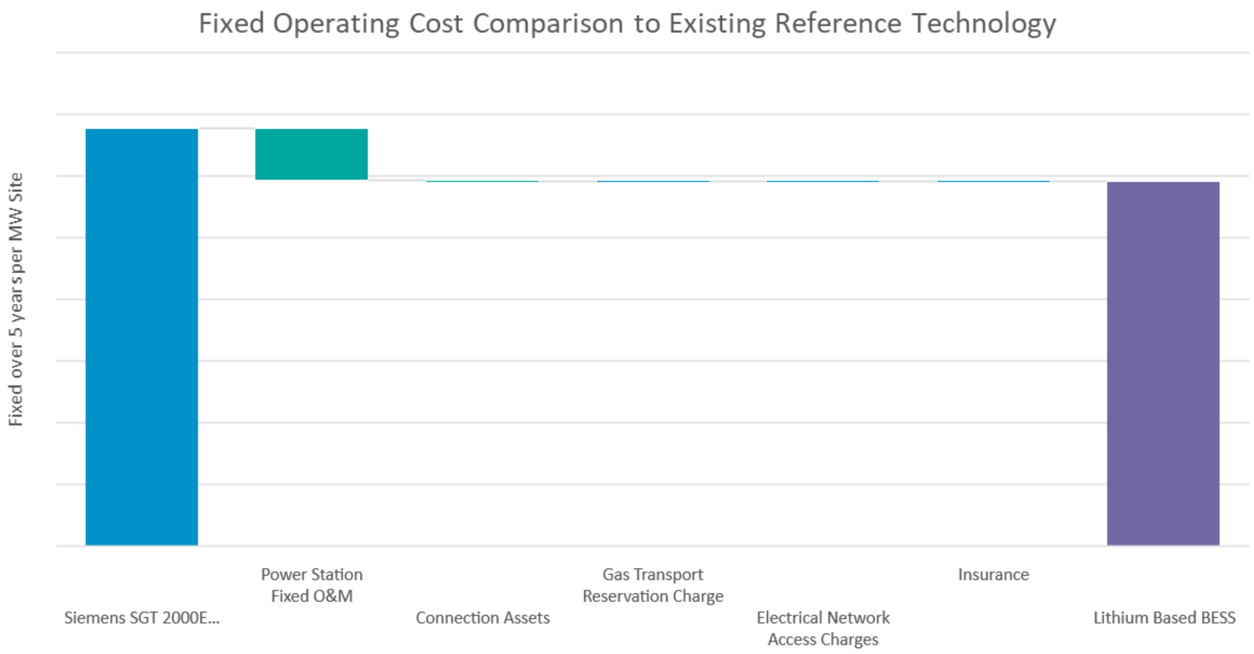


Figure 4. Components of fixed operating cost change

The components of the fixed operating cost changes are as follows:

- Power Station Fixed Operating and Maintenance Costs: Lower fixed operating costs of BESS due to less time-based maintenance activities.
- Connection Assets: The costs of the network connection are the same but the 200 MW BESS delivers more capacity within that cost.
- Gas Transport: No charge, same as the liquid fuel existing reference technology.

2.5.2 Implications

- The existing 160 MW OCGT with 14 hours of liquid fuel remains the least cost new entrant (per MW) until the 0.55tCO_2e / MWh emission threshold becomes binding on new entrant generators.
- The new reference technology will result in higher BRCP than the existing due to:
  - Emissions intensity threshold excluding liquid fuels, resulting in higher capital costs and/or gas transport charges.
  - Materially lower economic lives (25 years vs 50 years).
- There appears to be little difference in capital and fixed costs for Peak Service and Flex Service:
  - All shortlisted technologies except for the CCGT (HEGTs, Gas-fired Reciprocating Engines, Aero-derivative Gas Turbines and BESS) can meet the requirements of both Services.
  - The different operating profile required for the Flex Service will result in increased costs from more frequent maintenance requirements, where every cycle and hour of operation brings the facility closer to a major overhaul. However, this increased maintenance requirement is usually apportioned as a variable cost component, and therefore can be incorporated into energy offers.

2.6 Proposed BRCP Reference Technologies

The 200 MW/800 MWh BESS has the lowest capital cost and fixed O&M cost per MW per annum. As the economic lives are the same across the options, the 200 MW/800 MWh BESS is the lowest cost new entrant on a gross basis. This technology is capable of providing the Peak and the Flex Services as defined.

As a result, the proposed efficient new entrants for the Peak and Flex Services on a gross basis are:

Peak Service:

- Lithium BESS.
- 200 MW / 800 MWh.
- Connected at 330 kV.

Flex Service

- Lithium BESS.
- 200 MW / 800 MWh.
- Connected at 330 kV.

Proposal A:

The BRCP reference technology type for both the Peak and Flex Services is a 200MW/800MWh lithium BESS connected at 330 kV.

Consultation questions:

1. Based on the analysis, do stakeholders agree with the proposed reference technology for the Peak Capacity product?
2. Based on the analysis, do stakeholders agree with the proposed reference technology for the Flexible Capacity product?

2.6.1 RCMRWG Feedback

The material in section was presented to the RCM Review Working Group (RCMRWG) on 21 September 2023. Members were generally comfortable with the recommendations.

Key discussion points were as follows:

- Regarding the assumed 4-hour duration for storage technologies, there was a question if longer storage duration (e.g., 6 hours) should be considered to address future requirements.
  - Modelling to date indicates that longer duration storage will be required only after baseload plant retires (e.g., after 2030).
  - Setting the BRCP on longer duration storage now will inflate prices for consumers before the need actually arises.
  - Given the rapid industry transition, the BRCP technologies must be reviewed at regular intervals (e.g., every 3 years).
- A member was concerned that 4-hour storage will not cover long-term system security requirements e.g., “renewables droughts”.
  - Covering these is not the purpose of the Peak product (to meet peak demand) and Flex product (to meet the afternoon ramp).
- There was a question regarding the treatment of battery cell replacement as a variable cost, and not including it in the capital and fixed operating costs.
  - It was confirmed that this is consistent with the ERA offer construction guideline.

- There was a concern that, as diesel fuelled Gas Turbines are the lowest cost new entrant until emissions limits are binding, introducing the new BRCPs early may enhance incentives for new diesel plant to enter the system.
  - There was general agreement that it is unlikely that anyone will consider building new diesel fuelled Gas Turbines now, given that the emissions limits are imminent.

2.6.2 Market Advisory Committee Feedback

The material in this section was presented to the Market Advisory Committee (MAC) on 12 October 2023. Key discussion points were as follows:

- There was discussion regarding the assumed 25-year economic life.
  - This is an issue for the ERA to decide as part of its BRCP determination process, however a value needed to be assumed for this analysis.
  - 25 years is reasonable and driven by the 2050 net-zero target.
  - A longer life could be assumed for a gas-fired generator on the assumption that it would convert to using hydrogen fuel.
- There was discussion on the merits on using a storage device (i.e., the lithium-based BESS) rather than a generation device for the BRCP reference technology. The concern was that the price of lithium batteries will continue to decline significantly over time, with the result being that the only technologies that will enter the market will be BESS, rather than the mix of technologies that the WEM requires.
  - While, since the start of the RCM the price has been based on 160 MW OCGT with 14 hours of liquid fuel, and a range of technologies have entered the market.
  - The analysis shows that the price resulting from adopting lithium BESS as the reference technology will significantly increase the BRCP.
- It was questioned whether 4 hours of storage will be sufficient in a market with growing demand, and the potential for extended periods of low renewables output.
  - Previous modelling results from the RCM review showed that 4 hours will be sufficient in the near term.
  - Updated modelling results have been provided specifically addressing the issue of ‘renewables droughts’. These have also confirmed the extent to which a 200MW facility will be utilised (see the following section).
- There was concern expressed regarding the potential increase in cost to consumers from the change of reference technology. However, the need to incentivize the right sort of technology was recognised.
  - There was general support for adopting the new reference technology as soon as possible.

2.6.3 Additional modelling

Renewables Volatility

As noted above, previous modelling results from the RCM review showed that 4 hours duration storage will be sufficient to maintain system adequacy in the near term. However, it was noted during the RCMRWG and MAC meetings that this modelling did not contain a representation of the ‘renewables drought’ as recently experienced in WA, in which output from both wind and solar were significantly decreased for a period of several days.

To address this, the Wholesale Electricity Market Simulation (WEMSIM) model has been updated to use actual renewable generation profiles from October 2022 to September 2023, rather than profiles that are averaged over multiple years. This was based on SCADA and curtailment data provided by AEMO. In this way, the volatility in renewables output that has been experienced recently were included in the model.

The model was re-run, and the effect on system adequacy was examined via the Energy Not Served (ENS, i.e. dropped load) output of the model. The purpose of this modelling is to show whether system adequacy would be maintained under these conditions with 4-hour battery storage.

The results showed zero ENS for the 10-year modelling horizon starting from 2024 for the modelled scenario, confirming the adequacy of 4-hour storage for the near term. However, this is a result that will need to be monitored as developments in demand growth and new build will vary over time relative to this modelling scenario. This underscored the importance of frequent reviews of the BRCP reference technology.

Utilisation of a 200MW facility

These results also forecast the utilisation of a 200MW/800MWh BESS facility. The utilisation of the facility is shown in Figure 5. Utilisation of 200MW/800MWh BESS facility, in which 100% utilisation means discharging at its full MWh capacity on a daily basis:

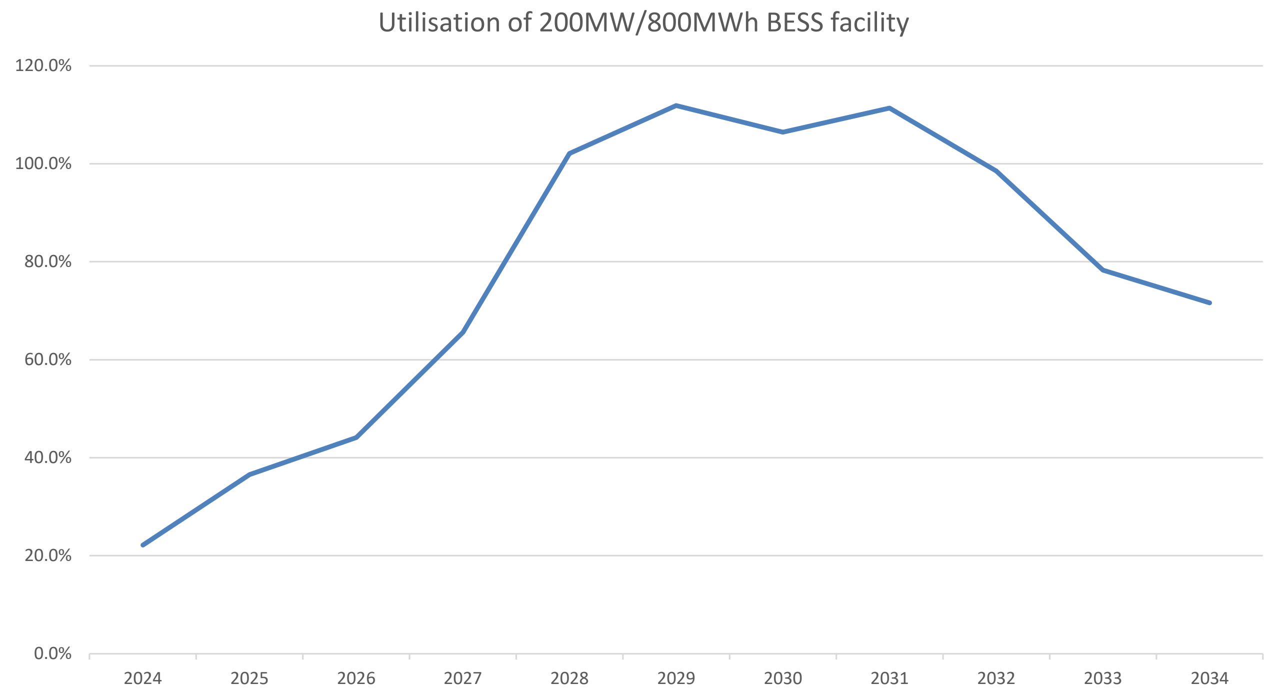


Figure 5. Utilisation of 200MW/800MWh BESS

Several features can be noted from these results:

- While utilisation is initially low in the first year, it climbs to high levels in the next few years.
- From 2028 to 2031, utilisation is greater than 100%, indicating there are occasions when cycling more than once in a day is economic.
- Utilisation decreases after 2031, as more BESS facilities enter the market, competing with this facility.

While the modelling results confirmed that system adequacy would be maintained under low renewable generation conditions with 4-hour battery storage, rapid advancements in technology and market dynamics mean that the selection of reference technology should be reviewed frequently.

Proposal B:

The BRCP reference technology should be reviewed every 3 years.

Consultation questions:

3. Do stakeholders agree with the proposed frequency of BRCP reference technology reviews?

3. Net vs Gross CONE Analysis

3.1 Introduction

This section details the analysis performed to address the question of whether gross or net CONE (Cost Of New Entry) should be adopted for the BRCP.

This involves financial modelling performed in RBP's WEMSIM model of the WEM to analyse whether the proposed new reference technology would be the marginal energy supplier and estimate the BRCP levels that would result from gross or net CONE approaches.

3.2 Criteria

The criteria applied to decide whether gross or net CONE should be applied are as follows:

- For Peak BRCP:
  - If the reference technology would be the marginal energy supplier (under the WEM Rules expected to be in place under the WEM Amending Rules implementing the RCM Review) – gross CONE should be applied.
  - If not, further assess whether applying net CONE would be more appropriate.
- For Flexible BRCP:
  - If the reference technology would be the marginal energy supplier in the intervals Flexible Capacity would be required (under the WEM Rules expected to be in place under the WEM Amending Rules implementing the RCM Review) – gross CONE should be applied.
  - If not, further assess whether applying net CONE would be more appropriate.

3.3 Methodology

The modelling methodology used is as follows:

- Perform market modelling of the WEM under the new Market Rules. The modelling is performed using RBP's WEMSIM model – an update of the same model used for the RCM review.
- Include a facility representing a unit of the recommended BRCP reference technology – i.e., 200MW/800MWh lithium BESS.

WEMSIM is a tool which simulates and optimises the dispatch of resources in a multi-regional transmission framework to meet the requirement demand. WEMSIM uses Linear Programming (LP) and/or Mixed Integer Programming (MIP) for solving the optimal dispatch problem while taking into account transmission and other technical constraints.

For the purposes of this review, the WEM from 2024 to 2034 has been modelled and the following market results have been forecast:

- Energy market prices – average and captured by the facility

- Marginal cost of generation for the BESS facility, including captured prices at time of charging
- Net market revenue for the BESS facility, including captured prices at time of discharging, and ESS revenues
- Gross CONE and net CONE

3.4 Assumptions

The same assumptions (e.g., retirement assumptions, technical characteristics of existing facilities, etc.) as those for Stage 1 and 2 of the RCM review have been used with the addition of the new candidate facility.

Modelling assumptions are documented in Appendix A.

3.5 Modelling results

The following sections show the key results of the modelling.

3.5.1 Marginal Energy Supplier

If the reference technology is the marginal energy supplier, we would expect the spot energy price to be reflective of the technology's short-run marginal cost (SRMC). In this case, this SRMC for a BESS is inclusive of the cost of energy to charge the battery – i.e. the captured price at the time of charging.

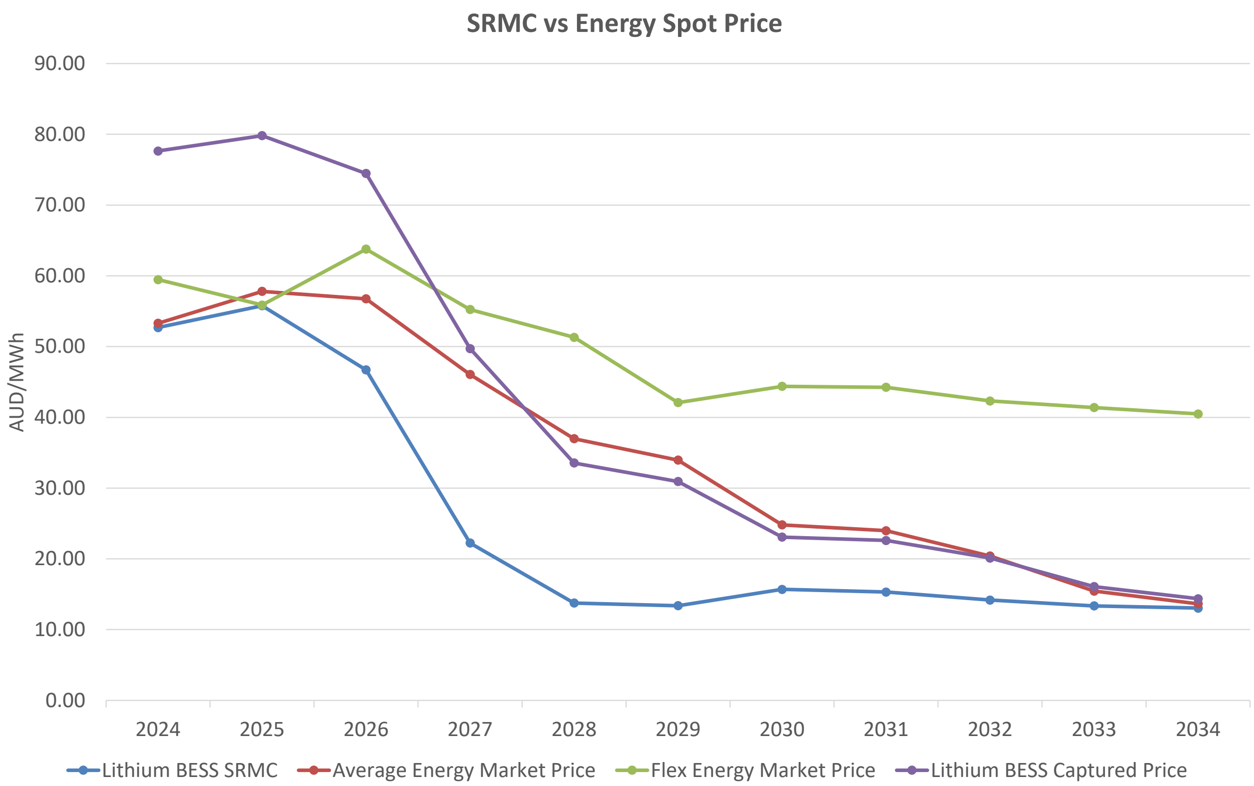


Figure 6 - Lithium BESS SRMC vs energy spot price

The market modelling results in Figure 6 show that lithium BESS SRMC (including cost of charging at captured market price) is generally significantly lower than the energy clearing price, and the clearing price during flex intervals. The modelling approach was consistent with ERA's Offer Construction Guideline which allows the inclusion of the opportunity costs of charging (including cycling costs).

Conclusion: A lithium BESS would not be the marginal energy supplier (for either Peak or Flex products) for the next 10 years.

However, the gap narrows as more renewable and BESS facilities are built, lowering the clearing prices. The modelling forecasts that the gap is almost zero by 2034.

3.5.2 Gross and Net CONE

This section provides the gross and net CONE results from the market modelling.

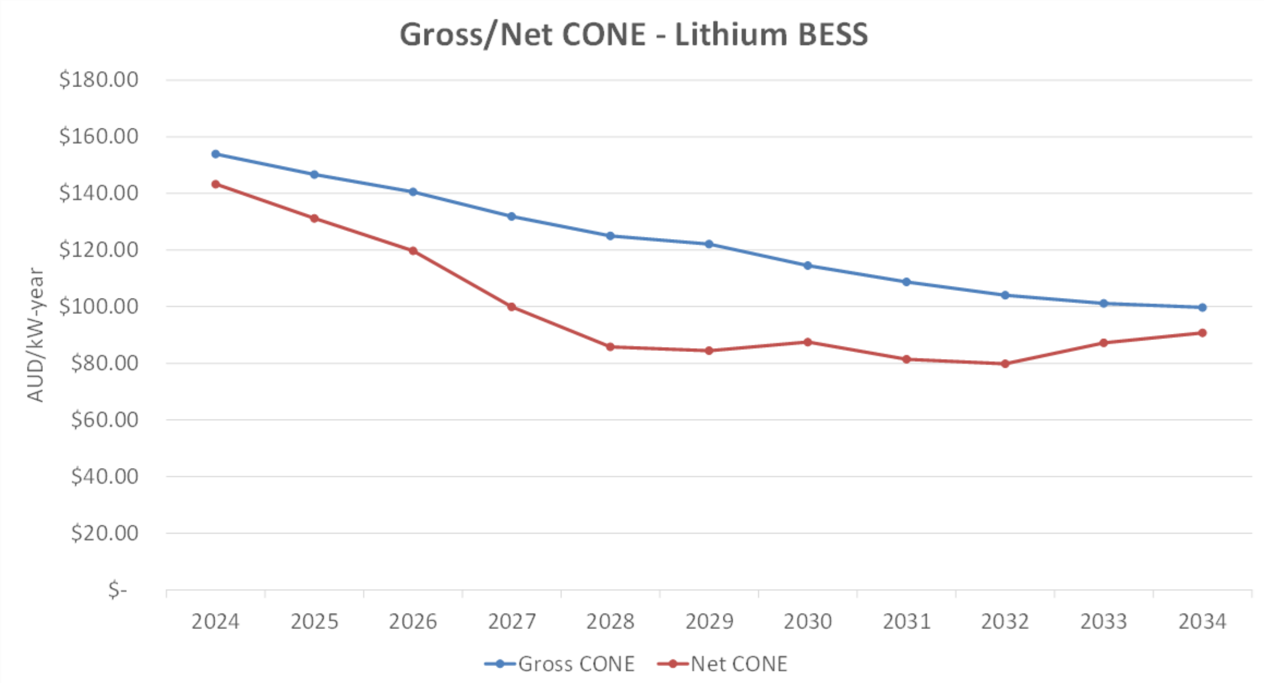


Figure 7. Gross/Net CONE - Base

Figure 7 shows that in most years, net CONE is significantly lower than gross CONE, indicating that the facility is making substantial net revenue from the energy and Essential System Service markets. Therefore, net CONE could result in significant savings for consumers.

However, these results are highly dependent on input assumptions. As a demonstration of the sensitivity of the net CONE analysis, Figure 8 shows the results of a scenario in which an additional two BESS facilities are constructed in 2025 (each 200MW/800MWh).

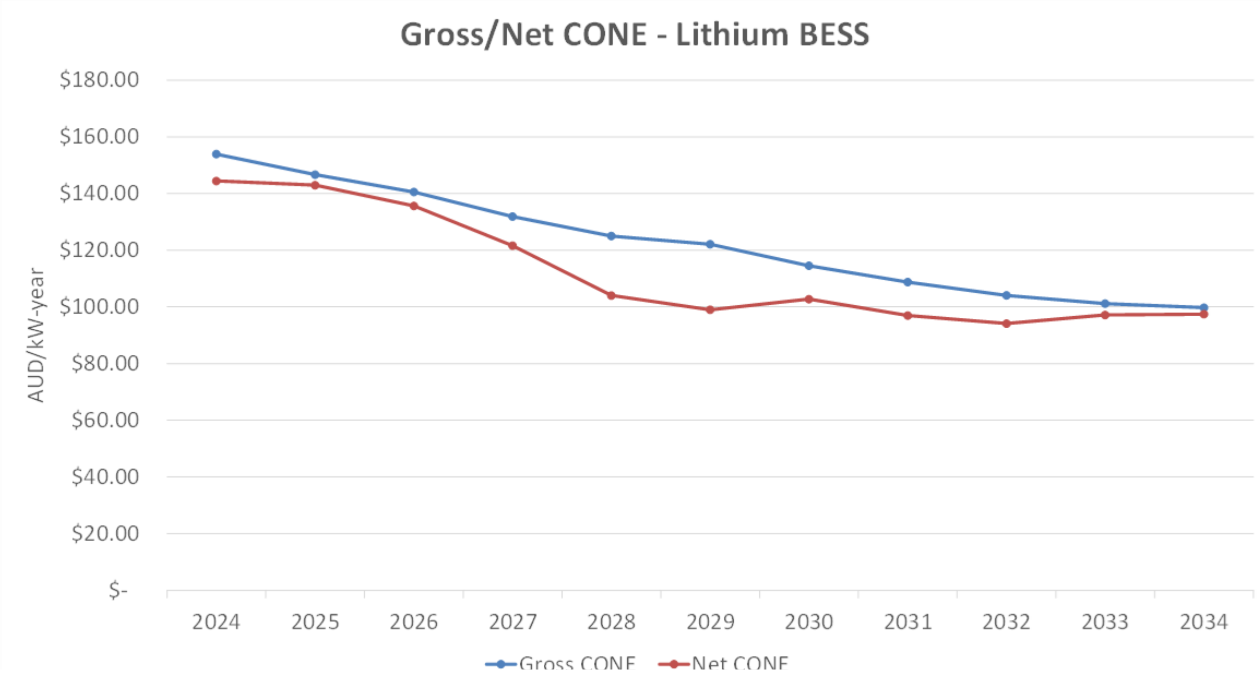


Figure 8. Gross/Net CONE - Sensitivity

The difference between gross and net CONE is significantly reduced as the competition reduces the original facility's net revenue.

Gross and Net CONE – High Efficiency Gas Turbine

Figure 9 shows the result of the above analysis repeated, but for a High-Efficiency Gas Turbine (HEGT) rather than a lithium BESS. The purpose is to show whether the lithium BESS is still the least-cost option when calculated on a net CONE basis. While the analysis presented in section 2 above showed that a lithium BESS was the least cost option on a Gross CONE basis, the purpose of this sensitivity is to confirm that this is still true on a net CONE basis.

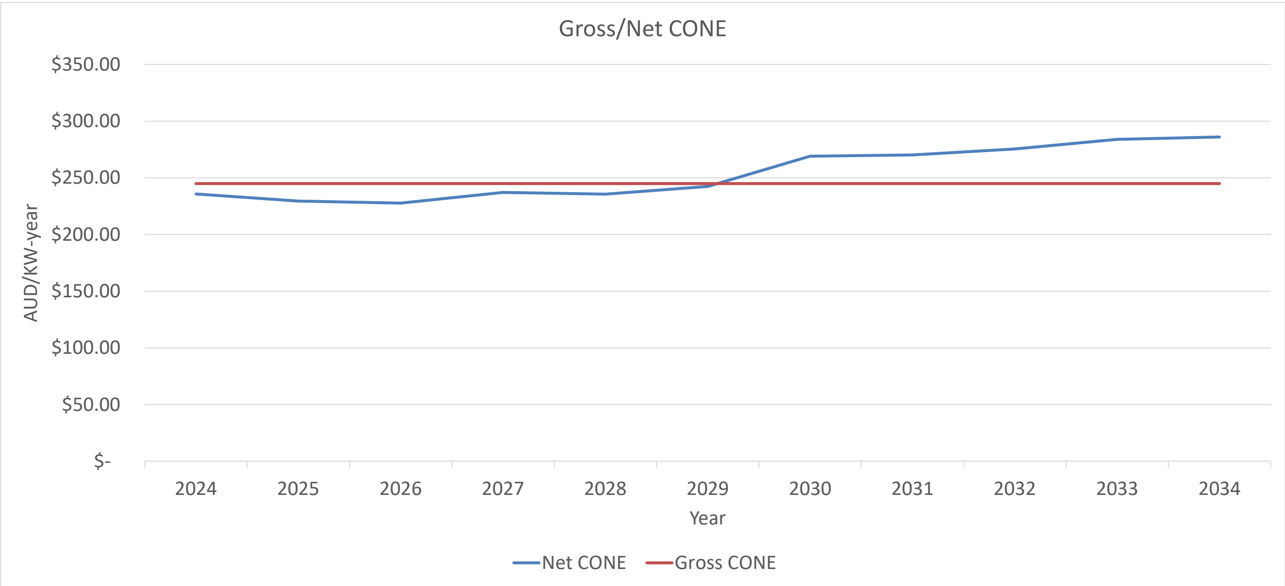


Figure 9. Gross/Net CONE - HEGT Sensitivity

These results show that the net CONE of the HEGT is significantly higher than the lithium BESS. This confirms that the BESS is the least cost option on both a gross and net CONE basis.

3.6 Further Assessment

The following is an assessment of the relative advantages and disadvantages of gross CONE and net CONE approaches:

Net CONE Advantages

- Potentially lower cost to consumers

Net CONE Disadvantages

- Requires forward-looking modelling to forecast net revenues
- This is highly sensitive to input assumptions, such as cost changes, other new build, retirements, renewables output, fuel prices, etc.
- Consensus will be difficult to achieve
- Resulting uncertainty may deter investment, undermining cost savings and reliability

Gross CONE Advantages

- Relatively predictable BRCPs provide investment certainty
- More straightforward BRCP determination process
- Consistent with current BRCP methodology

Gross CONE Disadvantages

- Potentially higher cost to consumers

3.7 Conclusion and recommendation

From the above analysis, EPWA has drawn the following conclusions:

- While net CONE may result in lower costs to consumers, the amount of reduction is highly sensitive to other factors.
- Implementing net CONE adds significant complexity and uncertainty to the BRCP determination procedure.
- The resulting uncertainty may deter investment, undermining cost savings and reliability.

Consequently, EPWA proposes to retain a gross CONE approach.

Proposal C:

Retain a gross Cost Of New Entry approach to BRCP determination.

Consultation Question:

4. Do stakeholders agree with the proposal to retain the gross Cost Of New Entry approach to BRCP determination?

Appendix A. Modelling assumptions

A.1 Load assumptions

The demand profile was generated using values from the 2022 Electricity Statement of Opportunities (ESOO). It is noted that the annual demand values are slightly different than the ESOO figures, as the modelling uses the calendar year while the ESOO uses the Capacity Year.

It is also noted that a higher demand growth rate (as in the 2023 ESOO) would mean that the effects seen later in the period (i.e. the BESS SRMC converging to the energy market price, and narrowing the gap between gross and net CONE) would happen earlier. This would further strengthen the case for retaining the gross CONE. The volatility of demand growth forecasts from one ESOO to the next underscores the importance of the proposal for another review in three years.

Table 10: Demand Assumptions

Year	50% POE Peak (MW)	Expected Annual Demand (GWh)
2024	3,821	16,153
2025	3,855	15,838
2026	3,899	15,738
2027	3,934	15,723
2028	3,967	15,687
2029	4,018	15,610
2030	4,075	15,706
2031	4,141	15,920
2032	4,269	16,180
2033	4,341	16,112
2034	4,419	16,094

A.2 Fuel Prices

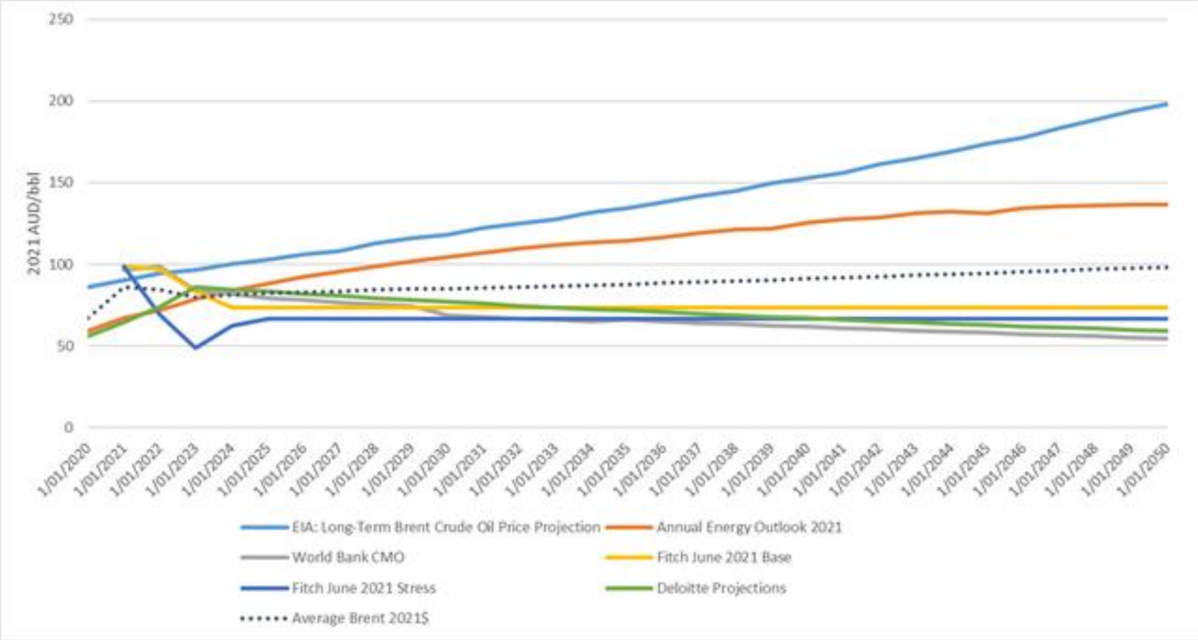
A.2.1 Crude

Crude oil forecasts are used as inputs to the energy price forecasts. The following six published crude outlooks were used as data sources in the model to project the crude oil prices until 2050:

- EIA: Long Term crude oil price projection.
- Annual Energy Outlook 2021.
- World Bank Commodity price forecast.
- Fitch Oil price projections:
  - Base case.
  - Stress case; and
- Deloitte price forecast.

These six crude oil outlooks are illustrated in Figure 10.

Figure 10: Brent Crude Price Projections



The average of the six crude oil price outlooks were used to generate the assumed Brent Crude Prices that was used in the model.

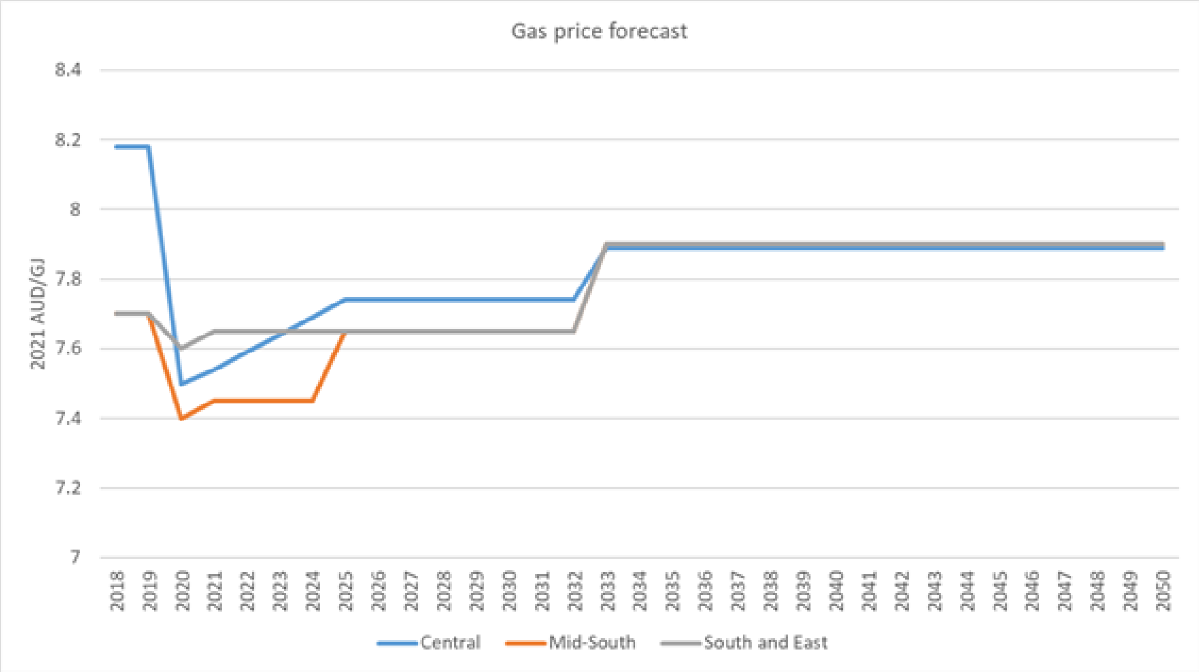
A.2.2 Natural Gas

Natural gas prices were provided by the base case of AEMO's *Wholesale, Delivered Gas Price Scenarios | 2020 – 2050, Core Energy & Resources, (2021)*. Prices differ regionally as per CORE forecasts and are separated into three groups:

- Central: Kwinana, Pinjar, Neerabup, and Cockburn.
- Mid-South: Wagerup and Pinjarra.
- South and East: Kemerton and Kalgoorlie.

Based on these forecasts, the gas prices used in the model are illustrated in Figure 11.

Figure 11: Gas Price Projection



A.2.3 Coal

Coal-fired generators in WA receive coal directly from WA coal mines under a contract. The terms of these contract are not public, so the cost of this coal must be estimated for modelling purposes.

WA coal is not exported beyond WA, so it does not receive global market prices.

Data on the quantity and value of coal produced in WA is provided in the *2020 Major Commodities Resources Data*, published by the Government of Western Australia Department of Mines, Industry Regulation and Safety.[5] The projected coal prices in Figure 12 are calculated by taking the average of the last five years' coal prices and assuming a calorific value of 19.7 GJ/t.[6]

5 https://www.dmp.wa.gov.au/About-Us-Careers/Latest-Statistics-Release-4081.aspx

6 Guide to the Australian Energy Statistics 2017: https://www.energy.gov.au/sites/default/files/guide-to-australian-energy-statistics-2017_0.docx

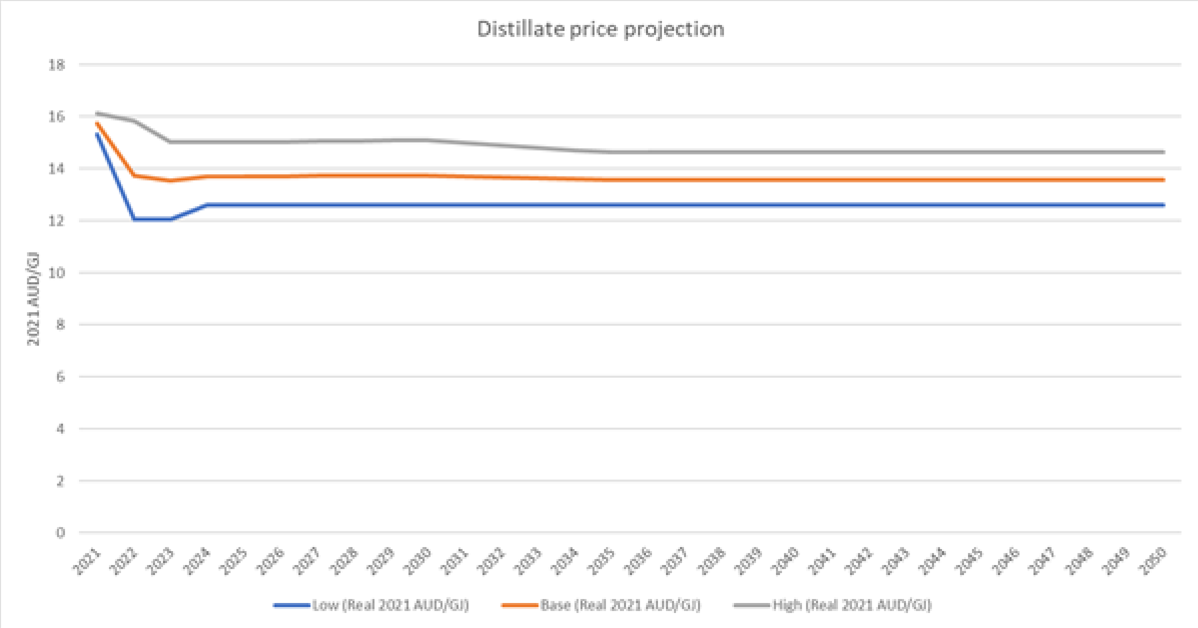
Figure 12: Coal Price Projection

A.2.4 Distillate

Historical "Perth Terminal Gate" prices for distillate (i.e., diesel) are available from the Australian Institute of Petroleum.[7] Diesel prices are strongly correlated with global crude oil prices (e.g., the Brent Crude price), and a linear correlation can be obtained based on historical diesel and crude oil prices. The modelling used the distillate price forecast illustrated in Figure 13, which was obtained by applying this correlation.

7 https://www.aip.com.au/pricing/terminal-gate-prices/perthDiesel

Figure 13: Distillate Price Projection (2021AUD /GJ)



A.3 Candidate technology assumptions

The technical and financial parameters of the technologies used for setting the BRCP is outlined in Table 11 below:

Table 11: Maximum Asset Life

Technology Type	Gas Recips 15MW	OCGT Aero with H2	Lithium Based BESS	Vanadium based BESS
Installed Capacity (MW)	200	202	200	200
Heat Rate (GJ/MWh)	8	10		
VO&M Cost ($/MWh)	7.6	12	0	0
Auxiliary Use (%)	1%	2%	2%	1%
Maintenance rate (days/year)	2/machine	3/machine	3	3
Average maintenance outage length (days)	2/machine	3/machine	3	3
Forced outage rate (days/year)	5/machine	5/machine	3	3
Maintenance rate	0.0054794	0.0082191	0.0082191	0.0082191
Forced outage rate	0.0136986	0.0136986	0.0082191	0.0082191
Average forced outage length (hours)	24	24	24	

Technology Type	Gas Recips 15MW	OCGT Aero with H2	Lithium Based BESS	Vanadium based BESS
Round trip efficiency	-	-	87%	80%
Storage (hours per day)	14	14	4	4
Capital Cost ($/kW)	$1,373.86	$1,149.12	$1,244.81	$2,079.33
Fixed O&M Cost ($/kW-year)	$18.52	$10.53	$6.77	$20.88
Technical life (years)	30	30	10	30
Construction time (years)	2	3	2	2

A.4 Retirements

The retirements used in the modelling are based on either known retirement dates, maximum asset life assumptions or the commitment to zero fossil-fuel generation by 2050. The maximum asset life assumptions are listed in Table 12.

Table 12: Maximum Asset Life

Technology Type	Maximum Asset Life
Black coal	50
OCGT	40
Cogeneration	40
CCGT	40
Diesel engine	35
Wind	40
Solar PV	40
Steam turbine	40

The resulting facility retirement dates within the modelling horizon are shown in Table 13.

Table 13: Facility Retirement Dates

Facility Name	Retirement Date
COLLIE_G1	1/10/2027
MUJA_G5	1/10/2022
MUJA_G6	1/10/2024

Facility Name	Retirement Date
MUJA_G7	1/10/2029
MUJA_G8	1/10/2029
PINJAR_GT10	1/07/2032
PINJAR_GT11	1/07/2032
PINJAR_GT2	1/07/2029
PINJAR_GT3	1/07/2029
PINJAR_GT4	1/07/2029
PINJAR_GT5	1/07/2029
PINJAR_GT7	1/07/2029
PINJAR_GT9	1/07/2032

A.5 New Build

First, the model assumes the candidate facility is being built in 2025, which in this case is a lithium BESS.

The modelling assumed that additional capacity was added to meet the Reserve Capacity Target, using estimates of a capacity type's Certified Reserve Capacity in the year of build.

If the model identified energy/reserve shortfalls, then additional capacity was added to limit unserved energy to acceptable levels. Figure 14 and Table 14 show the new build required to meet these targets.

Figure 14: Assumed New Build

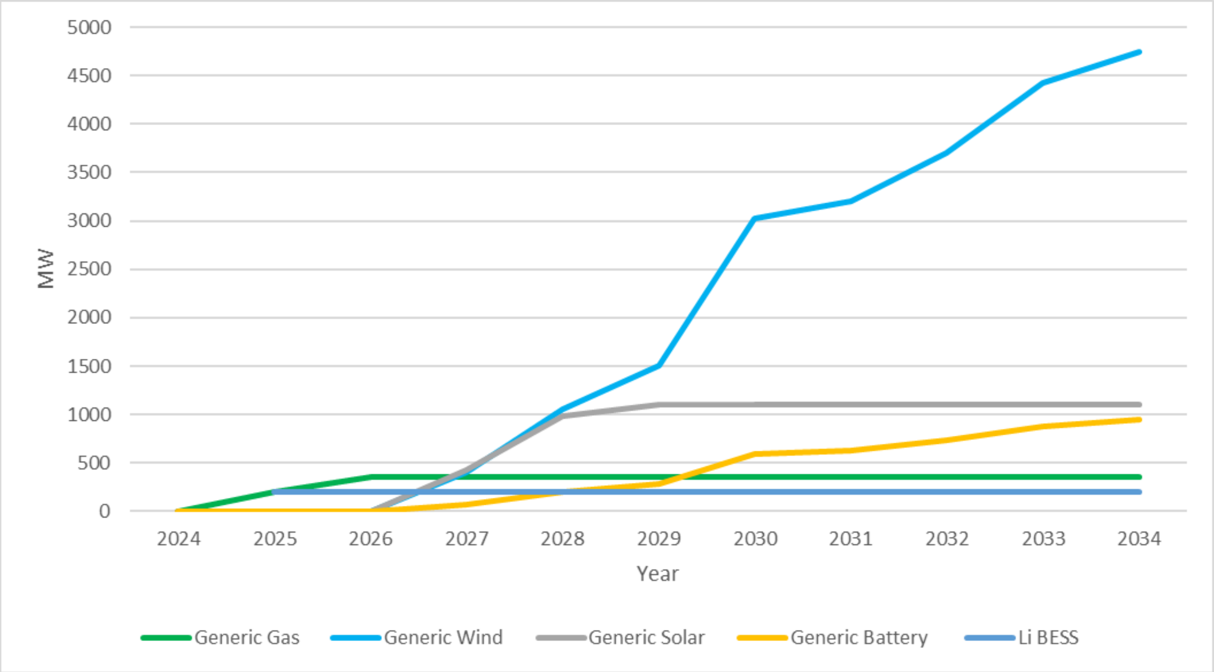


Table 14: Generic New-build Capacity (MW, Cumulative)

Year	Gas	Wind	Solar	Battery[8]
2024	0	0	0	0
2025	200	0	0	0
2026	350	0	0	0
2027	350	40	43	72
2028	350	106	99	197
2029	350	150	110	288
2030	350	303	110	592
2031	350	320	110	628
2032	350	370	110	730
2033	350	443	110	876
2034	350	474	110	942

A.6 Service provision

The modelling assumes that:

- FCESS are only provided by gas facilities and storage facilities.
- wind and solar facilities do not provide flexible capacity services.
- storage facilities can provide synthetic inertia, as otherwise by the end of the modelling horizon there are no facilities left to provide the RoCoF service.

A.7 Commercial parameters

A.7.1 Weighted average cost of capital

When calculating the CONE for each facility type, a nominal weighted average cost of capital (WACC) of 5.2% was assumed, to account for financing costs, as specified by the ERA.

8 2025-2030: 4 hours. 2030-2040: 8 hours, 2040-2050:16 hours.

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