Department of
Energy and Economic
Diversification

GOVERNMENT OF
WESTERN AUSTRALIA

Energy
Policy WA

Meeting Agenda

Meeting Title:	Capability Class 2 Technologies (CC2T) Review Working Group
Date:	Thursday 4 December 2025
Time:	9:30 AM – 11:30 AM
Location:	Online

Item	Item	Responsibility	Type	Duration
1	Welcome and Agenda • Conflicts of interest • Competition Law	Chair	Noting	1 min
2	Meeting Apologies/Attendance	Chair	Noting	1 min
3	Minutes of Meeting 2025_10_23 Approved out of session Published 21 November 2025	Chair	Noting	2 min
4	ESR derating evaluation and availability incentives	RBP	Discussion	115 min
5	General Business	Chair	Discussion	1 min

Please note, this meeting will be recorded.

Competition and Consumer Law Obligations

Members of the MAC (**Members**) note their obligations under the *Competition and Consumer Act 2010* (**CCA**).

If a Member has a concern regarding the competition law implications of any issue being discussed at any meeting, please bring the matter to the immediate attention of the Chairperson.

Part IV of the CCA (titled “Restrictive Trade Practices”) contains several prohibitions (rules) targeting anti-competitive conduct. These include:

(a) **cartel conduct**: cartel conduct is an arrangement or understanding between competitors to fix prices; restrict the supply or acquisition of goods or services by parties to the arrangement; allocate customers or territories; and or rig bids.

(b) **concerted practices**: a concerted practice can be conceived of as involving cooperation between competitors which has the purpose, effect or likely effect of substantially lessening competition, in particular, sharing Competitively Sensitive Information with competitors such as future pricing intentions and this end:

- a concerted practice, according to the ACCC, involves a lower threshold between parties than a contract arrangement or understanding; and accordingly; and
- a forum like the MAC is capable being a place where such cooperation could occur.

(c) **anti-competitive contracts, arrangements understandings**: any contract, arrangement or understanding which has the purpose, effect or likely effect of substantially lessening competition.

(d) **anti-competitive conduct (market power)**: any conduct by a company with market power which has the purpose, effect or likely effect of substantially lessening competition.

(e) **collective boycotts**: where a group of competitors agree not to acquire goods or services from, or not to supply goods or services to, a business with whom the group is negotiating, unless the business accepts the terms and conditions offered by the group.

A contravention of the CCA could result in a significant fine (up to $500,000 for individuals and more than $10 million for companies). Cartel conduct may also result in criminal sanctions, including gaol terms for individuals.

Sensitive Information means and includes:

(a) commercially sensitive information belonging to a Member’s organisation or business (in this document such bodies are referred to as an Industry Stakeholder); and

(b) information which, if disclosed, would breach an Industry Stakeholder’s obligations of confidence to third parties, be against laws or regulations (including competition laws), would waive legal professional privilege, or cause unreasonable prejudice to the Coordinator of Energy or the State of Western Australia).

Guiding Principle – what not to discuss

In any circumstance in which Industry Stakeholders are or are likely to be in competition with one another a Member must not discuss or exchange with any of the other Members information that is not otherwise in the public domain about commercially sensitive matters, including without limitation the following:

(a) the rates or prices (including any discounts or rebates) for the goods produced or the services produced by the Industry Stakeholders that are paid by or offered to third parties;

(b) the confidential details regarding a customer or supplier of an Industry Stakeholder;

(c) any strategies employed by an Industry Stakeholder to further any business that is or is likely to be in competition with a business of another Industry Stakeholder, (including, without limitation, any strategy related to an Industry Stakeholder’s approach to bilateral contracting or bidding in the energy or ancillary/essential system services markets);

(d) the prices paid or offered to be paid (including any aspects of a transaction) by an Industry Stakeholder to acquire goods or services from third parties; and

(e) the confidential particulars of a third party supplier of goods or services to an Industry Stakeholder, including any circumstances in which an Industry Stakeholder has refused to or would refuse to acquire goods or services from a third party supplier or class of third party supplier.

Compliance Procedures for Meetings

If any of the matters listed above is raised for discussion, or information is sought to be exchanged in relation to the matter, the relevant Member must object to the matter being discussed. If, despite the objection, discussion of the relevant matter continues, then the relevant Member should advise the Chairperson and cease participation in the meeting/discussion and the relevant events must be recorded in the minutes for the meeting, including the time at which the relevant Member ceased to participate.

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Energy Policy WA

Capability Class 2 Technologies (CC2T) Review

Evaluation of ESR derating approach and ways to incentivise availability

4 December 2025

Working together for a **brighter** energy future.

Agenda

Derating methods for ESR

Interjurisdiction review

Five Jurisdictions Reviewed

The jurisdictions we reviewed are:

- Great Britain (GB)
- PJM (USA)
- ISO New England (ISO-NE) (USA)
- Ireland (Northern Ireland and Ireland)
- Ontario (Canada)

	WEM[1]	GB	PJM	ISO-NE	Ireland	Ontario
Storage Capacity	1.325GW[2]	6.87 GW	5.17 GW	330 MW	1.11 GW	264 MW
Percentage of Storage relative to Total Installed capacity	18.5%	9.6%	2.6%	1.1%	7.4%	0.007%
Intermittent capacity[3]	19.2%[4]	25.5%	13.6%	7.1%	41.6%	11%

1. AEMO | Market data
2. Converted from System Size by dividing by 2.
3. Excludes DPV capacity (WEM DPV penetration is estimated to be around 20% of consumption)
4. Contains a small amount of storage from hybrid facilities

Three types of derating methods

Last-in Effective Firm Capacity (EFC)

- Probabilistic simulation
- Measures change in reliability standard when unit of firm capacity added.
- Models non-firm capacity needed to produce equivalent change in reliability standard.
- Last-in variant causes later correlated resources to be under-valued resulting in sum of individual EFCs not summing to fleet ELCC – GB is addressing this issue by moving to scaled EFC approach

Last-in Effective Load Carrying Capability (ELCC)

- Probabilistic simulation.
- Measures change in system adequacy when firm capacity or demand is incremented vs when non-firm capacity is added; OR
- Measures difference in demand increment needed to reach reliability standard with base case fleet vs when non-firm capacity is added.
- Last-in variant under-estimates contribution of later resources – Ireland tried to fix this with an adjustment factor that resulted in over-estimation

Linear derating method (LDM)

- Simple arithmetic calculation.
- Capacity equals discharge over duration.
- Further derated to reflect charge level degradation (WEM) or technical availability (Ontario).

WEM will implement ELCC for CC3 Technologies – should storage be incorporated?

The WEM ELCC algorithm uses probabilistic modelling to simulate system reliability, and measure a non-firm resource's reliability contribution by adding an increment of that non-firm resource to determine the change in system adequacy

1. Develop forecast demand traces

Load shape uses the previous four years in the most recent five-year period with the highest peak demand (ELCC period)

Load shape adjusted to reflect DPV generation in forecast Capacity Year

2. Determine Facility performance levels

Uses historical meter data or Independent Expert Report (IER) (ESMR 4.10.3).

3. Calculate Fleet ELCC (sequentially for Committed, Proposed, Early and Conditional CRC)

- Calculate demand adjustment to reach EUE=0.0002% of annual demand with non-intermittent fleet.
- Calculate demand adjustment to reach EUE=0.0002% with CC3 fleet
- ELCC is the difference between the two.
- ELCC calculated for ELCC period and individual for each year
  - final fleet ELCC is lower of whole period ELCC and average ELCC over the four years

4. Calculate RLM

Allocate fleet ELCCs to relevant fleet in proportion to actual or estimated performance during 12 Peak SWIS Intervals.

WEM CC3 ELCC approach addresses some known issues with ELCC methods

Calculating ELCC at fleet level and over multiple weather reference years reduces volatility and increases accuracy

- WEM approach calculates ELCC of the CC3 fleet instead of individual facilities one at a time.
  - Individual ELCC is based on performance during small historical sample – e.g. with four reference years, the sample size of trading interval output is four.
    This can result in volatile allocations to individual facilities due to the inherent variability of wind and solar.
  - Fleet ELCC smooths out the potential volatility by modelling the entire fleet as a whole over the same sample size – fleet ELCC likely to be less volatile than individual ELCCs.
  - Addresses the issue of later facilities' reliability contribution being under-estimated if correlated, resulting in a more accurate estimate of reliability contribution of the fleet.
- Fleet ELCC is allocated to individual facilities in proportion to historical or estimated performance during 12 Peak SWIS Intervals:
  - Reduces volatility, but results in capacity allocation that is not strictly economically efficient on a facility by facility basis.
- WEM approach applies 10% POE estimate and expected demand to four (out of five) historical load shapes:
  - Does not account for other peak and energy demand forecasts manifesting.

ESR Derating Approaches

Evaluating alternative options for the WEM

Propose four options to evaluate (including status quo)

Option	Description
Status Quo	Linear Derating Methodology (degraded maximum charge capability by the relevant ESROD value) • Incumbent batteries retain the original ESROD for ten years; and • Over-allocation of capacity to incumbent batteries is added back into the Planning Criterion.
Option 1: Incorporate storage into amended RLM	Incorporate ESR into the amended Appendix 9 (Last-in Fleet ELCC) (adopting same approach as for CC3).
Option 2: Implement individual ELCCs	Per Option 1, however, implement individual ELCCs for both ESR and CC3. This would require replacing the amended Appendix 9 which uses Fleet ELCCs so that all intermittent generation and storage is allocated individual ELCCs.
Option 3: Option 1 with least-worst regrets analysis	Same as Option 1 but replace demand scenarios with least worst regrets analysis. (This calculates ELCCs for multiple demand scenarios and capacity adequate portfolios and selecting the results of the demand scenario that minimises the worst regret cost).

Storage derating option evaluation

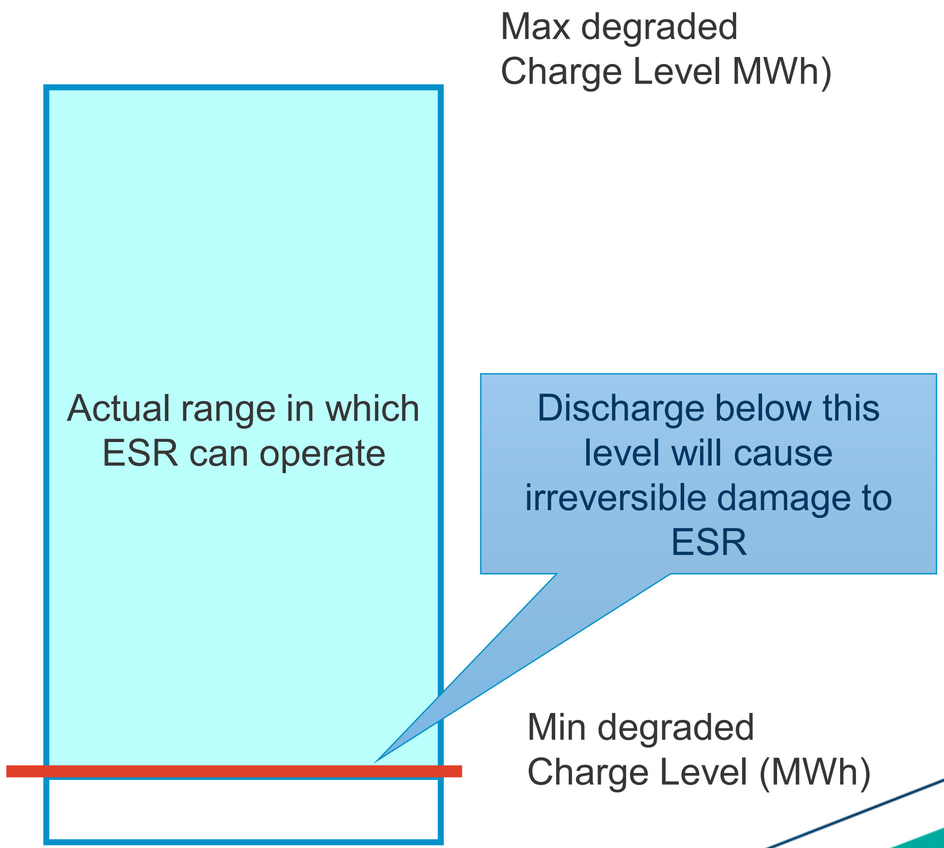
Status quo

CRC assigned equals Linearly Derated Capacity:

- The maximum capacity, in MW, of an ESR that can be guaranteed to be available over the Peak ESROD, being the minimum of:
  a) the nameplate capacity; and
  b) the maximum Charge Level capability (in MWh) divided by half the number of Trading Intervals in the Peak Electric Storage Resource Obligation Duration, being the maximum sustainable MW capacity, which could be delivered continuously across the Peak Electric Storage Resource Obligation Duration accounting for any charging limitations.

Issue 1: Participants are not submitting correct min Charge Level data

- Intention of ESMR is that the maximum discharge capability of the ESR is given by the blue area of the diagram:
  - In practice, participants indicating minimum charge level capability of 0% during certification.
  - This results in capacity allocation as depth of discharge is typically ~3%-5% of the theoretical maximum.
- Participant must indicate at time of certification their actual minimum Charge Level capability when operational.



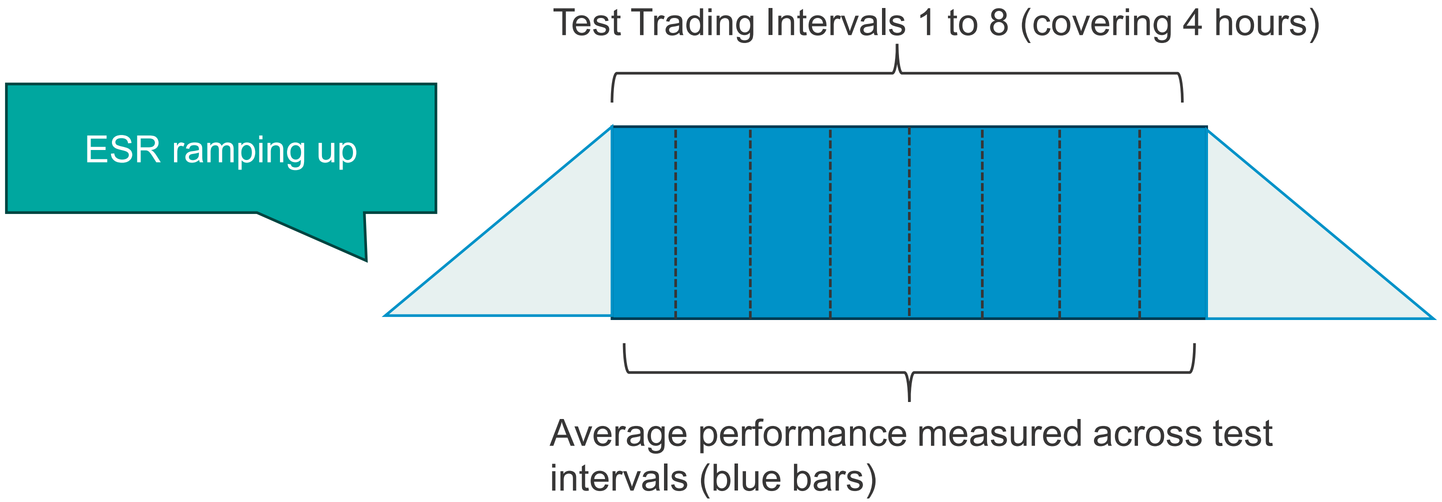
Storage derating option evaluation

Status quo continued

Issue 2: Reserve Capacity Testing rules do not account for ESR ramping:

- Mismatch between how test performance is measured (ESMR 4.25.2E) and operational realities of ESR.
- ESR uses energy when ramping to its Required Level and then when ramping down to its minimum discharge depth.
- The average performance during the testing intervals will therefore not deliver the ESR's Required Level.
- However, area under trapezium does accurately reflect the ESR's performance capability.

Propose amending ESMR 4.25.2E to assess test performance using the area under the trapezium.



Storage derating option evaluation

Status quo

- CRC assigned equals maximum sustainable MW capacity, which could be delivered continuously across the Peak ESROD accounting for any charging limitations
- ESR can retain their ESROD for ten years.
- Misalignment between capacity requirement and allocation added into Limb A of the Planning Criterion.
- New ESRs receive ESROD based on ADG calculations which looks at whether non-ESR capacity can meet demand in intervals adjacent to the previous cycle's ESROD.

Criteria	Draft evaluation
Provides value for money by reasonably approximating contribution of batteries to reliability	Reasonable job approximating contribution to peak period reliability, but does not represent contribution to overall reliability. The contribution will be over-estimated if depth of discharge is assumed to be 0 at time of certification. *Criteria met partially*
Method is transparent and predictable	LDM component is very simple and transparent. By contrast, the approach used to determine the ESROD is somewhat complex (but less complex compared to implementing an ELCC approach). *Criteria met substantially*
Method does not result in uncertainty or volatile allocation from year to year	No uncertainty in the LDM component as the participant will know their degradation profile ahead of time. Element of uncertainty for investors where the ESROD – grandfathering arrangements address this concern. *Criteria met substantially*
Cost and complexity of implementation is reasonable	Already implemented. *Criteria met fully*
Overall Performance	***Most criteria met substantially***

Storage derating option evaluation

Option 1: Incorporate ESR into amended RLM (Last-in Fleet ELCC)

- Fleet ELCC calculated for CC3 and ESR.
- New storage performance estimated based on peak or unserved energy minimisation heuristic
- 10% POE peak and expected demand scenario:
  - Historical load shape from past 4/5 years
  - Corrected for DPV
- Fleet ELCC calculated as lower of whole period fleet ELCC and average of individual year fleet ELCC.
- Fleet ELCC allocated in proportion to performance in 12 Peak SWIS Intervals
  - New ESR output determined using perfect foresight heuristic to minimise UE or peak

Criteria	Draft evaluation
Provides value for money by reasonably approximating contribution of batteries to reliability	• Reliability contribution of ESR fleet estimated more accurately than LDM • Individual ESR RL will not reflect marginal impact of the resource, however, Fleet ELCC is a good approximation to marginal contribution of fleet. • Discourages charging and encourages high output during high demand periods *Criteria met substantially*
Method is transparent and predictable	• ELCC algorithms are complex; unlikely that participants can predict their ELCCs unless they create the required modelling infrastructure. • Issue could be mitigated somewhat in the ESOO through sensitivity analyses providing insights on what drives ELCC outcomes *Criteria not met*
Method does not result in uncertainty or volatile allocation from year to year	• Some risk of volatile allocations – mitigated through use of fleet ELCCs and use of multiple historical reference years. • ESR is not inherently volatile like CC3 resources, so will result in less volatile allocations than for intermittent resources. *Criteria met partially*
Cost and complexity of implementation is reasonable	Option being implemented for CC3T – this option would require further incorporating ESR into the new RLM calculations. *Criteria met partially*
Overall Performance	◐ ***Some criteria met substantially or most met partially***

Storage derating option evaluation

Option 2: Implement Individual (Last-in) ELCC)

- Individual ELCC calculated for CC3 and ESR.
- 10% POE peak and expected demand scenario:
  - Historical load shape from past 4/5 years
  - Corrected for DPV
- Individual ELCC calculated as lower of whole period individual ELCC and average of individual year ELCC.

Criteria	Draft evaluation
Provides value for money by reasonably approximating contribution of batteries to reliability	• Reliability contribution of ESR fleet estimated more accurately than status quo but less so than Option 1. Individual last-in ELCC results in under-estimation of correlated resources so that the sum of the individual ELCCs does not accurately represent the fleet ELCC. • Discourages charging and encourages high output during high demand periods *Criteria met partially*
Method is transparent and predictable	See Option 1 *Criteria not met*
Method does not result in uncertainty or volatile allocation from year to year	Moderate to high risk of volatile allocations – as evidenced with PJM experience. *Criteria not met*
Cost and complexity of implementation is reasonable	Would need to replace previously consulted on RLM. Method is more computationally intensive and complex *Criteria not met*
Overall Performance	○ ***Most criteria not met***

Storage derating option evaluation

Option 4: Incorporate ESR into amended RLM with least worst regrets

- Fleet ELCC calculated for CC3 and ESR.
- Multiple POE peak and expected demand assumptions combined with multiple historical load shapes used to create multiple scenarios.
- Fleet ELCC calculated for each demand scenario.
- Regret cost calculated for each demand scenario (if another scenario manifests).
- Choose ELCC of demand scenario with lowest regret cost.
- Fleet ELCC allocated in proportion to performance in 12 Peak SWIS Intervals.

Criteria	Draft evaluation
Provides value for money by reasonably approximating contribution of batteries to reliability	• Similar to Option 1, except ELCC calculated for many different demand scenarios, and fleet ELCCs selected from a single scenario to minimise regret cost. • Performs better than Option 1 as it considers a wider range of demand scenarios and models impact of other scenarios manifesting *Criteria met fully*
Method is transparent and predictable	Significantly more complex than Option 1 due to multiple demand scenarios and least-worst regrets analysis *Criteria not met*
Method does not result in uncertainty or volatile allocation from year to year	See Option 1 *Criteria met partially*
Cost and complexity of implementation is reasonable	Would need to replace previously consulted on RLM. Method is more computationally intensive and complex Misaligned with Planning Criterion and RCR definitions that are tied to 10% POE peak demand. *Criteria not met*
Overall Performance	◔ ***Some criteria met partially***

Storage derating option evaluation

Summary

- Status quo performs the best due to simplicity and certainty of allocations
- Option 1 also performs moderately well:
  - Would result in consistent treatment of ESR and CC3;
  - Replaces ESROI requirements with obligations year round (with allowance for charging).
- **Question for Working Group**
  - Should DSP be rolled into a fleet ELCC calculation?

	Status Quo (LDM & ESROD)	Option 1: Fleet ELCC	Option 2: Individual ELCC	Option 3: Fleet ELCC with least worst regrets
Overall performance	◕	◑	○	◔
Provides value for money by reasonably approximating contribution of batteries to reliability	Met partially	Met substantially	Met partially	Fully met
Method is transparent and predictable	Met substantially	Not met	Not met	Not met
Method does not result in volatile allocation from year to year	Met substantially	Met partially	Not met	Met partially
Cost and complexity of implementation is reasonable	Fully met	Met partially	Not met	Not met

Reserve Capacity refunds for ESR Facilities

Draft evaluation

Reserve Capacity refunds are a key mechanism to ensuring compliance with Reserve Capacity obligations

Refunds are a function of a dynamic refund rate and the shortfall in a participant's offer obligations in the real-time market:

- The tighter the capacity margin, the higher the refund;
- ESR operators incur refunds if they have insufficient charge to meet their Dispatch Interval obligation; and
- Refunds capped at total Reserve Capacity payments payable during the relevant Capacity Year

Facility Reserve Capacity Deficit Refund
ESMR 4.26.1A

=

Trading Interval Refund Rate
ESMR 4.26.1

Function of Reserve Capacity Price and spare capacity on the system

×

Market Reserve Capacity Deficit
RTMRCD(f,t)
ESMR 4.26.1B

Real-time Market Operating Shortfall, RTMOSF(f,t)
ESMR 4.26.1G, 4.26.1H

ESR Charge Shortfall, ESRCSF(f,t)
ESMR 4.26.1E, 4.26.1F

Not-in-Service Capacity Refund Quantity, NISCRQ(f,t)
ESMR 4.26.1D

Capacity Adjusted Forced Outage, CAFO(f,t)
ESMR 3.21.7B

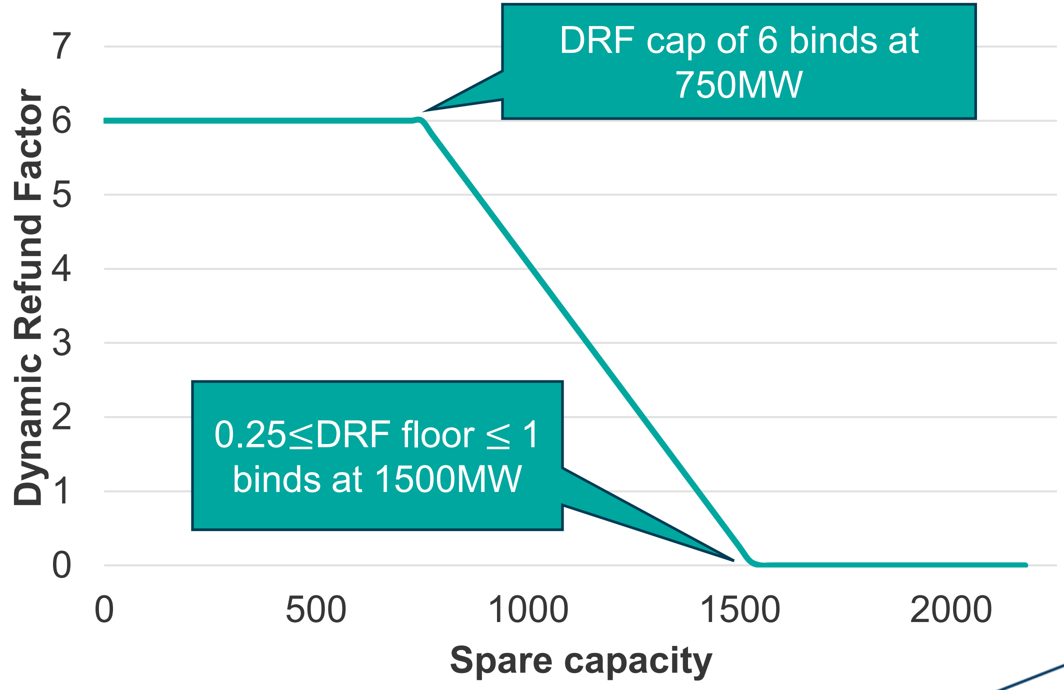
Refund payable Planned Outage, NIGRPPO(f,t), ESRRPPO)f,t)
ESMR 4.26.1C, 4.26.1CA

Dynamic refund factor (DRF) incentivises availability during tight system conditions

DRF is given by ESMR 4.26.1(d):

$$RF\_Dynamic(t) = 11.75 - \left(\frac{5.75}{750}\right) \times \sum_{\substack{f \in Registered \\ Facilities}} Spare(f, t)$$

- Slope and intercept of uncapped DRF is a function of:
  - Where cap (currently 6) binds (currently 750MW); and
  - Where the floor binds (currently 1,500MW if the floor is 0.25).
    - Refund factor floor defined in ESMR 4.26.1(f) (function of Facility's % availability over previous 90 days and ranges between 1 and 0.25)
- Cap (6) historically set to balance availability incentives with overly punitive refunds
  - MW threshold at which cap binds was historically a rare but credible event.
  - MW threshold at which floor binds indicates level of spare capacity at which need for full availability lessens – the shallower the curve the higher this threshold and more refunds the participant pays overall.



Market Reserve Capacity Deficit (RTMRCD(f,t)) denotes capacity shortfall

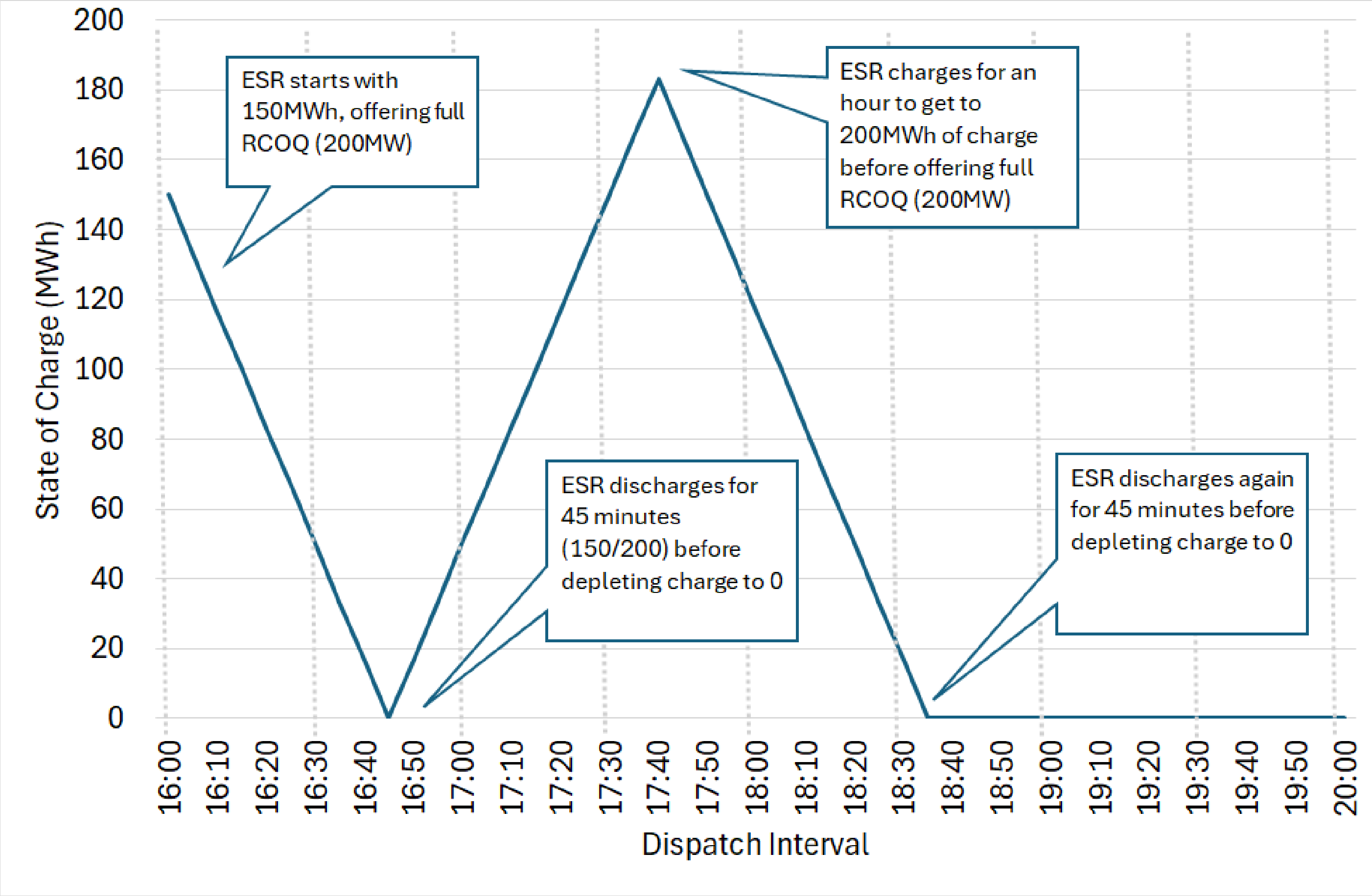
Real-time Market Offer Shortfall (RTMOSF) and ESR Charge Shortfall (ESRCSF) are of interest

- DI level RTMOSF calculates shortfall as RCOQ less all energy offered.
- TI level RTMOSF deducts CAFO, NISCRQ and ESRCSF quantities to avoid double counting the shortfall.
- ESR that fails to maintain enough charge for upcoming Dispatch Interval incurs charge shortfall.
  - ESR does not start incurring refunds until it is out of charge.
  - ESR can enter ESROIs with partial charge and only incur refunds after Mid-Peak ESROI when refunds would be lower than at the peak.
- Batteries with low State of Charge (SOC) at start of ESROD could reduce refunds by charging during ESROIs so they can meet obligations later in the ESROD
  - Could exacerbate system stress; but disincentivising charging early during the ESROD could result in worse outcomes at the peak.
  - Scenario would occur if ESR is not fully charged at ESROD start, charge cost < refund cost and Withdrawal is cleared.

Example

Battery enters ESROIs with insufficient charge and then charges to reduce refund exposure

- Battery RCOQ is 200 MW
- ESROD = 4 hours
- ESROIs: 16:00 – 19:30 inclusive
- ESR requires 800MWh of charge at start of ESROD:
  - ESR enters ESRO1 with 25% charge (150MWh)
  - Enough to discharge at full capacity for 45 minutes
- ESR runs out of charge at 16:45 and starts to charge to avoid refunds at the peak:
  - ESR charges for an hour to get to 200MWh of charge
  - ESR discharges from 17:40-18:30
  - Charge depleted at 18:35.



Example continued

Battery enters ESROIs with insufficient charge and then charges to reduce refund exposure

- ESR does not start paying charge shortfalls until 16:45 when its charge is depleted
- ESR avoids refunds from 17:40 – 18:30 by charging from 16:45 – 17:40.
- Charging during the ESROIs can be used to avoid highest refunds at the peak
- Key incentives for ESR to enter ESROIs with full charge is:
    - Avoidance of refunds.
    - High energy prices during ESROIs.

ESROI	ESR Charge Shortfall, MW ESRCSF_TI (4.26.1E)	Real-Time Market Offer Shortfall, MW RTMOSF_TI (4.26.1G)	Real-Time Market Reserve Capacity Deficit, MW RTMRCD_TI (4.26.1B)
16:00	0	0	0
16:30	33.333	66.667	100
17:00	0	200	200
17:30	0	66.667	66.667
18:00	0	0	0
18:30	166.667	0	166.667
19:00	200	0	200
19:30	200	0	200

Incentivising ESR availability

Does the refund regime on its own incentivise and charge management?

- Dynamic refund factor incentivises availability and maintaining charge at times when spare capacity is tight.
- Some potential to strengthen this by increasing the size of the DRF cap and the threshold at which it binds
  - Historical analysis indicates low spare capacity intervals are becoming more prevalent: 0.1% of Trading Intervals in 2024 < 500MW (0.7% of Trading Intervals < 750MW)
  - Could increase DRF cap and decrease threshold at which new cap binds.

Two such options evaluated

- Is the above enough?
  - Refunds capped at maximum capacity payments receivable by Facility. Is potential refund exposure a sufficient deterrent if capped? Particularly, for those participants who have recovered most or all of their capital costs?
- Two potential options to further strengthen incentives:
  - Re-institute allocation of refunds to capacity providers to incentivise better performance than peers
    - Extensively consulted and changed to allocated refunds to customers. <u>This option is not evaluated</u>.
  - Implement a PJM style performance-based penalty/reward scheme to apply during emergency. This would involve:
    - Replacing the existing capacity-based refund scheme that applies during all Trading Intervals with a performance-based scheme that only applies during emergency conditions.
    - <u>This option is not evaluated due to its significant implementation complexity</u> and the fact that similar incentives can be derived by amending the existing refund regime.

Incentivising ESR availability

How else can prudent charging behaviour be incentivised?

- Subject of ongoing technical analysis
- Identify system conditions and triggers that can be used to mandate charge obligations:
    - What are the characteristics of the power system when a stress event occurs?
    - Can these characteristics be framed as triggers which indicate the ESR fleet must be charged to a certain level by a certain time to maintain Power System Security and Reliability (PSSR)?

Reserve Capacity Refunds – alternative options

Changes to Dynamic Refund Factor

Could availability incentives be strengthened at low spare capacity?

Consider two options to increase the DRF cap

Option	Description
Status Quo	• DRF cap of 6 binds at 750MW • DRF floor binds at 1500MW
Option 1a	• DRF cap of 8 binds at 500MW • DRF floor still binds at 1500MW
Option 1b	• DRF cap of 6 binds at 750MMW • Second DRF cap of 8 binds at 750MW • DRF floor still binds at 1500MW

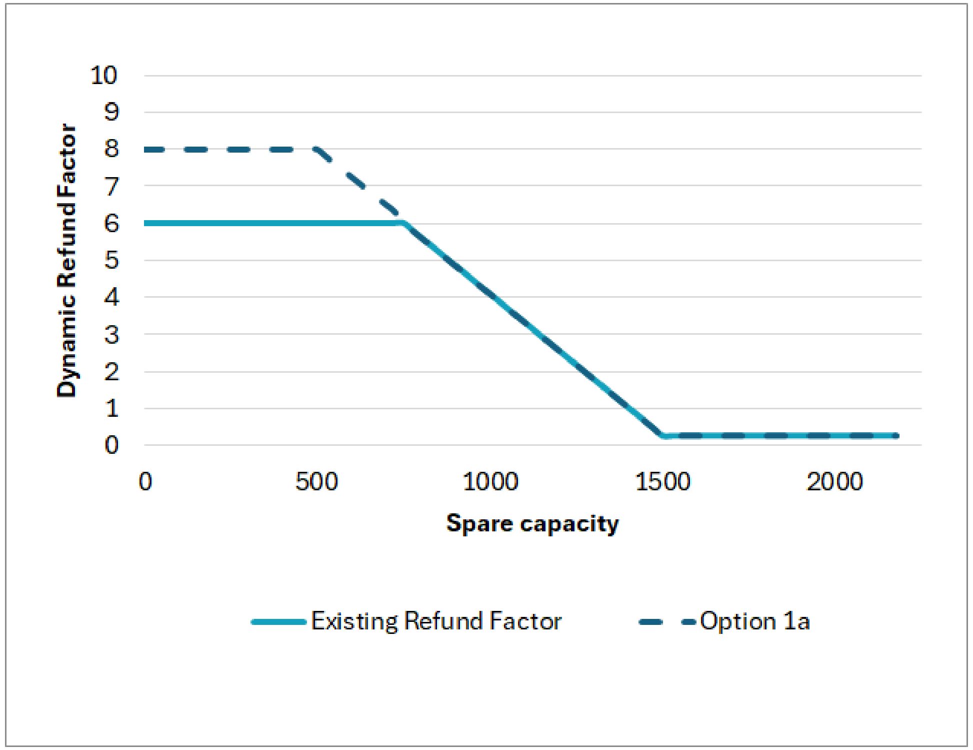
Capacity refund options - evaluation

Option 1a- DRF cap of 8 binds at 500MW

- New DRF curve comprises two linear segments:
  - First segment is the same as the status quo.
  - Second segment has slightly different slope but same intercept.

$$RF_{Dynamic(t)} = \begin{cases} \text{Min}\left(6, 11.75 - \left(\frac{5.75}{750}\right) \times \sum_{\substack{f \in Registered \\ Facilities}} Spare(f, t)\right) & if \sum_{\substack{f \in Registered \\ Facilities}} Spare(f, t) < 500 \\ \text{Min}\left(8, 11.75 - \left(\frac{3.75}{500}\right) \times \sum_{\substack{f \in Registered \\ Facilities}} Spare(f, t)\right) & Otherwise \end{cases}$$

- Two segments needed to ensure floor still binds at 1500MW – otherwise single segment curve would shallower and result in higher refunds at lower spare capacity



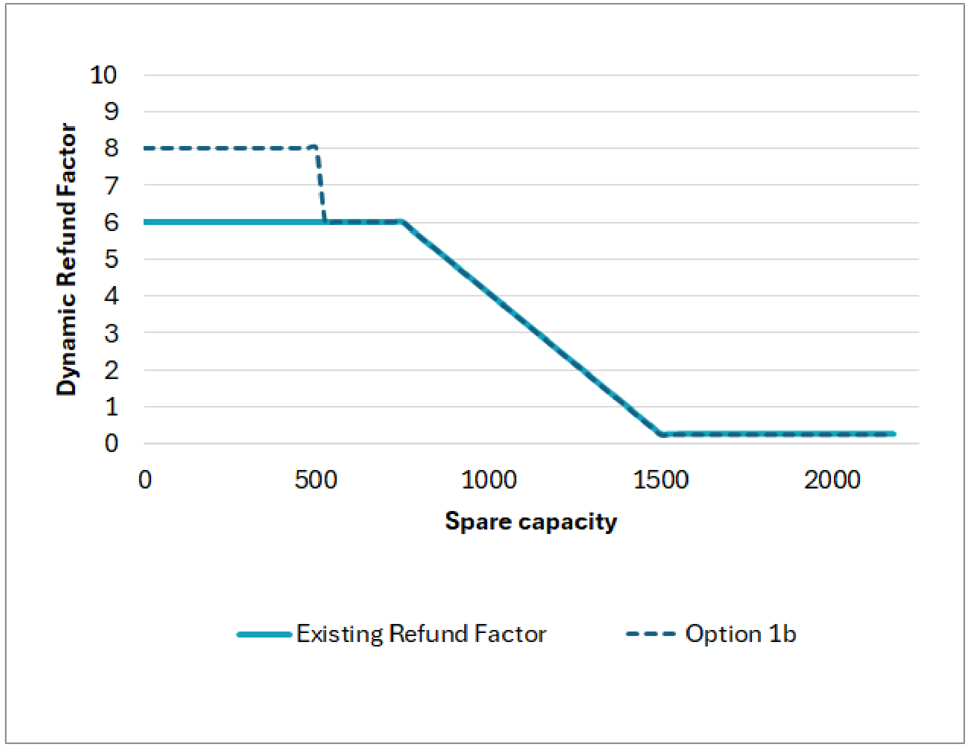
Capacity refund options - evaluation

Option 1b- DRF cap of 6 binds at 750MW , 8 at 500MW

- Similar to Option 1a – however, to reduce participant impact, cap does not increase between 500MW and 750MW.

$$RF_{Dynamic(t)} = \begin{cases} \mathrm{Min}\left(6, 11.75 - \left(\frac{5.75}{750}\right) \times \sum_{\substack{f \in Registered \\ Facilities}} Spare(f,t)\right) & if \sum_{\substack{f \in Registered \\ Facilities}} Spare(f,t) < 500 \\ 8 & Otherwise \end{cases}$$

- This option results in less refunds being paid than under Option 1a.

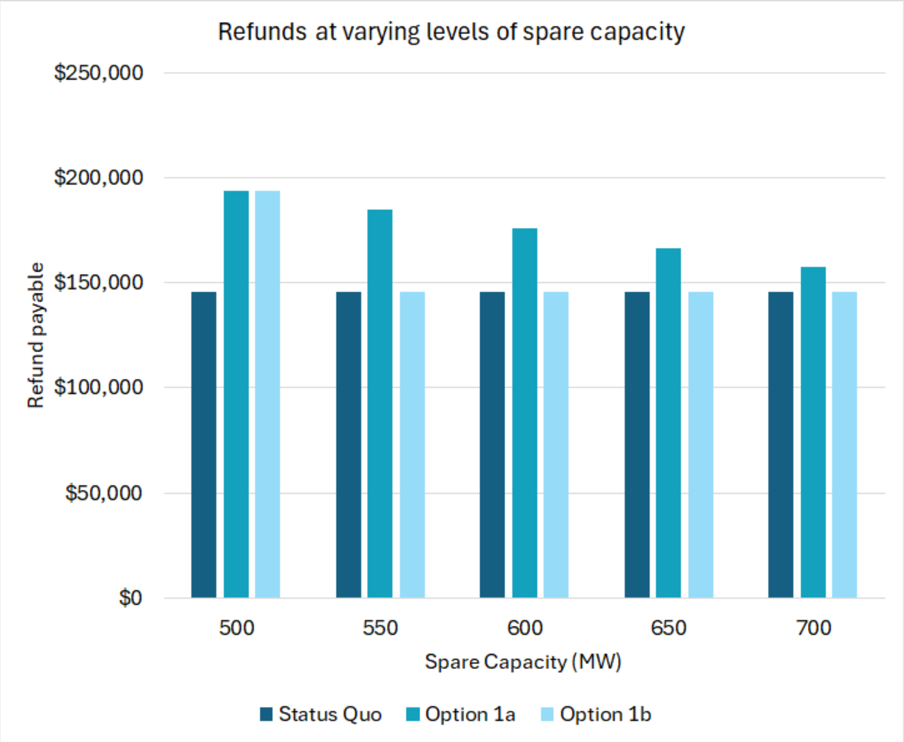


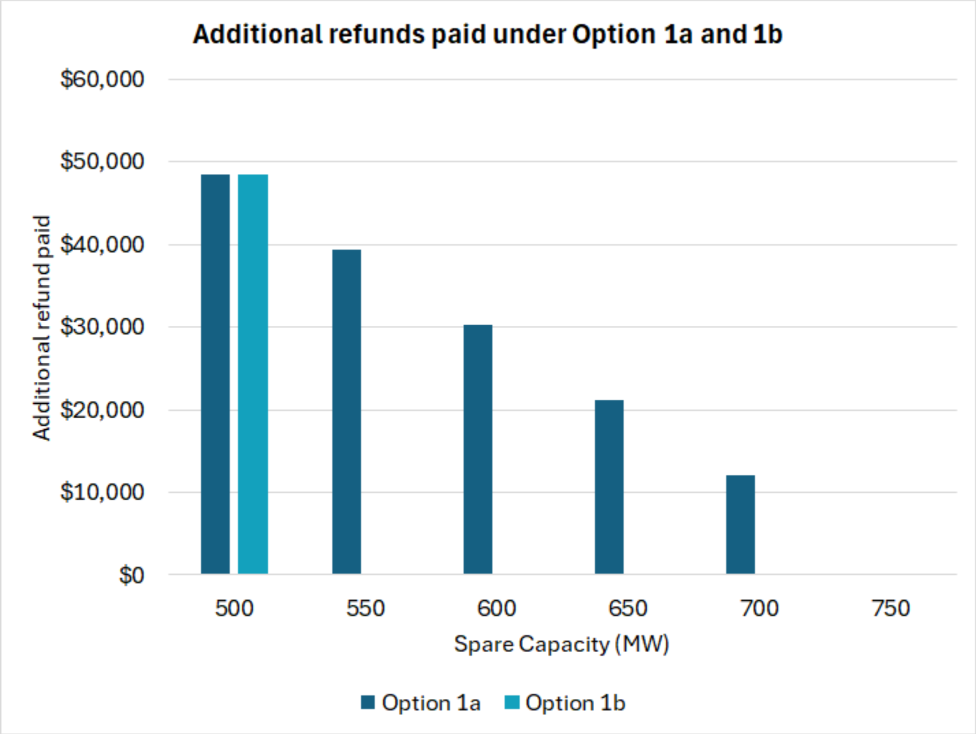
Hypothetical battery used to explore refunds payable under different options

200MW / four- hour battery with RCOQ = 200MW

- Reserve Capacity Price = $360,700/MW/Year.
- Trading Interval price (for a 31-day month) = $121.203/MW/ESROI.
- Battery has been fully available for past 3 months - DRF floor is 0.25.

Refund exposure calculated at varying levels of Spare Capacity given the above parameters (for single Trading Interval).





Evaluation against SEO

Criteria	Status Quo	Option 1a	Option 1b
Provides strong financial incentives for availability	Performs moderately well Opportunity to provide sharper incentives at very low levels of spare capacity (which are now more prevalent). *Criteria met partially*	Provides sharper incentives at Spare Capacity below 750MW Higher cap of 8 binds at 500MW of Spare Capacity (LOR declaration likely at this level). *Criteria met fully*	Provides sharper incentives than status quo for Spare Capacity values below 500MW. Option 1a provides stronger incentives between 500MW and 750MW. *Criteria met substantially*
Approach is transparent and predictable	Well understood by Market Participants and can be easily applied to forecast refund exposure as a function of system Spare Capacity. *Criteria met fully*	Slightly more complex but still an easy calculation to understand and apply. *Criteria met fully*	See Option 1a . *Criteria met fully*
Approach does not distort RTM investment signals	Existing refund factor was historically set to balance availability incentives with excessively punitive outcomes. *Criteria met substantially*	Additional refunds payable under this approach is reasonable: hypothetical ESR paid 2.1% more in refunds under this option than the status quo. Increase in DRF cap offset by low likelihood of observing low spare capacity values. *Criteria met substantially*	Option 1b results in only a 0.8% increase in refunds payable compared with the status quo, and as such is unlikely to result in distortionary impacts. *Criteria met substantially*
Cost and complexity of implementation is reasonable	This option is already implemented. *Criteria met fully*	Requires minor and simple changes to ESMR and settlement systems. *Criteria met substantially*	See Option 1a. *Criteria met substantially*
Overall performance	**Most criteria met substantially**	**All criteria met substantially**	**All criteria met substantially**

Evaluation against SEO

Discussion

- All options (including status quo) perform well.
- Options 1a and 1b perform better due to the sharper incentives at lower spare capacity.
- Option 1a performs better than 1b in terms of incentive strength.

Questions for Working Group

1. Should refund options be focused on incentivising availability only during low spare capacity or across the board?
    - Options evaluated assume the former.
2. Does the WG have any views or thoughts on Options 1a and 1b?
    - Which is preferable?
    - Should other thresholds and caps be examined? Why?

SWIS generation mix

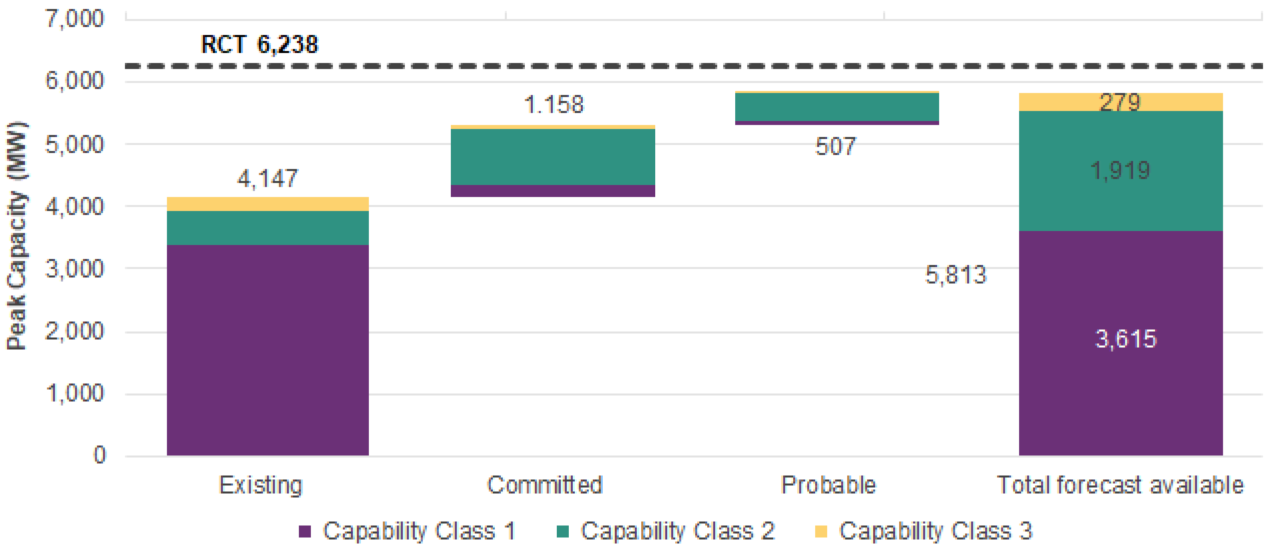
How much storage is too much storage?

Storage requires CC1 and CC3 generation to charge

Do the Reserve Capacity Mechanism (RCM) Rules result in a capacity mix that ensures PSSR?

- LT PASA reliability modelling will indicate if EUE exceeds 0.0002% threshold when too much storage is on the system (relative to CC1 and CC3) (ESMR 4.5.12(i).
- Tranche 8 introduced ESMR 4.5.12A which allows AEMO to add CC1 and CC3 capacity alongside NAFFs (Step 4 of Part A & B of Appendix 3) if 4.5.12(i) indicates additional CC1 and CC3 capacity is required
- Is this sufficient to ensure CC2 capacity is not oversupplied?.
  - Are further changes needed (e.g. not adding any CC2 capacity once Peak RCR is violated?
  - Why?
- Technical analysis by AEMO will provide further insights into “ideal” levels of storage.

Peak capacity allocated for 2027-28 by Capability Class and status



Source: WEM ESOO 2025

Working together for a **brighter** energy future.

Appendix 1

Interjurisdiction review – insights from reviewed jurisdictions

Great Britain (England, Scotland and Wales)

Last-in EFC

- Uses Last-in-EFC method to calculate reliability contribution of storage and intermittent resources.
- Current method estimates marginal reliability value of storage by:
  - Adding increment of firm capacity to base case generation mix and measuring change in reliability standard;
  - Adding increment of non-firm capacity to get the **same change** in system adequacy; and
  - The difference is the EFC of the non-firm resource.
- GB moving to scaled EFC approach that scales the individual EFCs to the fleet EFC so that fleet EFC equals sum of individual EFCs
  - Last-in Individual EFC under-estimates contribution of correlated resources that are added later.
  - Sum of individual EFCs do not sum to fleet EFC
- EFC measures reliability contribution assuming 100% technical availability.
  - GB derates EFC further based on technical availability of pumped storage; and
  - GB plans to use actual storage outage rates in future.

Total Installed Capacity	71.7 GW
Peak Demand	47.4 GW
Annual Electricity Demand	319 TWh
Storage Capacity	6.87 GW
Percentage of Storage relative to Total Installed capacity	9.6%
Wind & solar capacity as % of Total installed capacity	25.9%

PJM (USA)

Last-in ELCC

- PJM uses ELCC to estimate unforced capacity (UCAP) of intermittent generation, storage, and demand-side resources.
- The method measures reliability contribution of non-firm resource by:
  - Adding increment of firm capacity and measuring the change in unserved energy;
  - Replacing increment of firm with non-firm capacity and measuring unserved energy; and
  - ELCC is the difference in the unserved energy
- ELCC is adjusted using historical forced outage rates.
- Method currently under review:
  - Last-in ELCC has resulted in material reductions in capacity allocated to intermittent and storage.
  - Lower allocation to intermittent and storage has resulted in higher than otherwise capacity requirement to fulfil LOLE standard resulting in large price spikes due to insufficient capacity (in part due to long interconnection queues).
  - PJM facing litigation from market participants over these issues.

Total Installed Capacity	198.8 GW
Peak Demand	160.2 GW
Annual Electricity Demand	770 TWh
Storage Capacity	5.17 GW
Percentage of Storage relative to Total Installed capacity	2.6%
Wind & solar capacity as % of Total installed capacity	13.6%

ISO-NE (USA)

Adopting Last-in ELCC (Marginal Reliability Impact)

- Currently, ISO-NE accredits Qualified Capacity (QC) to storage resources within its Forward Capacity Market based on sustaining maximum output for 2 hours.
  - 50MW/2 hour battery receives QC of 50MW; or
  - 40MW/3 hour battery receives QC of 40MW despite contributing more energy.

  Approach overvalues short-duration batteries and undervalues longer-duration ones.
- Two major changes occurring:
  - Shifting from annual (three-year ahead) auctions to two seasonal (weeks to months ahead) auctions. This enables more accurate forecasts of capacity requirements.
  - Adopting last-in ELCC approach to measure marginal reliability impact (or the marginal reliability contribution) of resources in summer and in winter.

Total Installed Capacity	29.7 GW
Peak Demand	28.1 GW
Annual Electricity Demand	116.7 TWh
Storage Capacity	330 MW
Percentage of Storage relative to Total Installed capacity	1.1%
Wind & solar capacity as % of Total installed capacity	7.1%

Ireland (Northern Ireland and Ireland)

Last-in ELCC with least worst regrets

- Ireland uses last-in-ELCC method and a least-worst regrets approach to minimise the maximum cost associated with over-or under-procuring capacity
- All technologies derated by:
  - Defining multiple net demand scenarios to correlate demand and weather-dependent resources.
  - Identifying Capacity Adequate Portfolios (CAPs) for each demand scenario that meets reliability standard and use last-in ELCC to measure reliability impact of each resource for each CAP.
  - Simulating CAPs under all other demand scenarios to calculate excess expected unserved energy and excess capacity costs, quantifying the “regret” of over/under procuring capacity.
- The demand scenario with the lowest maximum regret cost determines the derated capacity and derating factors.
- Last-in ELCC approach results in correlated resources being under-value:
  - Ireland addressed this by adding a storage adjustment factor, but this overestimated the reliability contribution of new storage.
  - Consequently, the Storage adjustment factor has been removed.

Total Installed Capacity	~15 GW
Peak Demand	5.5 GW
Annual Electricity Demand	31.9 TWh
Storage Capacity	1.11 GW
Percentage of Storage relative to Total Installed capacity	7.4%
Wind & solar capacity as % of Total installed capacity	41.6%

Ontario (Canada)

Simple derating method

- Unforced capacity (UCAP) of storage calculated as follows:
  - UCAP = ICAP x ADF x PAF
  - ICAP = Lower of maximum discharge rating divided by nameplate duration and MW capacity
  - Availability Derate Factor (ADF) is 95%
    It is unclear why 5% outage is assumed
  - Performance Assessment Factor (PAF) based on performance tests. Resources are derated if tests failed to deliver capacity commitment.
- IESO is investigating the ELCC method as an alternative.

Total Installed Capacity	37.6 GW
Peak Demand	24.9 GW
Annual Electricity Demand	139.4 TWh
Storage Capacity	264 MW
Percentage of Storage relative to Total Installed capacity	0.007%
Wind & solar capacity as % of Total installed capacity	14%

Appendix 2

Evaluation Framework

Evaluation Framework

The State Electricity Objective has three limbs that we want to capture in our framework

The State Electricity Objective is to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity in relation to:

a) The quality, safety, security and reliability of supply of electricity

b) The price of electricity

c) The environment, including reducing greenhouse gas emissions.

SEO Evaluation Criteria

Capacity certification/derating approach

Outcome sought	Map to SEO
1. Provides value for money by reasonably approximating contribution of batteries to reliability	Over-estimating contribution can lead to under-procurement, adversely affecting the security & reliability limb. Under-estimating contribution can lead to over-procurement, adversely affecting the pricing limb.
2. Method is transparent and predictable	Complex opaque methods may deter investment in new batteries which could adversely affect the security & reliability, pricing and environment limbs of the SEO.
3. Method does not result in volatile allocation from year to year	Uncertainty and volatility of capacity revenue streams may deter investment in new batteries which could adversely affect the security & reliability, pricing and environment limbs of the SEO.
4. Approach does not distort RCM and RTM investment signals	The RCM and RTM provides scarcity pricing signals to investors. Policies involving frequent intervention or off-market procurement to provide the same service (e.g. getting energy/capacity through SRC/NCESS) will erode investment signals in the WEM and could result in higher than otherwise long-term costs for the consumer therefore affecting the pricing limb of the SEO.
5. Cost and complexity of implementation is reasonable	Costly implementation will add to market participant costs (through increased market fees) which adversely affects the pricing limb of the SEO.

SEO Evaluation Criteria

CC2 duration and availability obligations

Outcome sought	Map to SEO
1. Duration and availability obligations are aligned with power system and consumer needs	Failing to make ESR/DSPs available during intervals of system stress will adversely affect the security & reliability limb.
2. Approach is flexible enough to change as power system needs evolve and change	Power system characteristics are evolving rapidly with more uncertainty due to the Energy Transition. Approaches to setting duration and availability obligations must be flexible enough to adapt to such changes so that the alignment with system need is maintained. Failure to do so would adversely affect the security & reliability limb.
3. Approach is transparent and predictable	Opaque approaches to setting dynamic duration and availability obligations could deter battery entry if operators are unable to plan operations efficiently. This could adversely affect the security & reliability, pricing and environment limbs of the SEO.
4. Approach does not distort RCM and RTM investment signals	The RCM and RTM provides scarcity pricing signals to investors. Policies involving frequent intervention or off-market procurement to provide the same service (e.g. getting energy/capacity through SRC/NCESS) will erode investment signals in the WEM and could result in higher than otherwise long-term costs for the consumer therefore affecting the pricing limb of the SEO.
5. Cost and complexity of implementation is reasonable	Costly implementation will add to market participant costs (through increased market fees) which adversely affects the pricing limb of the SEO.

SEO Evaluation Criteria

Refunds

Outcome sought	Map to SEO
1. Provides strong financial incentives for availability	Strong financial incentives to make capacity available intervals of system stress will contribute positively to the security & reliability limb. On the other hand, an overly punitive scheme could deter battery entry. This would adversely affect the security & reliability, pricing and environment limbs of the SEO.
2. Approach is transparent and predictable	Participants should be able to predict their refunds given their availability. Opaque incentives could result in sub-optimal participant decisions around availability. This could adversely affect the security & reliability, pricing and environment limbs of the SEO.
3. Approach does not distort RTM investment signals	Overly punitive refund or penalty schemes may distort RTM prices if participants reflect the risk of refunds into their offers. This would adversely affect the pricing limb of the SEO.
4. Cost and complexity of implementation is reasonable	Costly implementation will add to market participant costs (through increased market fees) which adversely affects the pricing limb of the SEO.

Measuring performance against the criteria

Options are qualitatively evaluated against each criteria and scored as follows

Evaluation Criteria 1

Evaluation Criteria 2

Evaluation Criteria 3

Evaluation Criteria 4

Evaluation Criteria 5

Evaluate how well design options perform against each criteria

○	Most criteria not met
◔	Some criteria met partially
◑	Some criteria met substantially or most met partially
◕	Most criteria met substantially
●	All criteria met substantially

Annex

Abbreviations

Abbreviations not previously introduced

Term	Definition
ADG	Availability Duration Gap
CC1	Capability Class 1
CC2	Capability Class 2
CC3	Capability Class 3
CRC	Certified Reserve Capacity
DSP	Demand Side Programme
DPV	Distributed Photovoltaics
ESR	Electric Storage Resource
ESROD	Electricity Storage Resource Obligation Duration
ESROI	Electricity Storage Resource Obligation Intervals
ESMR	Electricity System and Market Rules
EUE	Expected Unserved Energy
I-SEM	Ireland's Integrated Single Electricity Market
ISO-NE	Independent System Operator – New England

Abbreviations not previously introduced

Term	Definition
LOLE	Loss of Load Expectation
LT PASA	Long Term Projected Assessment of System Adequacy
MW	Megawatt
NAFF	Network Augmentation Funding Facility
NAQ	Network Access Quantity
PJM	Pennsylvania - New Jersey – Maryland
POE	Probability of Exceedance
RCOQ	Reserve Capacity Obligation Quantity
RL	Relevant Level
RTM	Real-Time Market
SEO	State Electricity Objective
SWIS	South West Interconnected System