ESSENTIAL SYSTEM SERVICES (ESS)

Update on AEMC reform work program – ESS & system security

March 2025

AEMC

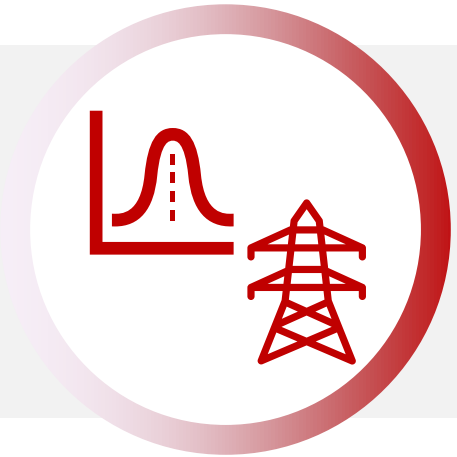
Contents

Overview of ESS and system security in the NEM

How we think about system security vs reliability in the NEM

RELIABILITY

- There is enough capacity (generation, demand response and networks) to supply customers.



SECURITY

- The system is able to operate within defined technical limits, even if there is an incident such as the loss of a major transmission line or large generator.
- Relates to the technical parameters of the power system such as voltage and frequency; the rate at which these parameters might change; and the ability of the system to withstand faults.

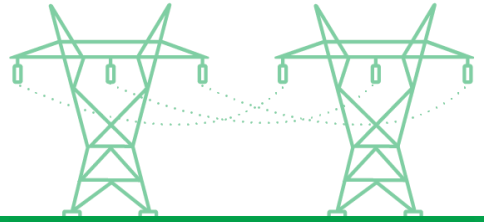
Australia is facing unique power system security challenges

A big focus has been on the challenge of ***maintaining power system security*** – which is ensuring the power system is operating within the acceptable range of technical limits – for example, voltage and frequency.

While the energy transition is giving rise to power system security challenges worldwide, ***it has been especially challenging domestically because:***

Change in generator types

Australia is seeing a *comparatively large shift from retiring synchronous generation to inverter-based plant.* ***The Integrated System Plan*** forecasts a tripling of the grid-scale variable renewables by 2030 and a six-fold increase by 2050. Operating a low-synchronous power system presents unique engineering and security challenges.



Transmission grid shape

Our *transmission grid is an exceptionally long and thin structure with limited interconnection* – this exacerbates the challenges with system security arising from high penetration of inverter-based plant.

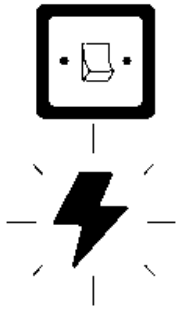
Uptake of PV rooftop solar

The massive uptake of PV rooftop solar further contributes to power system security issues – especially when rooftop solar output is very high, creating very low minimum demand. This creates operational challenges that can make the system more unstable.

System security responsibilities and mechanisms in the NEM

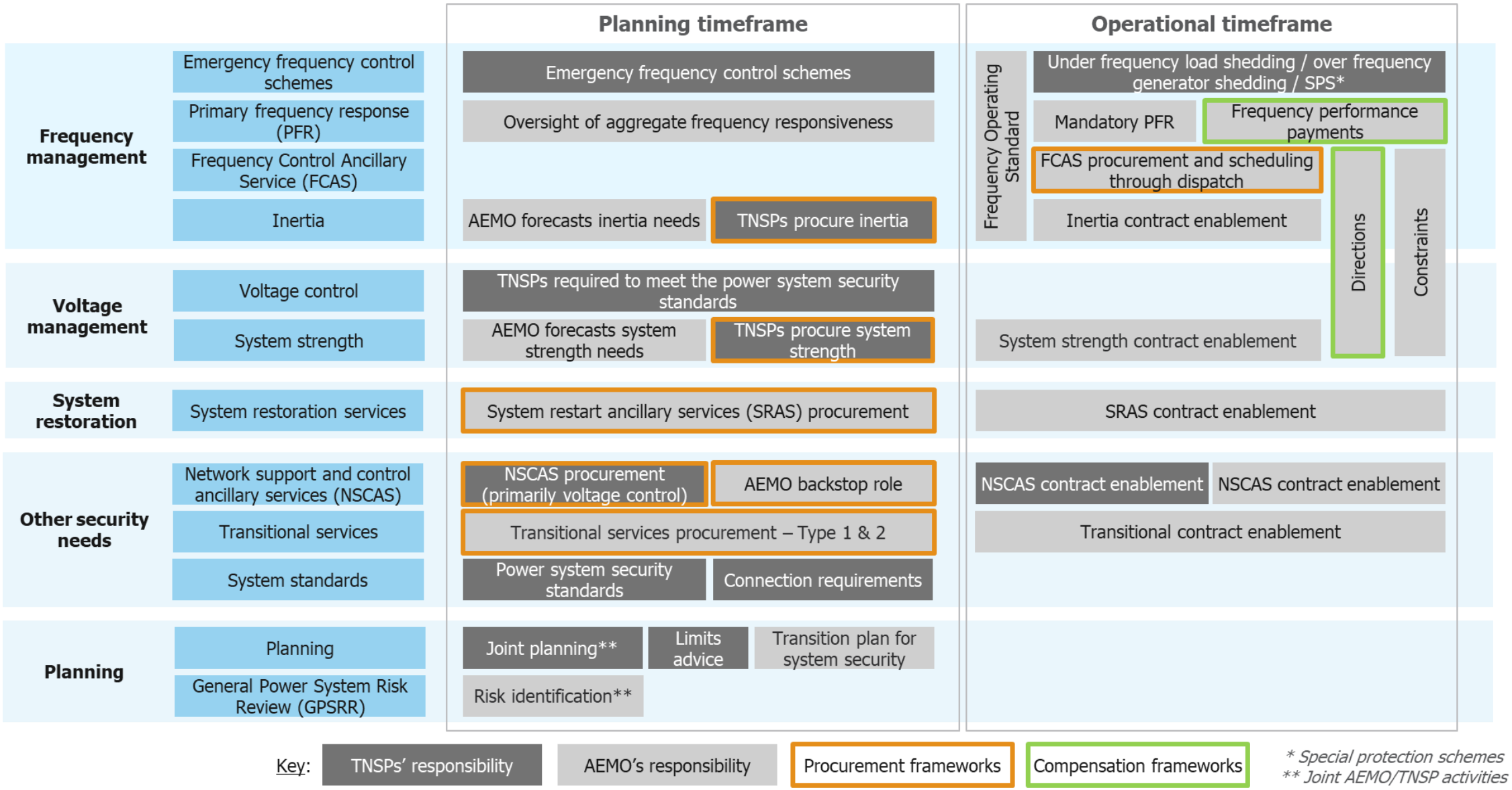
Current system security responsibilities – a high-level overview

	AEMO	Network Service Providers (NSPs)	Registered Participants (generators, batteries and loads)	Reliability Panel

Secure operation of the power system 	• Must **maintain and improve power system security** (s49 of the NEL)
	• Must determine the **technical envelope** of the power system to operate securely.
	• In real-time, AEMO maintains security by:
	  • Invoking constraints on dispatch that maintain thermal, voltage, frequency or transient stability
	  • Procuring and scheduling system security services through FCAS markets or contract enablement
	  • Issuing directions or instructions to Registered Participants, if necessary.
		• Must co-operate with and assist AEMO to maintain power system security.
		• Must operate their networks to achieve the **system standards** (frequency, voltage, fault clearance times, three phase fault levels).
		• If required, must execute emergency frequency control schemes (EFCS), load shedding schemes and system restart services, in co-ordination with AEMO.
			• Must operate their plant in accordance with any jurisdictional laws, the NER, their connection agreements, and good electricity industry practice.
			• Must comply with dispatch instructions and other instructions from AEMO or NSPs.
			• Must not adversely affect power system security or the quality of supply for other network users.
				• Determines the Frequency Operating Standard (FOS) that AEMO must comply with during operation.
				• Can declare non-credible contingency events as 'protected events', which affects operation.
				• Sets out a generator compliance template that Registered Participants must comply with.

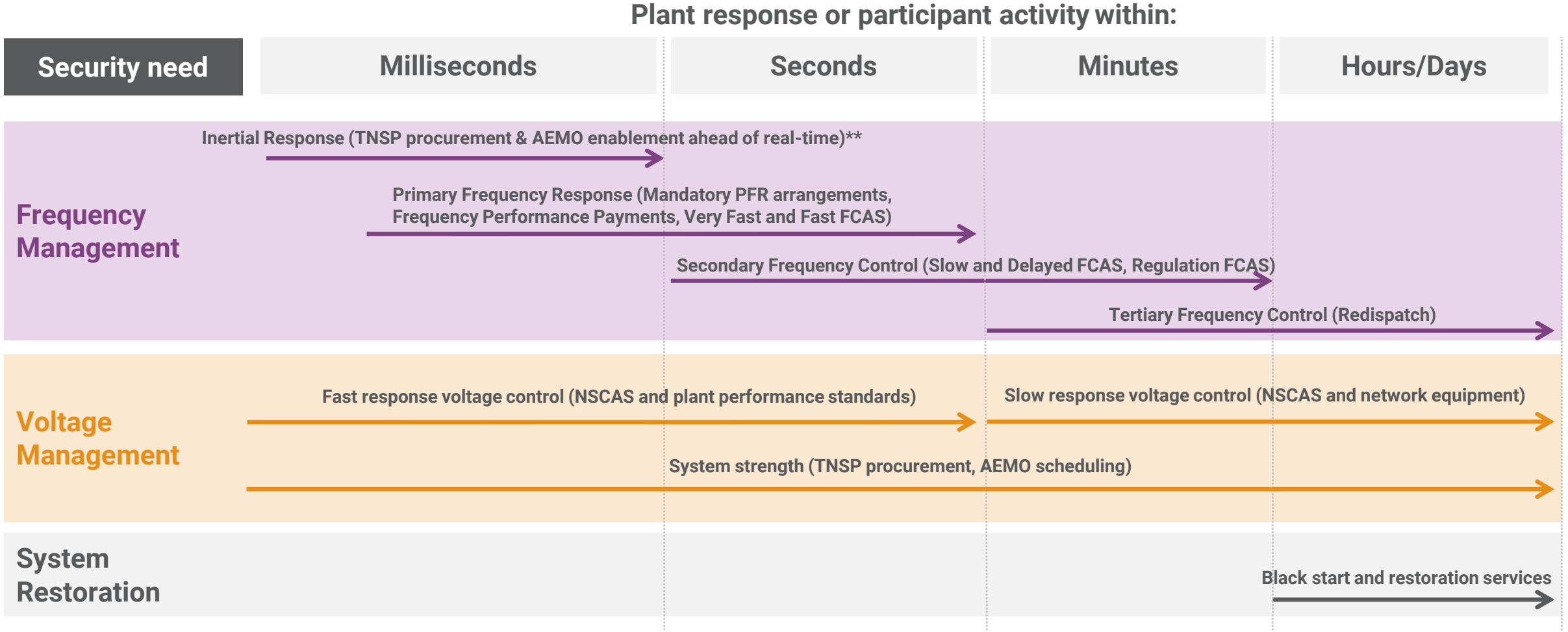
Security planning for future operation 	• AEMO and NSPs conduct joint planning to ensure the future power system can remain secure. This is achieved by:
	  • Determining future system strength, inertia and NSCAS requirements
	  • TNSPs being obliged to install new network equipment or procure system security services to meet system standards and shortfalls declared by AEMO
	• AEMO must publish an annual Transition Plan to describe how it will maintain security through the transition. This plan will identify security issues further into the future, and prompt work to address these that will then feed into new methods of operation. AEMO also includes security information in the ESOO and ISP.
		• NSPs must prepare annual planning reports to describe (amongst other things) how they will maintain network security over at least the next 10 years.	• While not obliged, usually participate in NSP or AEMO consultations and provide information about committed (but not yet commissioned) plant, and its effect on system security.
			• May offer long-term contracts for system security services, participation in trials, etc.
				• Determines the System Restart Standard that AEMO and NSPs must adhere to when procuring and co-ordinating system restart schemes.
				• Can determine system standards.
				• Provides feedback to AEMO on the Transition Plan for System Security.

Current NEM security frameworks



Operational timescales for services needed

There are many types of responses by plant, equipment and market participants that contribute to system security. The timescales of these responses can vary from milliseconds to hours or days.

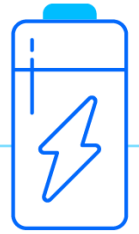


****NB:** While inertial responses and some system strength responses are inherent and instantaneous, AEMO will enable contracts up to 12 hours ahead of real-time to ensure that plant can inherently and instantaneously respond, when needed.

AEMC system security work program

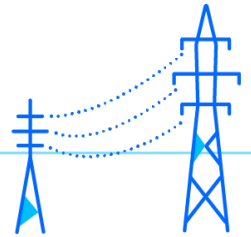
Power system security reforms are a key focus

Much of the AEMC's ESS work program had its genesis in the Energy Security Board's Post 2025 Market Design program. This set out reforms for system security agreed by the three market bodies. The overall vision was that services would be 'unbundled': separately defined, valued and procured, where possible.



Earlier reforms focused on frequency control

- Earlier reforms created frameworks for different types of frequency response.
- We implemented a new market for fast frequency control, as well as an incentive scheme for primary frequency response.

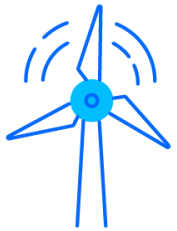


A framework for 'system strength' was developed

- System strength refers to a range of voltage-related characteristics of the network.
- We created a new planning standard that requires transmission companies to procure adequate system strength services.

Now we have a new framework for procuring 'transitional services'

- AEMO may now procure security services that are less easy to define.
- This framework also enables the trialling of new approaches for the delivery of security services.

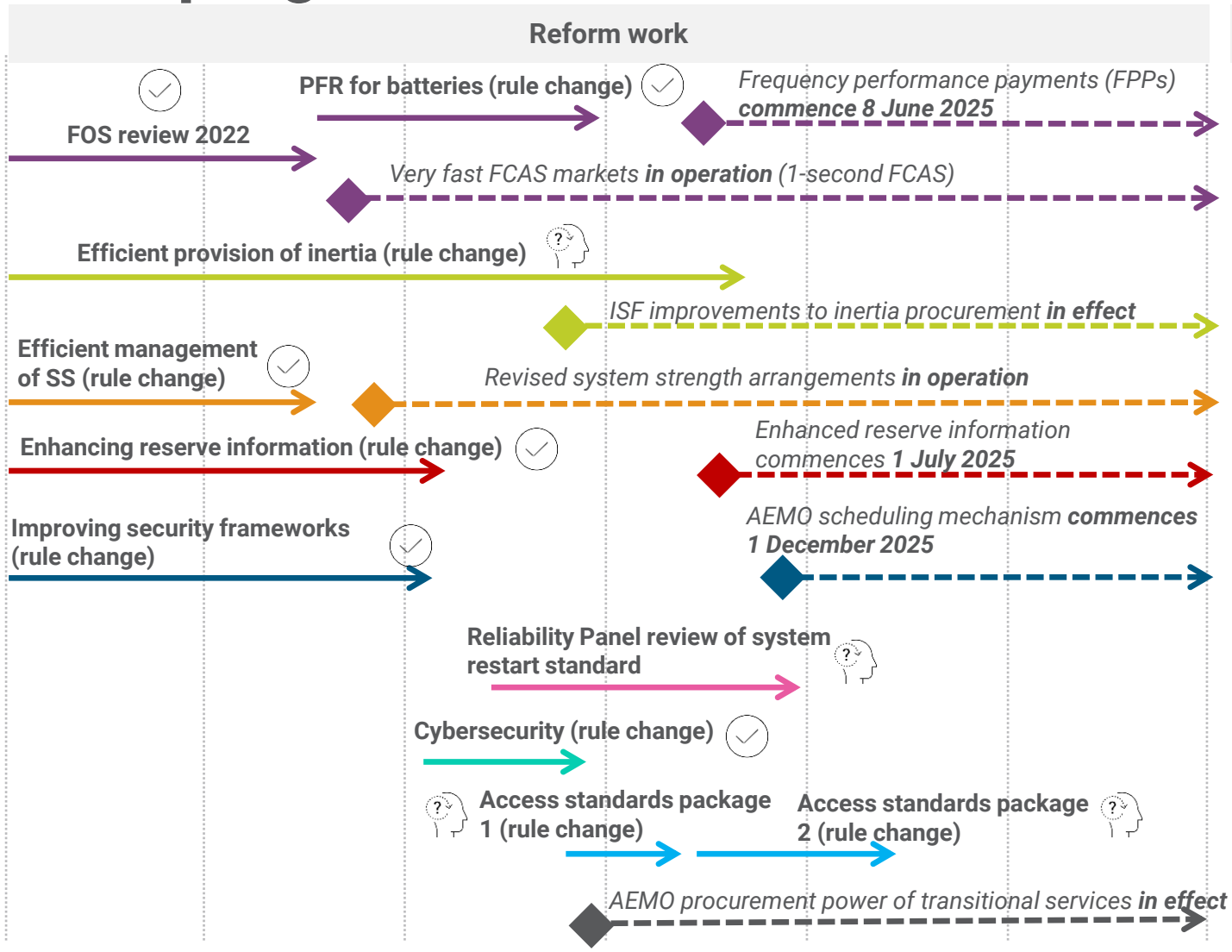


Connection reforms

- Updating system security access standards for connecting inverter-based generators and storage.
- Improving the connections process to enable the large amount of connecting plant.

System security work program

System service	Related frameworks
Frequency control	• Mandatory primary frequency response (PFR) • Frequency control ancillary services (FCAS)
Inertia	• Long-term inertia procurement
System strength	• Efficient management of system strength rule
Operating reserves	• Energy spot market
Procurement & scheduling	• New AEMO enablement tool (ISF)
System restoration	• Black system restart
Cyber security	• Cyber security roles and responsibilities
Access standards	• Connection applicant access standards
Transition planning	• AEMO Transition Plan for System Security • Transitional services contracts



Outcomes
Incentives for plant to contribute to frequency control A new market for very fast frequency control; vital for a low-synchronous system
Procurement of inertia and system strength now more proactive - to meet security needs as we transition. We are further considering real-time inertia procurement
Improved market visibility of storage capacity
AEMO can enable contracts to meet day-to-day security needs at least cost.
Will help ensure adequate system restart capabilities
AEMO has clearer responsibilities to mitigate cybersecurity threats
Will improve the connections process and plant contributions to power system security
More transparent AEMO forward planning for security, and new powers for AEMO to procure and trial security services

KEY

Rules have been made (*commencement date shown by diamond and dashed lines*)

Rule change currently under consideration

There are a variety of mechanisms for providing system security

Regulated provision	Contracted procurement	Centralised real-time procurement	Decentralised real-time procurement
Mandating that all plant have specific security capabilities	*Security services are procured through contracts*	*AEMO procures security services in real-time markets*	*Financial incentives indirectly procure security services*

Examples in the NEM

Access and system standards

All sufficiently large generators and loads must operate their plant in accordance with their connection agreements, set by reference to the access standards in the NER.

System strength impact assessment and remediation

Large generators and loads must ensure they do not adversely affect system strength, either through self-remediation or by paying for network services.

System strength, inertia, NSCAS and SRAS contracts

TNSPs (or AEMO, for SRAS) may procure these from Registered Participants. These services are provided as agreed with the NSP and may be enabled by AEMO ahead of real time.

Transitional service contracts

AEMO may procure transitional services to either:

- Help maintain system security (and cannot otherwise be provided through other contracts)
- Trial new technologies and applications that will help AEMO to manage system security throughout the transition.

Regulation and contingency FCAS

AEMO procures frequency response through multiple 5-minute real time ancillary markets.

These markets provide frequency response both for normal operation and for returning frequency back to 50 Hz after a contingency event.

There are 2 regulation FCAS markets (Raise/Lower) and 8 contingency FCAS markets across different timescales (Raise/Lower for each timescale: 5 min, 60 sec, 6 sec and 1 sec).

Frequency performance payments

An incentive payment to encourage plant to provide primary frequency response beyond the mandatory access standard.

Providers are paid if they provide helpful frequency responses and are penalised if they provide unhelpful frequency responses (for example, if they deviate from dispatch targets).

Our system security work program is extensive

Our work seeks to ensure that technical needs are met effectively and efficiently both today and in future.

As we decarbonise, we shift towards a more dynamic power system, with increased supply and demand variability. We need to become more dynamic in how we manage system security operationally, where appropriate.

Our work program is focused on working with AEMO and others to:

Be more proactive & innovative in determining future security needs

AEMC work: Improving Security Frameworks (ISF)

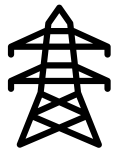
We need a greater focus on determining future needs now, rather than relying on 'just in time' planning, given asymmetric risks and the pace of transition, to lower costs for customers.

We want to see trials of new technologies to promote innovation in how security is provided and managed.

Work towards more dynamic measurement & valuation of system security services

AEMC work: Efficient provision of inertia

We want to move towards more granular management of system security services in operational timeframes, where this is possible, to improve efficiency, security and resilience.



Improve network and system transparency

AEMC work: Improving Security Frameworks (ISF)

Key to a successful transition is improved transparency from NSPs and AEMO (e.g. publication of network models) on system security, allowing for greater scrutiny and collaboration to meet future security needs.

Technical evolution and innovation

Market frameworks and transparency

Appendix
More details on the AEMC's security reforms

AEMC 2024-25 work program priorities

	Consumers	CER	Long-term market design	Transmission
What	*Progress work relating to urgent issues for consumers under the regulatory framework, including how we inform, empower and protect customers individually and as a collective.*	*Progress work relating to the technical aspects of CER including the efficient integration of new technologies into the market and system.*	*Progress work relating to longer-term market design to ensure our frameworks provide the appropriate reliability settings, efficient provision of system services and investment signals for the net-zero future.*	*Progress work relating to the cost-effective and efficient delivery of major transmission and network infrastructure.*
Key projects	• Pricing for a consumer driven future • Acceleration of smart meter deployment • Access to real time consumer data • Understanding consumer behaviour and preferences • Preventing price increases for a fixed period • Removing fees and charges • Assisting hardship customers • Ensuring energy plan benefits last the length of the contract • Removing unreasonable conditional discounts • Improving the ability to switch to a better offer • Improving the application of concessions to bills	• Integrating price responsive resources rule change • Unlocking CER benefits rule change • Leading the DSO workstream of the CER taskforce • Contributing to EV work via the CER Taskforce and our consumer pricing review	• Preparing for the future of gas, including stage two gas reform rule changes • Technical access standards rule changes • Efficient provision of inertia • Cyber security roles and responsibilities • Our work on future wholesale market design • Understanding the impact of a changing climate on the reliability, resilience and security of the energy system • Offshore wind report • Review of the reliability standard and settings	• Outstanding rule changes from the Transmission Planning and Investment Review • Providing flexibility in the allocation of interconnector costs rule change • Improving regulatory frameworks for non-networks options • Inter regional settlement residue arrangements for transmission loops • ISP rule changes

Frequency reform program

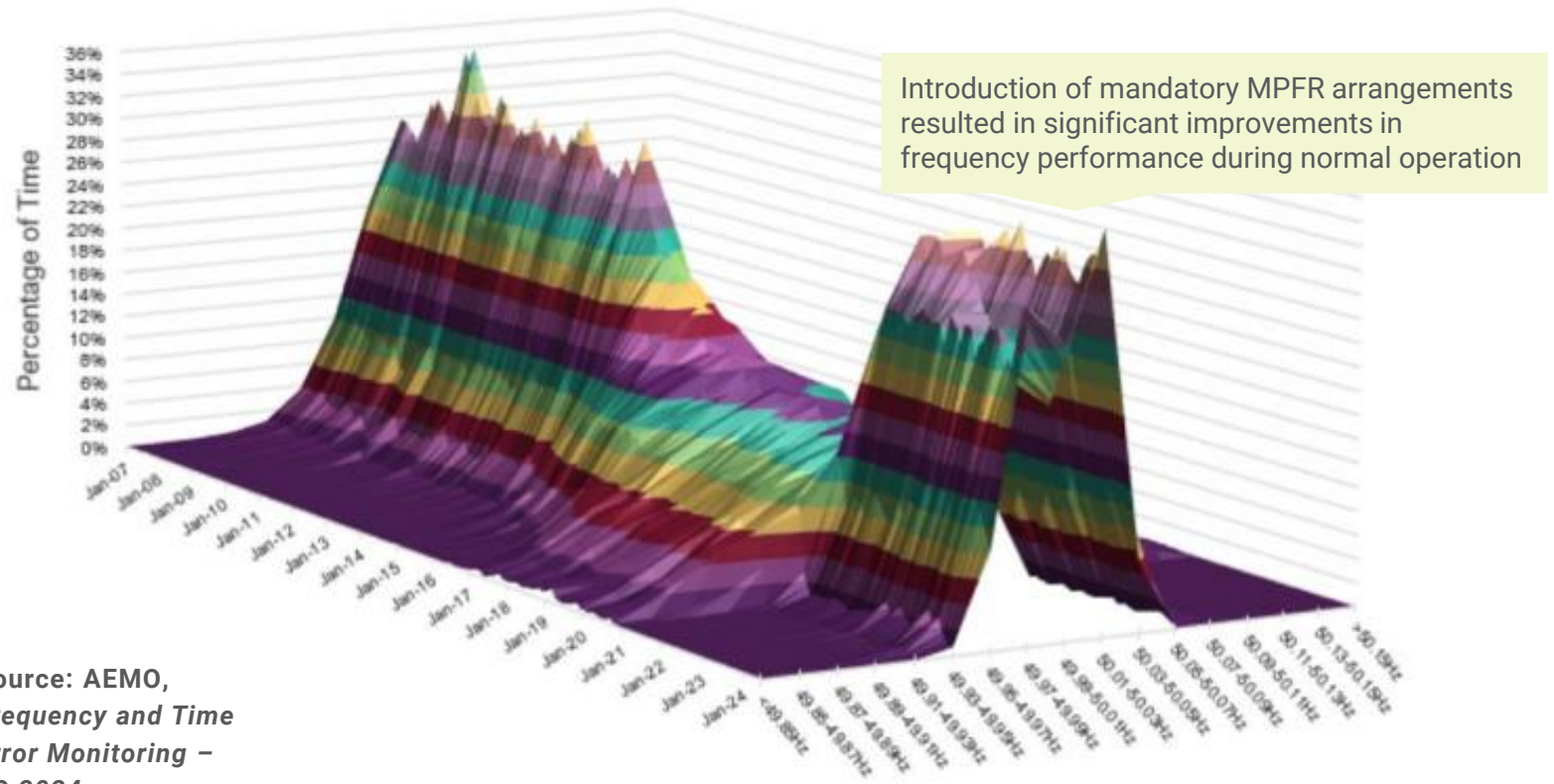
Frequency control has been under increased focus in recent years	Policy reforms introduced to address the deterioration in PFR	Policy reforms introduced to address higher ROCOF

• Frequency control was under increased focus due to:
  • a deterioration in the provision of primary frequency response (PFR) from generators leading to a flattening of the distribution of frequency around 50Hz
  • a reduction in inertia from the retirement of synchronous generators leading to higher rates of change of frequency (ROCOF) following contingency events
	• Policy reforms introduced to address the deterioration in PFR have included:
	  • The mandatory provision of PFR from all scheduled and semi-scheduled generators within a narrow frequency band (49.985 - 50.015 Hz) – commenced in **June 2020**
	  • The introduction of double-sided frequency performance payments to encourage plant behaviour that helps to control power system frequency – commencing **July 2024**
		• Policy reforms introduced to address the reduction in inertia have included:
		  • Two new markets for fast frequency response (FFR) services to operate similar to the existing arrangements for frequency control ancillary services (FCAS) – commenced **October 2023**
		  • The AEMC is also currently considering a proposal to introduce a separate market for inertia (see slide 19)

The introduction of mandatory primary frequency response arrangements has resulted in an improvement in performance

Monthly frequency distribution

(January 2007 to January 2024, percentage of time)



Source: AEMO, ***Frequency and Time Error Monitoring – 2Q 2024.***

- In **2020,** the Commission completed a final rule requiring mandatory PFR from all generators resulting in a **significant improvement in frequency performance** during normal operation.
- Commencing in **June 2025**, all market participants will receive **frequency performance payments (FPPs)** based on their contribution to maintaining system security:
  - payments for units having a positive effect on frequency control
  - costs allocated to units having an adverse effect on frequency.

Inertia

Inertia helps keep the system stable

- **Inertia** is a fundamental characteristic of the power system that is vital for system stability. Inertia helps maintain frequency after disturbances and damps oscillations.
- Inertial responses can be provided by synchronous generators and load, synchronous condensers and grid-forming inverter-based plant.
- As the NEM transitions, synchronous generation will exit and inertia from these sources will decline. However, inverter-based generation – and likely their inertia provision - will increase over time. Also, the NEM's demand for inertia may decrease over time with the change in generation mix.

The AEC proposed an inertia spot market

- The AEC considers that the NEM's **long-term procurement framework** for managing inertia is inefficient and not fit for purpose because:
  - Declining inertia due to retiring synchronous generation may pose a future threat to power system security and operations.
  - Inertia is not efficiently procured or allocated in real-time – procurement is based on static annual requirements and does not allow co-optimisation.
  - Clearer investment signals are needed to meet long-term inertia needs.
- **The AEC has therefore proposed an ancillary service spot market** for inertia.
- Since the rule change was submitted, the AEMC **updated** the long-term procurement framework of inertia through the ISF rule change. It is now more proactive, includes an inertia 'floor', and allows for 'synthetic inertia' to meet requirements.

We found there may be benefits to operational procurement

- We are **focusing on operational procurement options** in this rule change (e.g. a spot market) given the ISF updated the long-term framework.
- Our **Directions paper** assesses the economic case for operational procurement:
  - We applied a test to help determine whether services are appropriate for operational procurement
  - We then estimated the benefits of operational procurement with information on inertia supply, demand and costs.
- We found that there may be benefits to consumers from procuring 'additional inertia' – that is, inertia above minimum levels that can help reduce overall system costs.
- We also explored some key questions on future inertia demand and supply – including provision of inertia through synchronous condensers, and the potential for higher demand in future due to larger contingencies (e.g. from REZs).
- Our next step is to consider policy designs and costs in more detail. The draft determination is due in **June 2025.**

System strength

System strength is an evolving concept

- System strength is the ability of the power system to resist changes to its clean, stable, sine wave signal; both during normal operation and following a disturbance
- Synchronous units provide system strength naturally by virtue of their large spinning mass which produces a 'heavy' continuous sine wave, which remains available even during external disturbances to the system
- Non-synchronous units typically use electronics to match the system's sine wave; however, without a 'heavy' signal to follow nearby – they can be subject to oscillation, or interaction with each other
- As well as encompassing the electrical characteristics and power system interactions, system strength is often approximated by the amount of electrical current available during a network fault (fault level).

We reformed the system strength arrangements in 2021

- In **2021**, we made a rule to introduce a **proactive** system strength procurement framework
- The framework introduced a new planning standard for TNSPs to centrally procure system strength to meet AEMO forecasts of inverter based resources, 3 years into the future
- TNSPs commenced planning for system strength in **Dec 2022** to meet the standard by **Dec 2025**
- Connecting generators have a choice as to how to address their system strength impact- remediate its general system strength impact; or pay a charge to use some of the NSP provided system strength

The new framework is being implemented

- The AER is providing guidance on the framework as it is implemented; and AEMO is continuing to refine procedures and guidelines as their engineering knowledge increases
- System strength continues to be a topic of conversation in the market as AEMO determines the capabilities of new technologies to provide it, and TNSPs conduct procurement to meet their obligations

Operating reserves

The changing energy system may give rise to a greater need for operating reserves

- Operating reserves (OR) are defined as the capability to respond to large continuing changes in energy requirements.
- Minimum levels of reserves are required for AEMO to maintain system security and reliability.
- The NEM is undergoing a transition towards more weather-dependent and energy-limited VRE generation.
- This changing risk profile gives rise to an increase in variability and uncertainty in the power system.
- A separate market for the procurement of OR was proposed in two rule change requests received from Iberdrola and Delta in 2020.

We explored the potential benefits of a separate market for operating reserves

- Reserves are currently priced implicitly and are made available by participants to manage their financial risks, which in turn meets the physical needs of the system.
- By creating an explicit price for reserves, an OR market can be considered a fundamental change to the way reliability needs are met in the NEM.
- AEMO strongly supported an OR market. All other stakeholders unanimously supported not introducing an OR market.

We determined not to introduce a market for OR but instead made changes to increase transparency

- In the final determination, the Commission determined not to introduce a separate OR market. The Commission found that:
  - existing arrangements are sufficiently flexible and wouldn't offer any material improvements but would increase costs
  - an OR market may dilute investment signals and be at odds with the direction of recent reforms (e.g. 5MS)
- To support participants' operational decision-making, the final rule introduced a requirement for AEMO to publish real-time information on generator energy availability.

Improving Security Frameworks for the Energy Transition (ISF)

We were looking at how to value security services

- **Problem:** The changing generation mix has led to more interventions in the NEM for security, which is inefficient.
- We need to ensure that there are long-term incentives to provide enough security services to meet the needs of the future system.
- It is difficult to define and operationalise some security needs in 'real-time' in the NEM – AEMO manages security through system configurations

- **Two rule changes**, which the Commission consolidated:
- Delta Electricity – proposed an ex-ante, day-ahead procurement mechanism for security services
- Hydro Tasmania – proposed real-time valuation of security services, by co-optimizing units' online status in NEMDE & allowing units to bid prices and availability.

We originally proposed close-to-real-time procurement

- We originally proposed the 'Operational Security Mechanism' (OSM) to procure and schedule security services close to real-time (e.g. 30 min ahead). Ch 3 of the draft determination outlines its design.
- Stakeholders had a range of views on the right approach. Ultimately the Commission had concerns with the OSM (see 2.2 of the Second directions paper):
  - Unlikely to get clear long-term investment signals where the security service is difficult to define
  - Spot market interactions
  - Market power concerns
  - Complexity of the mechanism
- Instead of a close to real-time procurement mechanism, the Commission pivoted its focus to a simpler approach. We focused on building on the existing long-term procurement frameworks to meet security needs in the short- to medium-term.

We ultimately improved long-term procurement frameworks & provided transitional tools

Changes in the Improving Security Frameworks final rule:

- inertia procurement timeframes now aligned with system strength, all TNSPs required to procure inertia, inertia 'floor' introduced, and increased opportunities to procure synthetic inertia (**from Dec 2027**)
- adjusted TNSP cost recovery procedures for non-network security options (**from Dec 2024**)
- new transitional non-market ancillary services (NMAS) framework - AEMO can procure security services necessary for the transition and trial new sources of security (**active**)
- AEMO will enable (or 'schedule') security contracts in dispatch (**from Dec 2025**)
- new AEMO Transition plan for system security (**annually from Dec 2024**)
- improved directions reporting and transparency (**active**)

System restart

What is system restart?

- In the event of a major supply disruption, system restart ancillary services (SRAS) may be used to restart power stations as the initial stage of restoring the power system.
- The Reliability Panel is responsible for determining the system restart standard (SRS), which guides AEMO's procurement of SRAS.
- The Panel's last fulsome review of the standard was in 2016 with a more limited review undertaken in 2020 to set a standard for the combined Queensland sub-network.

What are the current issues?

- AEMO has identified that it is becoming increasingly challenging to secure the necessary level of SRAS sources at the appropriate level of reliability across the NEM.
- Associated challenges include:
  - an increasing reliance on a limited and shrinking pool of SRAS providers and a scarcity of SRAS capability amongst new transmission-level generation.
  - high levels of distribution connected PV generation present a growing risk to system restoration.

What are we proposing to do?

- The Reliability Panel has recently commenced a review of the standard in two stages
  - Stage 1 – review the broader regulatory framework with respect to system restoration and provide recommendations on potential actions to update the framework, including changes to the NER and AEMO procedures
  - Stage 2 – review and set the standard to reflect an up-to-date understanding of the power system
- Submissions to the issues paper closed on 30 January 2025. A final report is due in December 2025.

Cyber Security

The problem we looked to solve

- Cyber security is a prevalent issue. AEMO's cyber security role and responsibilities were previously not specified within the NER.
- While AEMO had powers to respond to an actual or pending cyber security incident (i.e directions powers to maintain system security) they did not have specific prevention and preparedness functions.
- Previously, these were undertaken in a limited capacity, with limited resourcing, and had no liability coverage.

Outcomes of the rule change

The final rule (published in December 2024):

- clarified AEMO's cyber security functions in Chapter 4 of the NER
- allowed AEMO to recover costs and confirms its immunity from liability to perform cyber prevention and preparedness functions
- Included **four functions** for AEMO
  1) **Function 1 -** AEMO will take on the role of *cyber security incidents coordinator*
  2) **Function 2 -** AEMO will *support cyber preparedness and uplift*
  3) **Function 3** AEMO will *examine cyber risks and provide advice to government and industry*
  4) **Function 4** AEMO will *facilitate the distribution of critical cyber security information to market participants*

Notes to be aware of

- AEMO has commenced consultation on whether its new cyber security roles and responsibilities may be determined a 'declared NEM project'.
- This consultation seeks to determine the way in which AEMO recovers its costs for the new cyber security roles and responsibilities.
- If AEMO determines, through consultation, that the new roles and responsibilities do not meet the criteria to be a declared NEM project, it will seek to recover its costs in accordance with the current fee structure, until new NEM-wide participant fees are set.

Connections reforms – access standards

The problem we are solving

- NEM access standards for new grid connection applicants have several issues. They are:
  - Not fit-for-purpose in an increasingly IBR-connected NEM, or refer to defunct standards, or put unnecessarily onerous obligations on applicants to prove and maintain compliance, which adds significant costs and delays to the connections process
  - Not prescriptive enough, often relying on engineering judgment and lengthy negotiations between applicants, NSPs and AEMO, causing further delays. This has been exacerbated in recent years by a shortage of engineers in the industry combined with a surge in connection applications.
- AEMC's connections reforms work program aims to improve NEM access standards to increase grid connection efficiency and accelerate renewable deployment to meet Australia's emissions reduction targets.

Proposed solutions

- Following a review, AEMO identified numerous opportunities to improve the technical standards that would:
  - More efficiently utilise the available performance range of plant
  - Improve power system resilience through fit-for-purpose standards
  - Lower the costs and time taken to connect
  - Remove impediments for the connection of grid-forming IBR
  - Broaden the application of access standards to synchronous condensers and HVDC links
  - Consistent standards for types of plant, regardless of registration category, owner or operator
  - Obligations on large inverter based loads (e.g. data centres)
- AEMC is progressing these numerous amendments through two packages of rule changes.

Notes to be aware of

- Package 1 is using a fast-track process, with a draft determination published in December 2024. The final determination is due in May 2025.
- We plan to commence package 2 in May 2025.

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