AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Emerging Generation and Energy Storage in the NEM

November 2018

Stakeholder Paper

Important notice

PURPOSE

This is a report for stakeholders to invite comment on potential strategic improvements to the NEM (including rules, procedures and systems), including how to better integrate grid-scale energy storage systems (ESS) into the National Energy Market (NEM), enabling the NEM framework to incorporate new business models.

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VERSION CONTROL

Version	Release date	Changes
1	05/11/2018	Initial document

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Executive summary

The current regulatory framework supports a traditional electricity supply chain model, where electricity is produced by large generators (suppliers) and transported through transmission and distribution systems to industrial, commercial, and residential customers who purchase the electricity.

The market, however, is changing. For example:

- Storage is being used to optimise the integration of variable renewable energy (VRE) into the National Electricity Market (NEM).
- Industrial and commercial customers seek to:
  - Supply their load with onsite generating systems or energy storage systems (ESS).
  - Enter commercial agreements directly with Generators.
- Residential customers with installed devices (otherwise known as distributed energy resources [DER], such as rooftop photovoltaic [PV] generating units and batteries) are also seeking to provide services to the NEM.

These market changes have led to the emergence of new business models, which seek to better utilise assets to deliver services and value to customers.

AEMO is receiving an increasing number of enquiries and registration applications from proponents with 'non-traditional' business models, and expects this growth to continue. These include requests to register and connect ESS as stand-alone systems or in a 'hybrid' system (ESS coupled with new or existing generating systems and industrial loads).

These requests raise concerns about the appropriate Registered Participant categories to apply to an ESS, and more broadly around participation of ESS under the regulatory framework. AEMO has also become aware that its systems and processes were not designed for ESS or the types of new grid-scale business models that are being proposed now or may be proposed in the future.

In consultation with stakeholders, AEMO has identified, and begin to implement, opportunities to improve short-term practices and processes in its registration and connection areas.

For ESS integration, there are two parallel streams of work progressing:

- Stream 1 seeks to define ESS and create a new category for bi-directional technologies to facilitate participation in the NEM, including integrating into dispatch with a single offer, where required. This would initially cover ESS offered into the market and operated as a stand-alone resource. AEMO expects to submit a rule change to the Australian Energy Market Commission (AEMC) by March 2019.
- Stream 2 is further consultation with stakeholders and analysis of the appropriate participation model and requirements to facilitate aggregation of 'hybrid systems', where a proponent has ESS and other on-site generation or load and wishes to offer it to the market as an aggregate resource, rather than separately participating in the market via the individual resources.

This paper focuses on areas of potential strategic improvement to the NEM (including rules, procedures and systems), including how to better integrate grid-scale ESS into the NEM, enabling the NEM framework to incorporate new business models.

It outlines issues and potential changes in three key areas:

- Definition of ESS.
- Participation and operation.
- National Electricity Rules (NER) recovery mechanisms for the costs of power system services.

AEMO has also set out issues and options for action in other areas, arising from stakeholder feedback and AEMO's experience, including:

- The opportunity to amend the NER to clarify that a Performance Standard is applicable to a Registered Participant connecting to an exempt network.
- The opportunity to amend NER clause 2.7 to specifically allow any person intending to build a grid-scale resources, such as a generating system, to be eligible for registration as an Intending Participant.
- The separation of operational and financial arrangements.
- The broader use of logical metering arrangements.

AEMO is seeking stakeholder feedback to understand industry views on these potential NEM improvements and determine their priority to stakeholders. Stakeholder feedback will inform AEMO's view of the regulatory changes needed to ensure participation models are appropriate and unnecessary barriers to NEM participation are addressed.

Written feedback from stakeholders can be sent to eges@aemo.com.au by Tuesday 4 December 2018.

AEMO will also host stakeholder sessions on 16 November 2018 in Brisbane, and 22 November 2018 in Melbourne, to share and discuss its thinking on the key areas of this paper.

Following consideration of this feedback, AEMO will produce a program of work, including opportunities for further stakeholder involvement.

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1. Introduction

1.1 Background to this paper

While energy storage systems (ESS) have been connected to the grid since NEM start, with pumped storage hydro, the NEM has now reached the point where proponents are including ESS as a part of their systems and portfolios. AEMO expects the role of ESS in the power system, to provide energy and system support services, will continue to grow.

Following the registration and connection of the first NEM grid-scale battery (the Hornsdale Power Reserve battery system), AEMO has received an unprecedented growth in registration and connection applications relating to ESS, as both:

- Individual connections (typically co-located with existing generating systems), or
- As part of a 'hybrid' system (ESS coupled with a generating system and/or industrial loads).

These applications have highlighted the need to review the existing NEM framework (including the NER, procedures, and systems) and processes associated with the participation of these new types of facilities and business models:

- AEMO has been able to register these facilities to participate in the NEM, but the experience with these registration and connection applications and subsequent operation in the market has raised concerns about how ESS participates in the NEM, and the appropriate Registered Participant categories to apply to ESS.
- It is also evident that existing AEMO systems and processes were not designed for ESS, or the types of new grid-scale business models that are being proposed now or may be proposed in the future.

AEMO expects continued growth in the number of applications for grid-scale ESS, either stand-alone or as part of a 'hybrid' system.

While AEMO has identified and implemented immediate changes to address some issues, there is a need to be future-focused and consider broader changes that facilitate ESS and the effective operation of the NEM.

1.2 Structure and approach of this paper

Chapter 2 of this paper sets out issues and proposed improvements to reflect ESS explicitly in the regulatory framework, including how to better integrate grid-scale ESS into the NEM, and enable the NEM framework to incorporate new business models. These issues and options relate to:

- Definition of ESS.
- Participation and operation.
- NER recovery.

Chapter 3 outlines a number of additional issues raised by AEMO and stakeholders, with options to address these issues:

- The NER is unclear about whether a performance standard can be applied to a generating system or load in an exempt network.

- Where a person is intending to build a generating system and does not intend to own, operate, or control it, it does not meet the Intending Participant registered participant category. Under this category, an Intending Participant can request access to network data needed to build the asset.
- Separation of operational and financial responsibilities under the regulatory framework.
- The further application of logical metering arrangements.

These last two are fundamental changes to the NEM design, and will require more detailed analysis and engagement to determine whether there is benefit in making these changes.

Every issue discussion in chapters 2 and 3 ends with specific questions for stakeholders.

1.3 Scope

The challenges and initiatives in this paper relate to grid-scale ESS, generation, and load. This paper focuses on areas of potential strategic improvement to the NEM, including Rules, procedures, and systems.

AEMO is also conducting separate work to identify how DER can provide services to the wholesale market, including through Virtual Power Plant (VPP) arrangements[1]. AEMO, the AEMC and ARENA collaborated to establish the Distributed Energy Integration Program, which involves a range of industry bodies working together to maximise the value of customers' Distributed Energy Resource (DER) to the Australian energy system and all energy users.

Although this work is separate and is not included in the scope of this paper, AEMO is considering the relationships between grid-scale ESS and DER for future NEM arrangements.

1.4 Stakeholder engagement

In December 2017 and March 2018, AEMO hosted two stakeholder workshops to discuss stakeholder and AEMO challenges with registering and connecting grid-scale generation and ESS under the existing NEM framework[2]. The purpose of these workshops was to identify opportunities to:

- Facilitate and support efficient participation of emerging generation and energy storage.
- Efficiently integrate technologies on the basis of technical requirements and capability of the technology.
- Improve process and system efficiency by having flexible, robust and transparent arrangements.

As a result of the December 2017 workshop, AEMO developed a program of work to:

- Improve processes and educate stakeholders.
- Investigate issues and improvements that could be made to NEM arrangements.

In the March 2018 workshop, AEMO presented short-term improvements to both registration and connection processes that it had begun to implement. This received positive stakeholder feedback and we are committed to continue dialogue with stakeholders to ensure improvements, that have a market benefit, are delivered.

In the March 2018 session, stakeholders and AEMO also identified:

- Challenges associated with registering and connecting new grid-scale generation and ESS under the current NEM framework.
- Emerging generation, load, and ESS and generation scenarios that must be planned for (see Section 1.5.)
- Key ideas that required further exploration to ensure any new arrangements are fit for purpose.

[1] For more information, see http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/DER-program.

[2] The December 2017 and March 2018 workshop presentation and meeting notes can be found on AEMO's website at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/Future-arrangements-for-Emerging-Generation-and-Energy-Storage.

Stakeholder key themes that emerged in the March 2018 session included:

- Current registration arrangements are inefficient and complex for batteries and 'hybrid' arrangements.
- A single dispatch offer is needed for batteries.
- AEMO systems should allow all resource combinations, including aggregate bids and offers of resources, such as wind, solar, battery, and/or load.
- Separate ownership and financial responsibilities of 'resources' behind a common connection point.
- Performance standards should be applicable to a Registered Participant's asset connecting to an exempt network.
- Intending Participant category should allow access to NEM information for newer business models, for example, project developers.
- Sharing an inverter between technologies should be planned for[3].

As a result of this stakeholder engagement, AEMO has been working to develop these ideas. This paper sets out AEMO's consideration of issues and opportunities, potential options and risks, and AEMO's assessment, and seeks stakeholder feedback to inform future positions to be pursued.

1.5 Future scenarios the NEM needs to plan for

Stakeholders and AEMO identified a range of relevant, plausible scenarios to help effectively plan for the future of the NEM, including regulatory framework and subsequent system changes.

Table 1 Future scenarios identified

ID	Scenarios
1	ESS
2	VRE and ESS
3	Synchronous and VRE
4	Synchronous and ESS
5	Synchronous, VRE, and ESS
6	Load and ESS
7	Load and VRE
8	Load, VRE, and ESS

1.6 Next steps for stakeholder involvement

Stakeholders are encouraged to review each section and address relevant questions or provide further written comment to eges@aemo.com.au by Tuesday 4 December 2018. AEMO will also hold two stakeholder workshops to discuss the key areas of this paper, on:

- Friday 16 November in AEMO's Brisbane office.
- Thursday 22 November in AEMO's Melbourne office.

[3] This paper does not address this theme.

AEMO appreciates the time and insight provided by stakeholders that has shaped its thinking in developing the concepts expressed in this paper, and looks forward to continuing this interaction to inform its final position on the topics in this paper.

After receiving this feedback, AEMO will develop a work program to outline the topics to be addressed, which would cover any NER, procedures, registration applications, and AEMO IT system changes.

2. Defining and integrating grid-scale ESS into the NEM

While ESS are not specifically addressed in the NER, accommodations have been made to allow ESS to participate in the NEM.

This chapter:

- Summarises the AEMC's 2015 review of NEM regulatory arrangements and subsequent Rule change, and explains how ESS has been accommodated in current arrangements.
- Outlines the key issues AEMO and stakeholders have identified with current arrangements, with options to address them, AEMO's comments, and stakeholder questions. These issues are discussed under the headings:
  - Definition of ESS.
  - Participation and operation.
  - NER recovery mechanisms.

2.1 Background – AEMC reviews and 2016 Rule change

In 2015, the AEMC recognised the increasing interest and application of ESS and began its Integration of Energy Storage Review. One of the review's key findings was that a new category of Registered Participant was not required to integrate ESS into the NEM[4].

In the Rule change consultation, stakeholders discussed whether the definition of generating unit captured all ESS. The AEMC recommended that an interested party submit a Rule change to ensure the definition of 'Generator' and 'generating unit' unambiguously included ESS. Subsequently, AEMO submitted a Rule change and the AEMC made this Rule in 2016[5].

As a result of that Rule change, the NER definition of generating system is sufficiently broad to include an ESS export of electricity. Given this, participation of ESS (more recently battery systems) requires AEMO to interpret the existing NER. AEMO's view is that a person who owns, operates or controls a grid-scale battery or pumped hydro and wishes to participate in the NEM must register as a Market Generator (for the electricity being exported to the NEM), and Market Customer (for the electricity being imported from the NEM)[6].

[4] AEMC, Final Report, Integration of Energy Storage, 3 December 2015.

[5] AEMC, National Electricity Amendment (Registration of proponents of new types of generation) Rule 2016 No. 4.

[6] Where an ESS proponent does not wish to purchase electricity from the NEM, it is not required to register as a Market Customer.

More recently, in 2018, the AEMC Coordination of Generation and Transmission Investment (CoGaTI) review has been exploring ESS-related topics, including the appropriate Registered Participant category and transmission use of system (TUoS) charges[7].

The AEMC has acknowledged AEMO's work in analysing and consulting on the issues and potential solutions for a long-term approach on ESS, regarding the appropriate Registered Participant category and how it should operate. AEMO and the AEMC are working collaboratively to identify the issues and potential solutions.

2.2 Current NEM arrangements

The current NER arrangements that are being used to register and connect are:

- Stand-alone ESS, including connected via a 'private' network or 'retrofitted' behind an existing generating system by a different Registered Participant (who is also the Financially Responsible Market Participant - FRMP).
- 'Hybrid' systems, including co-location of a battery with generation or load.

2.2.1 Interim arrangements for stand-alone ESS

Under the NER, a person with a generating system must be registered, unless otherwise exempted by AEMO. If a generating system has a nameplate rating of 30 MW or more, it must either be classified as a scheduled generating unit or semi-scheduled generating unit.

AEMO can exempt a person from the requirement to register a generating system that has a nameplate rating less than 30 MW. Conditions for exemption are in AEMO's Guide to Generator Exemptions and Classification of Generating Units[8]. Under this guide, an owner, operator or controller of a battery system that has a nameplate rating that is:

- 5 MW or above is required to register as a Market Generator (classified as a scheduled generating unit) and Market Customer (classified as scheduled load)[9].
- Less than 5 MW is granted exemption from registration[10].

A person who owns, operates, or controls a pumped hydro, which would typically have a nameplate rating of 30 MW or more, registers and classifies its generating units as scheduled generating units.

Under AEMO's Interim Arrangements for Utility Scale Battery Technology (Battery Interim Arrangements), a person who owns, operates, or controls a grid-scale ESS must typically register as both a Market Generator (scheduled generating unit) and Market Customer (scheduled load)[11].

Consistent with NER requirements, they must separately meet the requirements of Market Customer and Market Generator. In its capacity as Market Generator, the Registered Participant must submit a dispatch offer in respect of its scheduled generating unit. In its capacity as a Market Customer with a scheduled load, the Registered Participant will also submit a dispatch bid. To cater for these separate requirements, AEMO's market systems require two separate dispatchable unit identifiers (DUIDs) The Registered Participant is responsible for managing its bids and offers to ensure the ESS does not simultaneously receive a dispatch target to both import and export electricity.

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[7] AEMC, Options Paper, CoGaTI, 21 September 2018.

[8] Refer to AEMO's website at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Exemption-and-classification-guides.

[9] In the case of a generating system with a battery that is integrated with another type of generation and will never be charging from the grid, AEMO will consider a proposal that the proponent not register as a Market Customer, provided that appropriate arrangements are put in place for the charging activity to be dispatched through central dispatch for reasons of power system security and operation.

[10] AEMO, Interim Arrangements for Utility Scale Battery Technology.

[11] For more information, see https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Interim-arrangements-Utility-Scale-Battery-Technology.

A Registered Participant can provide both energy and frequency control ancillary services (FCAS) as a market generating unit and market load, if it meets the Market Ancillary Services Specification (MASS) requirements and AEMO approves its application to do so. It may also be eligible to provide non-market ancillary services if it meets the requirements.

Although an ESS is connected to the grid through one connection point, and typically has one NER-compliant metering installation, AEMO must create two national metering identifiers (NMIs) to deal with the import and export from an ESS – one is a 'dummy NMI' for system purposes.

A separate marginal loss factor (MLF) is typically applied in dispatch and settlements to the imported and exported electricity.

Figure 1 illustrates a stand-alone battery system and Table 2 sets out the key NEM requirements for the battery system.

Figure 1 Stand-alone battery system

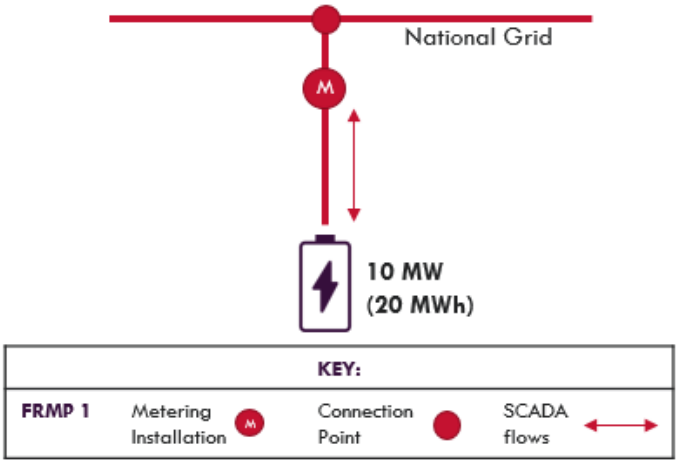


Table 2 Key NEM requirements for a stand-alone battery system

Registration	Performance standard	Central dispatch	Metering	Settlements and prudentials
• Generator, classifies as Market Generator and as a scheduled generating unit. • Customer, classifies as Market Customer and market load/ scheduled load.	Single performance standard, which covers load and generation.	Separate offer (scheduled generating unit) and bid (scheduled load) in AEMO market systems, represented by two unlinked DUIDs.	One metering installation required, must be capable of metering import and export of electricity.	• AEMO will settle the import and export electricity at the connection. • Maximum credit limit will be calculated for Market Generator and Market Customer separately, then netted to calculate any credit support required.

2.2.2 'Hybrid' system arrangements

Under the NEM arrangements, a proponent seeking to register and operate co-located ESS with generation or load must do so under the Generator and Customer Registered Participant categories.

As in a stand-alone ESS, the ESS in a 'hybrid' system will be subject to the interim arrangements discussed for stand-alone ESS and existing NER requirements for generation or load resources.

A Registered Participant with a 'hybrid' system can provide both energy and FCAS as separate market generating units and market loads, if these meet the MASS requirements and AEMO approves its application to do so. It may also be eligible to provide non-market ancillary services if it meets the requirements.

To bid into the market, the 'hybrid' system will have separate DUIDs (the ESS will have two DUIDs – one for imports and one for exports), and each generating unit and scheduled load will have separate DUIDs also. A separate MLF is typically applied in dispatch and settlements to the imported and exported electricity.

A Registered Participant is responsible for:

- Managing its separate bids and offers for each resource to ensure the ESS does not simultaneously receive a dispatch target to both import and export electricity.
- Describing its FCAS capability separately for each of the ESS DUIDs (those reflecting imported and exported electricity) so the combination of both provides information about the physical headroom possible.

Under the NER, Scheduled Generators, Semi-scheduled Generators or Market Participants can aggregate their relevant generating units, scheduled network services, or scheduled load[12]. The NER does not allow aggregation of generating units with a market load for energy or market ancillary services. Consequently, AEMO systems do not currently support aggregation of different resource types.

Therefore, and similar to the arrangements for an ESS, the generation and load must be treated separately.

Under this approach, a proponent has a number of options to register and connect, depending on their operational needs.

Figure 2 illustrates a 'hybrid' system with ESS (a battery system), generation, and load. Table 3 sets out the key NEM requirements including the typical way this 'hybrid' would be registered under the existing Registered Participant categories.

[12] Refer to NER clause 3.8.3.

Figure 2 'Hybrid' system

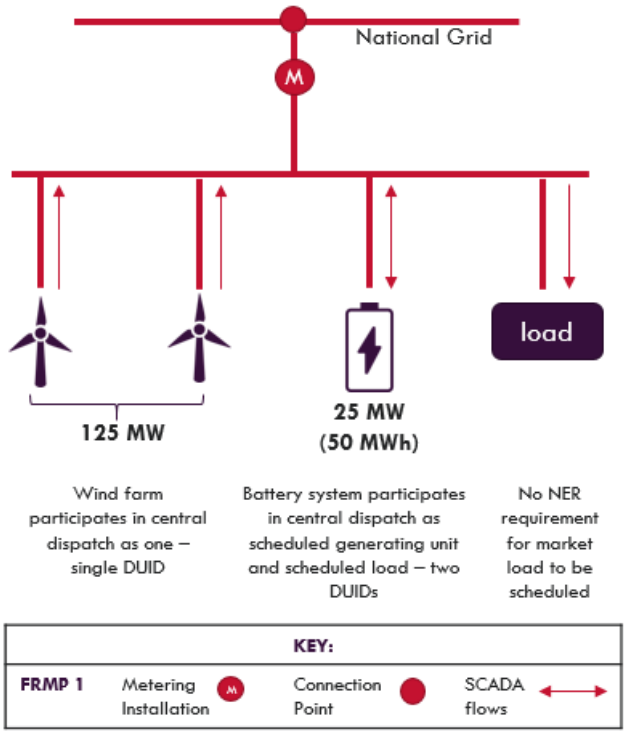


Table 3 Key NEM requirements for a 'hybrid' system

Registration	Performance standard	Central dispatch	Metering	Settlements/prudentials
Generator, classifies as Market Generator: • Wind as semi-scheduled generating units and aggregated under NER clause 3.8.3. • Battery as a scheduled generating unit. Customer, classifies as Market Customer: • Battery as market load/ scheduled load. • Market load, does not need to be scheduled.	Single performance standard.	• Wind farm – submits one aggregated offer, which is represented as one DUID in AEMO market systems. • Battery – submits separate offer (scheduled generating unit) and bid (scheduled load), In AEMO market systems, this is represented by two unlinked DUIDs.	One metering installation required, must be capable of metering import and export of electricity.	• AEMO settles the import and export electricity at the connection. • Maximum credit limit will be calculated for Market Generator and Market Customer separately, but will be aggregated for any credit support required.

Although an ESS is connected to the grid through one connection point, and typically has one NER compliant metering installation, AEMO must create two NMIs to deal with the import and export for the system, one is a 'dummy NMI' for system purposes. Separate MLFs will also be applied in dispatch and settlements to the imported and exported electricity.

2.2.3 NER recovery arrangements

Under the NER, AEMO is responsible for the power system being operated in a safe, secure, and reliable manner. To fulfil this obligation, AEMO controls key technical characteristics of the power system (such as frequency and voltage) through various market and non-market ancillary services and regulatory mechanisms.

Under Chapter 3 of the NER, AEMO recovers these services' payments or compensation payments from relevant Market Participants. Further, any settlement shortfall is recovered from Market Participants who are owed monies.

Table 4 identifies all NEM non-energy recoveries, with the Registered Participant category they are recovered from and relevant NER clauses.

Table 4 Current NEM non-energy settlement recovery

	Cost recovery from	NER Reference
Market ancillary services		
Frequency Control Ancillary Services (FCAS) – contingency raise	Market Generator including Market Small Generation Aggregator (MSGA)	3.15.6A (f)(3)
FCAS – contingency lower	Market Customers	3.15.6A (g)(3)
FCAS – regulation	Market Generator and Market Customers on causer pays basis	3.15.6A (i)
Non-market ancillary services		
Network support control ancillary services (NSCAS)	Market Customers	3.15.6A(c2)(1)
System restart ancillary services (SRAS)	Market Customers, Market Generators including MSGAs	3.15.6A(c2)(2)
Interventions		
Direction – energy	Market Customers	3.15.8(b)
Direction – FCAS	Market Customers, Market Generators on a causer pays basis	3.15.8(e)
Direction – other	Market Customers, Market Generators and MSGAs	3.15.8(g)
Mandatory Restriction	Market Customers	3.12A.7(e)
Reliability and Emergency Reserve Trader (RERT)	Market Customers	3.15.9(f)
Other events		
Market shortfall and surplus	Market Generators including MSGAs	3.15.23
Administered price cap or administered floor price compensation Payments	Market Customers	3.15.10(a)

2.2.4 NEM Participant fees and charges

Under NER Rule 2.11, AEMO also determines Participant fees to cover its budgeted revenue requirements associated with fulfilling its functions. AEMO fees and charges need to reflect the cost of participating in the NEM.

Table 5 sets out the Participant fees for specific functions AEMO has under the NER.

Table 5 Recovery of Participant fees and charges

Fees and charges	Cost recovery from	Reference
General (unallocated)	Market Customers and MSGA	Final Report – Structure of Participant Fees in AEMO's Electricity Markets 2016
Allocated direct costs	Market Customers – 54% Market Generators including MSGA and Market Network Service Provider – 46%	
Electricity Consumer Advocacy Panel	Market Customers	
Full Retail Competition	Market Customers (with a retail licence)	
National Transmission Planner	Customers and MSGAs	
Registration fees	Proponents registering	
Participant Compensation Fund	Market Generators (scheduled and semi scheduled)	NER cl. 3.16

2.2.5 Network Service Provider (NSP) based charges

Under the NEM arrangements, a person who owns, controls, or operates a battery with a nameplate rating of 5 MW or more is usually registered as a Market Generator and Market Customer.

Under the NER, the pricing methodology and calculation of network charges are the responsibility of NSPs, and these charges are regulated by the Australian Energy Regulator (AER). The AEMC's CoGaTI Review options paper provides a detailed explanation of these arrangements and their rationale[13].

In summary:

- Transmission use of system (TUoS) charges are one component of network charges to recover the costs of providing prescribed transmission services.
- It is a feature of the NEM's design that Market Customers pay TUoS and Generators do not.
- Generators pay for the costs associated with connecting to a transmission or distribution network.

Since a person who owns, operates, or controls an ESS with a nameplate rating of 5 MW or above and imports from the grid must be registered as a Market Customer, each NSP needs to consider whether it must recover TUoS charges consistent with the principles set out in the NER.

2.3 Issue

As set out in section 2.2 above, under the current regulatory framework, a single bi-directional asset (such as a battery system or pumped hydro system) is treated as two separate components. An ESS participates in the NEM as both load and generation. An ESS needs to import electricity to store for later export (either to the NEM or for local use). This bi-directional asset does not fit the existing regulatory model of treating an asset as either a Generator or Customer, which assumes a person either generates (supplies) or purchases electricity.

[13] AEMC, CoGaTI Review. See https://www.aemc.gov.au/markets-reviews-advice/reporting-on-drivers-of-change-that-impact-transmi.

The current approach to ESS in the regulatory framework (including rules, procedures and systems) may create problems, including:

- Lack of clarity for NER for proponents regarding how to register and participate in the NEM. Currently, ESS proponents need to refer to various AEMO explanatory guidelines to understand how their facilities may participate in the NEM.
- Complicated registration and participation arrangements, which result in proponents and AEMO spending more time and resources understanding the arrangements.
- Increased operational complexity and inefficiency. In particular, requiring a Registered Participant with a ESS (which has two DUIDs, one for load and one for generation) to:
  - Submit separate bids and offers for energy and FCAS into the market, which could result in simultaneous dispatch of the load and generation that needs to be managed by dispatch bids and offers;
  - Separately provide FCAS offers for the load and generation. The combined offers need to reflect the overall capacity to move from load to generation and vice versa;
- Difficulties for AEMO and other parties in understanding and analysing market data, as reference to two separate DUIDs is required to understand the operation of the ESS (as a single asset).
- Complicated IT arrangements for Registered Participants and AEMO.
- Uncertainty regarding the application of fees, recovery, TUoS, and non-energy recovery. In submissions to the AEMC's CoGATI, stakeholders have raised the uncertainty of TUoS charges as a key issue for ESS proponents.
- Insufficient information provided on the energy limited capacity reserves of batteries (which is an ESS). Currently, these are not optimised in pre-dispatch and PASA due to the NER not recognising and specifying any requirements for these assets. This lack of information might result in less informed decision-making for:
  - Registered Participants, as pre-dispatch information is less accurate.
  - AEMO when managing power system security and reliability, e.g., if ESS capacity is not known in a certain timeframe, it cannot be relied on when assessing system reserves and may result in AEMO underestimating available reserves and, for example, inefficiently intervening. Alternatively, relying on ESS capacity when energy limits are not accurate could lead to AEMO overestimating available reserves and not taking action early enough.

In the circumstance where a Market Customer is not registered for an ESS that has a nameplate rating less than 5 MW and being used to charge from the grid (therefore purchasing electricity from the NEM), the load component is treated as 'auxiliary' load. While the NER references 'auxiliary' load it does not define it. The Macquarie Dictionary defines 'auxiliary' as

> *1. giving support; helping; aiding; assisting.*
>
> *2. subsidiary; additional.*
>
> *3. used as a reserve.*

Auxiliary load is referenced in the NER definitions of generating system and continuous uninterrupted operation. In both definitions, auxiliary load refers to providing support or assistance. In this situation however, the electricity being imported is a primary input to the ESS, without it the ESS has no energy to store – it is its fuel rather than performing a supporting function. The AEMC also reached this conclusion in its CoGaTI Review[14].

Where this occurs, the NER does not specify the recovery of settlement non-energy fees and charges.

[14] AEMC, Options Paper, CoGaTI, 21 September 2018, p. 98.

2.4 Improvements to integrate ESS in the NEM

To address the issues identified above, AEMO has considered options to define and better integrate ESS into the NEM.

2.4.1 Defining ESS

It will be necessary to introduce a defined term of ESS into the NER to facilitate its integration.

AEMO considers that any new participation model for ESS should be technology neutral or sufficiently generic to allow different technologies to be covered by the definition for bi-directional assets, e.g. battery systems, pumped storage, fly-wheels. Using a generic definition future-proofs the regulatory arrangements by allowing future bi-directional technologies that have not yet become commercial to be covered.

For further information, some current international definitions of ESS being proposed or defined are in Table 6Error! Reference source not found.

Table 6 International definitions of ESS

Proposed or implemented definitions	Market
Electricity storage "- Electricity Storage in the electricity system is the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy. - Electricity Storage Facility in the electricity system means a facility where Electricity Storage occurs." [A]	UK – OFGEM
Electric storage resource "a resource capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid." [B]	All US markets subject to FERC Order 841
Energy storage facility Means a facility with technologies capable of storing and releasing electric energy.	Alberta Electric System Operator
Energy storage unit - A Generation Unit(s) using storage devices to generate and consume electricity as a or as part of, a PPM. Power Park Module - A Generation Unit or ensemble of Generation Units generating electricity which: • Is connected to the Network non-synchronously or through power electronics. • Has a single Connection Point to a Transmission System, Distribution System or HVDC System. Energy storage generator - A Generator which owns and/or operates any Energy Storage Power Station.[C]	Eirgrid

A. OFGEM, Clarifying the regulatory framework for electricity storage: licensing, p. 7.
B. FERC Order No. 841, United States of America Federal Energy Regulatory Commission. p. 26.
C. EIRGRID, Modification Proposal Form MPID 269 –Power Park Modules.

AEMO's assessment

ESS should be defined in the NER, to facilitate the integration of ESS in the NEM. The definition should be technology neutral and accommodate all energy storage types.

Suggested definition:

> Energy Storage System
>
> A resource capable of receiving imported energy from the national grid or other energy source and storing it for later export of energy to the national grid or Customer located (or connected) at the same site.

Questions for stakeholders

Question 1: Referring to Section 2.3, are there any other issues with the current arrangements for ESS?

Question 2: Do you have any views on whether a definition of ESS should be included in the NER?

Question 3: Do you have any views on whether a definition of ESS should be generic and encompass technologies other than batteries, for example, pumped hydro?

Question 4: Do you have any views on AEMO's suggested definition of ESS?

2.4.2 Participation and operation

This section identifies options to facilitate the participation of grid-scale ESS and integrate new business models into the NEM.

In assessing the options, a number of key areas need to be considered, including:

- The registration category and eligibility requirements.
- Bidding and dispatch requirements for energy and FCAS.
- Application of MLFs.
- Minimum metering requirements.
- Settlement and prudential requirements.
- Application of performance standards.
- Demand and supply forecasting.

The appropriate recoveries, fees and charges to apply to ESS is separately discussed in Section 2.4.3.

Option 1 – Create a new Registered Participant category for grid-scale ESS

This option involves creating a new Registered Participant category in NER Chapter 2 for ESS only. A person who is the owner, operator or controller of an ESS would be required to register with AEMO to participate in this category. AEMO would have a power to exempt a person who owns, operates or controls an ESS from registering. The exemption criteria should be specified in an AEMO guideline.

Key aspects of how an ESS Registered Participant could be integrated into the NER include:

- Similar to the provisions applying to Customers and Generators, the ESS could classify as market or non-market.
- The ESS Registered Participant would be allowed to participate in FCAS and energy markets. For each, through a single dispatch offer, with 10 price-quantity bands from full imports to full exports. Where an ESS has non-continuous operating range (those with energy and FCAS response dead-bands during flow reversals), the import and export will need to be separately dispatched.
- A person registered for an ESS would reflect their dual MLFs in prices offered across the 10 price-quantity bands and NEMDE will use a single MLF for dispatch, this would eliminate the risk of conflicting dispatch offers. The key challenges section explains this further. AEMO would continue to apply dual MLFs in settlements.
- The ESS Registered Participant would be integrated into NEM non-energy settlement recoveries, Participant fees and charges, and NSP charges using metered imports and exports, as discussed in Section 2.4.
- Consistent with existing arrangements:
  - The ESS would be required to have SCADA

- A performance standard is applicable at the connection point
- A NER compliant metering installation is required at the connection point
- AEMO would settle and calculate prudential requirements for the Registered Participant on the metered energy at the connection point.

- In addition to changes at a NER and procedural level, this would require changes to AEMO's market systems to more accurately reflect the physical characteristics of ESS – including their bi-directional power and energy limits. This would improve the current forecasting and decision-making tools for both AEMO and stakeholders by accounting for ESS in Dispatch, 5min Pre-dispatch, Pre-dispatch and PASA (PD and ST). This would ensure more accurate information is provided to:
  - Market Participants (unit energy loading, unit FCAS enablement and pricing information) to make informed business decisions.
  - AEMO to fulfil its duties regarding maintaining power system security and reliability.
- A person registered for an ESS would provide existing and additional inputs to the AEMO market systems, refer to proposed new requirements in Table 7. AEMO will consult with stakeholders on the requirements for ESS to understand the costs and benefit of requiring this information.

Table 7 Proposed new information requirements needed to better reflect ESS physical characteristics

Input	Unit	Information provided via	Description	Why is it needed?
Import efficiency	%	Schedule 3.1	Ratio of energy imported at the point of connection (when charging the ESS facility at its registered Maximum Charge Capacity), to the registered Maximum Energy Capacity of the ESS facility, expressed as a percentage.	Required in NEMDE/PASA for feasible dispatch, to account for losses from POC to facility when applying state of charge constraints.
Export efficiency	%	Schedule 3.1	Ratio of energy exported at the point of connection (when discharging the ESS facility at its registered Maximum Discharge Capacity), to the registered Maximum Energy Capacity of the ESS facility, expressed as a percentage.	Required in NEMDE/PASA for feasible dispatch, to account for losses from facility to POC when applying state of charge constraints.
Registered Maximum energy capacity	MWh	Schedule 3.1	Maximum storage capacity (i.e. energy stored when ESS is fully charged). This value is measured at the facility (can be referenced to point of connection). Note, the registered minimum SOC is assumed to be 0 MWh.	Required for verification and compilation of Maximum SOC in dispatch offers.
Registered Maximum Charge Capacity (note, Registered Maximum (Discharge) Capacity is existing	MW	Schedule 3.1	Maximum charging power that may be dispatched at the ESS facility. For ESS, this is a negative value and represents the maximum amount the unit will import to which it can be dispatched. This value is measured at the point of connection.	Required for validation of Maximum Charge Availability in dispatch offers.
Maximum Charge Availability	MW	Dispatch offer	The maximum available charging power of a unit submitted as part of the dispatch offer. For ESS, this is a	Required in NEMDE/PASA for feasible dispatch.

Input	Unit	Information provided via	Description	Why is it needed?
(note, Maximum (Discharge) Availability is existing)			negative value and represents the maximum active power capability of the load component of the ESS. This value is measured at the point of connection.	
PASA Maximum Charge Availability	MW	Dispatch offer	The maximum available charging power of the unit which is expected to be available over the PASA timeframe. For Energy Storage, this is a negative value and represents the maximum load of the unit which is intended to be available.	Not required at the moment.
Maximum State of Charge	MWh	Dispatch offer	Maximum storage capacity available to the market. This value is measured at the facility (can be referenced to point of connection).	• This would indicate any constraints given the current SOC and maximum allowable SOC. • It is expected that this would typically be equal to the registered maximum SOC, however may be reduced given technical constraints, such as planned battery pack outages.
Minimum State of Charge	MWh	Dispatch offer	Minimum storage capacity available to the market. This value is measured at the facility (can be referenced to point of connection).	• This would indicate any constraints given the current SOC and minimum SOC. • It is expected that this would be typically 0 MWh, however may be raised to avoid deep cycling of batteries or in the case of capacity that is reserved for last resort system security purposes.
State of Charge	MWh	SCADA	Instantaneous SOC. This is the amount of charge currently stored by the ESS. Measured at the facility terminals.	• Used in NEMDE Dispatch/5MPD (and potentially PD, STPASA) along with bid Max/Min SOC, to restrict energy dispatch and FCAS Raise enabled to the remaining energy. Benefit is feasible dispatch and intervention outcome. Instantaneous updates for state of charge will eliminate latency issues with the 5-minute granularity of the bidding and dispatch timeframe. • This SCADA signal should override bid Max SOC if it is lower.
Maximum state of charge	MWh	SCADA	Instantaneous maximum SOC (see maximum SOC definition, above). Measured at the facility terminals.	• All used in constraints for solver. Benefit is feasible dispatch and intervention outcome. For example, this input should not exceed the current offered SOC, unless there is an unplanned de-rating or outage. Instantaneous updates for SOC will eliminate latency issues with the 5-minuts granularity of the bidding and dispatch timeframe. • Potential to be used in NEMDE Dispatch/ 5MPD timeframes to restrict FCAS Lower enabled to remaining energy charging headroom. • This SCADA signal should override dispatch offer if it is lower.

Key challenges with option 1

AEMO has identified several key challenges with option 1 and considered ways to address these challenges. AEMO seeks feedback from stakeholders on the issues raised, and also feedback on any other challenges that would arise for stakeholders in the proposed model.

Table 8 Challenges and risks - Option 1

Challenge	Options considered	Comment
Potential for a single dispatch offer to not be monotonically increasing due to the application of a different MLF for import and export of electricity. This could occur between the import and export bands if the band prices are close in value and import band price * import MLF is greater than export band price * export MLF for those two bands.	• Option A: For dispatch purposes, a single MLF would apply for an ESS or an aggregated hybrid system across both imports and exports. Market settlements would still apply the different MLFs to imports and exports. AEMO proposes the dispatch MLF to be the average of the import and export settlement MLFs. • Option B: Keep the existing arrangement of applying different MLFs for imports and exports in dispatch. Market Participant structures the prices in their offers such that the prices multiplied by the MLFs for imports and exports will not decrease in any band • Option C: Introduce additional integer variables to the NEMDE solver	• Option A is preferred. • Option B is considered limiting for participants as sufficient gaps needs to be kept in the offer band prices where the junction between imports and exports may occur in any re-bid through the operational day. • Introducing extra integer variables in the optimisation (option C) will increase the time for the NEMDE solution exponentially with the number of ESS participating in central dispatch. At some point solve times would become unacceptably long.
Single dispatch offer for non-continuous operating ESS (those with energy and FCAS response dead-bands).	• Option A: Non-continuous ESS would separately bid imports and exports as currently done, this requires two DUIDs. • Option B: Introduce additional integers to the NEMDE solver.	• Option A is preferred. Non-continuous ESS would participate as the ESS registration category and not require registration as Market Generator and Market Customer, but would require separate dispatch offers for imports and exports. • Introducing extra integers in the optimisation (option B) will increase the time for the NEMDE solution exponentially with the number of ESS with non-continuous ranges participating in central dispatch. At some point solve times would become unacceptably long.

Option 2 – Create a 'hybrid' Registered Participant category

The following section identifies the options to create a 'hybrid' Registered Participant category, which could be an alternative to an ESS Registered Participant category. In these participation models, a proponent with ESS and other on-site generation or load could register in a single Registered participant category and operate in the market as an aggregated system, rather than separately offering the individual resources.

Option 2a – Create a new Bi-directional Resource Provider Registered Participant category that allows a person to register to provide a 'hybrid' system including grid-scale ESS, generation, or load

Creating a new Bi-directional Resource Provider Registered Participant category that allows a person to register to provide ESS, generation, load or any combination of these types of resources as a single offer and receive a single dispatch instruction. This option is illustrated by Figure 3. A person who is the owner, operator or controller of an ESS and/or generating unit/system or load would be required to register with

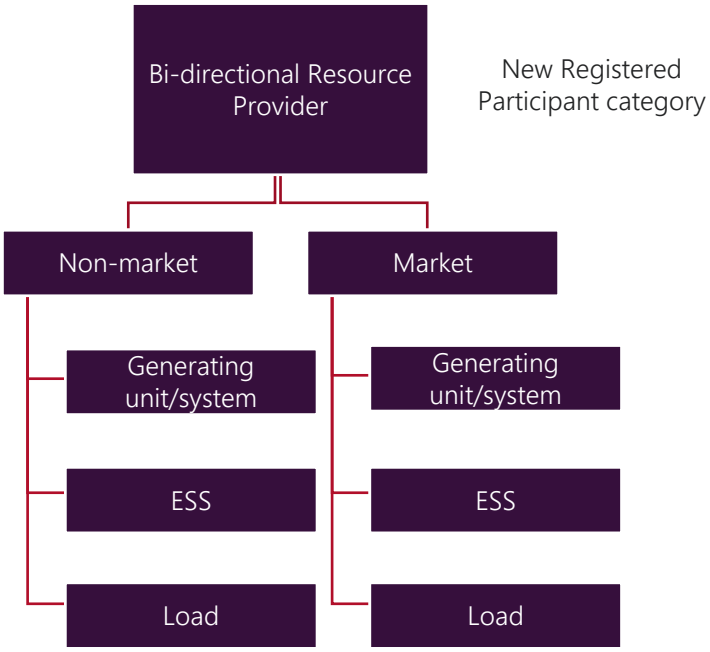
AEMO to participate in this Bi-directional Resource Provider category. AEMO would have a power to exempt a person who owns, operates or controls a 'hybrid' system from registering. The exemption criteria should be specified in an AEMO guideline.

AEMO considers the key benefit of this participation model is that a Registered Participant would provide and manage one offer and respond to a single dispatch instruction for each service. Under this concept, the Registered Participant aggregates the physical capabilities and optimises between components of the hybrid system. AEMO market systems would treat the entire 'hybrid' system as a single unit and would not be able to optimise the use of the individual resources.

Key aspects of how a Bi-directional Resource Provider Registered Participant could be integrated into the NER include the following.

- Similar to the provisions applying to Customers and Generators, the Bi-directional Resource Provider could classify as market or non-market.
- The most stringent dispatch compliance requirement on any individual resource within the hybrid system would dictate whether the entire system should be scheduled (e.g. a hybrid system, which includes an ESS with a nameplate rating of 5 MW or more, would be required to be scheduled).
- The Bi-Directional Resource Provider Registered Participant would be allowed to participate in energy and FCAS markets via a single dispatch offer, with 10 price-quantity bands for the Registered Participant to make a dispatch offer or rebid their offer. Offered MW totalling their registered capacity across the facility should be reflected across the 10 price-quantity bands. The maximum availability for dispatch should also be offered. This includes both maximum import and maximum export. Where the hybrid system has a non-continuous operating range, the import and export would need to be separately offered and dispatched.
- Non-market ancillary services could be offered as a single asset.
- All recovery would be based on the import and export at the connection point, except for where a market load is one of the resources in the 'hybrid' system.
- Consistent with existing arrangements:
  - Each resource in the 'hybrid' would be required to have SCADA.
  - A performance standard is applicable at the relevant connection point for the 'hybrid' system.
  - A NER compliant metering installation is required at the connection point. However, a separate metering installation is required for an ESS included in an 'hybrid' system with a market load. This is to ensure the import for the load is metered for TUoS charges.
  - AEMO would settle and calculate prudential requirements for the Registered Participant on the metered energy at the relevant connection point.

Figure 3 Proposed Bi-directional Resource Provider



Option 2b – Amend the Generator or Customer Registered Participant category to include ESS as a classification

An alternative approach to facilitate a 'hybrid' system with ESS would be to amend existing Registered Participant categories. This would include amending the Generator Registered Participant category to include ESS as a classification and allow aggregation of resources (refer Figure 4) and amending the Customer Registered Participant category to allow a Market Customer to include ESS as a classification (refer Figure 5). In both cases, AEMO would have a power to exempt a person who owns, operates or controls a 'hybrid' system from registering. The exemption criteria should be specified in an AEMO guideline.

AEMO considers the key benefit of this participation model is that no new Registered Participant category would be created. However, this would not allow a generating unit/system and a load to be aggregated either together or with an ESS.

Under this option, a Market Generator or Market Customer would either provide and manage one offer and respond to a single dispatch instruction for each service, for example, energy and FCAS. Under this concept, the Registered Participant aggregates the physical capabilities and optimises between components of the 'hybrid' system. For each AEMO market systems would treat the 'hybrid' system as a single unit and would be able to optimise the use of the individual resources (i.e. either Market Customer with an ESS or Market Generator and ESS).

Figure 4 Generator category with ESS as a classification

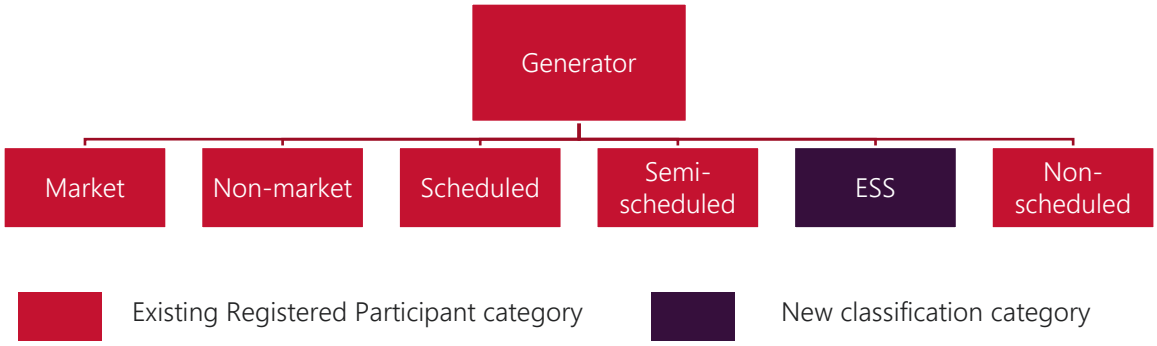
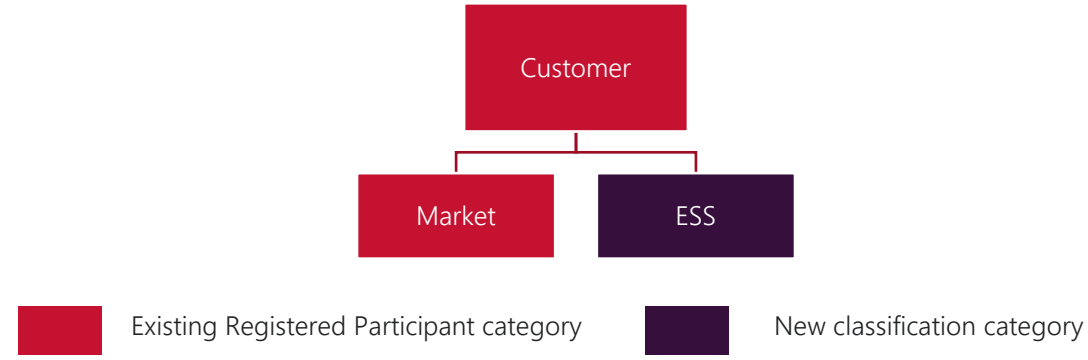


Figure 5 Customer with ESS as a classification



The key requirements are similar to those set out in Option 2a.

Key challenges with Options 2a and b

The challenges for Option 1 in Table 8 are relevant for Options 2a and b since all options include an ESS. Aggregating ESS with generation and/or load introduces further challenges, which are summarised in Table 9.

AEMO seeks feedback from stakeholders on the issues raised, and also feedback on any other challenges that would arise for stakeholders in the proposed model.

Table 9 Challenges and risks – Option 2a and b

Challenge	Risk
Market Participants would require more sophisticated energy management and bidding systems to aggregate information for the individual components before submitting the aggregated offer and then coordinating these components to accurately meet the dispatch target received.	Stakeholder challenge in implementing more sophisticated bidding and dispatching practices.
The FCAS trapezium for an aggregated model may change frequently if the disaggregated components are not technically similar. The capability to offer FCAS at any point in time would depend on the specific 'headroom' and capability of each of the components and would need to be dynamically offered as this capability changes. This would rely on Market Participants to determine overall capability and provide to AEMO in the offers.	Possibility that the FCAS enabled will be a sub-optimal outcome. The lowest performing component would determine the maximum upper angle of their registered FCAS trapezium (that is, an aggregation with intermittent generation requires a minimum FCAS raise and lower headroom to cover intermittent generation forecasting error). Market Participants may encounter additional curtailment in the energy market to ensure the FCAS requirement is technically achievable because AEMO would assume it is delivered from an intermittent generating system. Currently, AEMO registers FCAS trapeziums for intermittent generators with a minimum headroom to cover the uncertainty associated with their availability. This might produce a sub-optimal outcome if the FCAS is delivered by a non-intermittent resource such as an ESS.
Market Participant would need to provide pre-dispatch and PASA forecasts to ensure accuracy of Pre-dispatch and PASA outputs due to less information on each individual component.	Market Participants' forecasts may not match the accuracy of AWEFS and ASEFS and the overall accuracy of pre-dispatch and PASA reduces. This results in less accurate information to Market Participants on individual components and for AEMO to make decisions on when to intervene. Incentives for providing accurate forecast information will need to be reviewed and there may be a need to consider how AWEFS and ASEFS could be used in an aggregated hybrid system.

AEMO's assessment

AEMO considers the most appropriate participation model is the Bi-directional Resource Provider described as Option 2a above. AEMO believes this model would allow proponents to register and operate more efficiently and ensure the NER's arrangements are clear for participation of bi-directional models. Under this option, a proponent would register in one Registered Participant category and operate the entire facility as an aggregated hybrid system across both imports and exports. Facilities may have the following combination:

- ESS only.
- ESS and generating unit/system.
- ESS and market load.
- Market load and generation.
- ESS, generating unit/system and market load.

To achieve this, a progressive approach is possible to integrate ESS; starting with the participation model for ESS and then extending it to include aggregation options for a hybrid system once the additional challenges of aggregation (in Table 9) are worked through.

AEMO considers ESS needs to be integrated in two parallel streams of work:

- Stream 1 – define ESS and create a new category for bi-directional technologies to facilitate participation in the NEM, including integrating into dispatch with a single offer, where the ESS has a continuous operating range. This would initially cover ESS offered into the market and operated as a stand-alone resource. AEMO expects to submit a rule change to the AEMC by March 2019

- Stream 2 – further consult with stakeholders and analyse the appropriate participation model and requirements to facilitate aggregation of 'hybrid' systems, where a proponent has ESS and other on-site generation or load and wishes to offer it to the market as an aggregate resource, rather than separately offering the individual resources. As discussed, there are a number of challenges that AEMO and stakeholders need to work through to determine the design options for an aggregated model.

Appendix A1 includes a scenario of an aggregated 'hybrid' system to demonstrate how this would register and participate (also includes stakeholder benefits) – now, under stream 1 and 2. Appendix A2 also includes an example of the ESS single offer for generation and load.

The new Registered Participant category should have a generic term (for example, Bi-directional Resource Provider), to allow a person with an ESS to register initially. On completion of stream 2 findings, this category could be expanded to cover those seeking to register an aggregated 'hybrid' system.

AEMO does not consider option 2b is the best option. Under this option, ESS would be aggregated with a generating unit/system or a load, however this would not allow a generating unit/system and a load to be aggregated either together or with an ESS.

Stakeholders are requested to indicate whether implementation of this option would deliver benefits to participants owning and operating an ESS or to the market generally. Additionally, AEMO needs to work with stakeholders to understand if its conceptual design options are workable, acceptable and meet stakeholder needs. AEMO also plans to do additional testing internally to identify how ESS would initially be able to participate in market systems, and whether there are further challenges and requirements needed.

Questions for stakeholders

Question 1: What are your views on the appropriate participation model for integrating ESS into the NEM?

Question 2: Would the proposed participation model (2b) meet your future needs, both in terms of participating in the NEM with an individual ESS or where multiple resources (e.g. ESS and generating units) are to be aggregated?

AEMO is particularly interested to understand the additional benefit that you would derive from aggregating hybrid systems and offering them to the market as a single resource that is not available by separately offering the components to the market.

Question 3: Refer to Table 8, are there other potential challenges and risks associated with option 1?

Question 4: Refer to Table 9, are there other potential challenges and risks associated with options 2a and b?

Question 5: Do you have any views on AEMO's proposed approach to implement a single participation model to integrate ESS?

Question 6: Do you have any views on the proposed key requirements AEMO has identified for an ESS participation model?

Question 7: Do you have any views on whether existing ESS should be transitioned to the proposed participation model (2b)?

2.4.3 NER recovery mechanisms

As set out in the list above, defining ESS provides a foundation to appropriately tailoring of fees, recovery, TUoS, and non-energy recovery for ESS, including for ESS with a nameplate rating under 5 MW.

Options

The following are options to integrate a new Bi-directional Resource Provider category for non-energy recovery, AEMO Participant fees and charges, and TUoS charges:

- Charge only on the basis of imported electricity from the NEM, treat in the same way as Market Customers.
- Charge only on the basis of exported electricity from the NEM, treat in the same way as Market Generators.
- Charge on the basis of imported and exported electricity from the NEM, treat in the same way as Market Customers and Market Generators are charged. As discussed in Section 2.3.1, this is the same as AEMO's interim approach for grid-scale batteries.
- Not charge at all.

AEMO's assessment

Non-energy recovery and NEM Participant fees and charges

AEMO considers that the proposed new Bi-directional Resource Participant should pay non-energy recovery and NEM Participant fees and charges on the basis of imported and exported electricity from the NEM, that is, treat in the same way as Market Customers and Market Generators are charged. This is consistent with the existing NEM arrangements.

Since an ESS both imports (increases load) and exports (increases market generation) electricity from the grid, AEMO considers that non-energy recoveries and NEM Participant fees and charges should typically be recovered from an ESS in the same way as a Market Customer and Market Generator. However, a detailed analysis of how this should be applied will be undertaken to address any required exceptions. AEMO considers that this approach:

- Is consistent with existing NEM settlement recovery arrangements for the import and export of electricity.
- Maintains technology neutrality.
- Would ensure that ESS providers are recovered from if they contribute to the need for or benefit from non-energy services, this encourages better market outcomes.

Currently all Market Generators and Market Customers pay for non-energy services and NEM Participant fees, if an ESS was exempt from paying for these services this would not be technology neutral and create an inappropriate competitive advantage for ESS.

TUoS charges

AEMO proposes that an ESS that is a scheduled resource and can be constrained off should not be required to pay TUoS charges. If a Bi-directional Resource Participant has a market load in the aggregation, TUoS should be recovered only based on the electricity from that market load, which should be separately metered.

AEMO has reviewed the AEMC's CoGaTI Options Paper and agrees that a permanent approach is needed for TUoS charging arrangements for ESS and 'hybrid systems' that include ESS.

AEMO considers that there is a broader issue with the pricing arrangements for distribution and transmission networks that needs to more holistically review how network costs are recovered and from whom. A holistic review is the appropriate mechanism to identify whether it is appropriate to charge TUoS for ESS, whether participating in the NEM as a stand-alone ESS or aggregated with other resources.

In the meantime, AEMO's rationale for the proposal for ESS not to incur TUoS charges is based on the following:

- NSPs would not increase the capacity of the shared network to provide unrestricted access to the ESS. In this regard, a scheduled ESS is part of the supply chain and the load on the network when importing will

be reduced if it competes with non-scheduled load. Not charging TUoS for an ESS will not increase charges to others

- Irrespective of whether it is a stand-alone ESS or part of a 'hybrid' system connected to the grid, ESS is treated as a connecting asset and NSPs charge negotiated connection charges, in this way it is being treated in a more similar way to a generating system

A non-scheduled ESS (an ESS with a nameplate rating less than 5 MW), on the other hand, will appear to the grid as uncontrolled load and will compete for capacity with end-use consumers. In this regard, the consistent treatment would be for non-scheduled ESS to incur TUoS charges.

Table 10 provides more information on how each of AEMO's positions meets the principles mentioned previously.

Table 10 How ESS and 'hybrid systems' with ESS align with the recovery mechanisms and principles

	ESS non-energy recovery	Participant fees and charges	TUoS
Proposed approach	Non-energy services recovery based – ESS charged on the basis of electricity imports from and exports to the NEM.	NEM Participant fees and charges – ESS charged on the basis of electricity imports from and exports to the NEM.	Scheduled ESS should not pay TUoS. Where a 'hybrid system' includes market load, this needs to be separately metered.
Principles			
Technology neutrality – avoidance of special treatment of technologies	Yes, consistent with the treatment of Market Customers and Market Generators for the import and export of electricity, where exceptions are needed these will be considered.		Consistent with the treatment of generating systems.
Consistency with existing NEM recovery arrangements	Yes, consistent with the treatment of Market Customers and Market Generators for the import and export of electricity.		N/A since there is no consistent approach to TUoS charging.
Maximum level of transparency	Yes, ESS would be NER defined and clarified in Chapter 3.	Yes, ESS would be NER defined and clarified in AEMO's next fee determination.	Yes, ESS would be NER defined and TUoS in Chapter 6.

2.4.4 Questions for stakeholders

Question 1: What are your views on how to integrate ESS into the NEM's recovery mechanisms?

3. Other NEM improvements

In the stakeholder sessions, AEMO and stakeholders identified four possible improvements to the NEM arrangements to allow better integration of new NEM business models. The following sections discuss these opportunities.

Two are initiatives that AEMO considers are consistent with the existing market design and should be changed to facilitate comprehensive operation of the NEM arrangements across the entire power system:

- Changes to effectively apply performance standards to a generating system or load in an exempt network (Section 3.1).
- Providing NEM information to project developers (Section 3.2)

Stakeholders identified these two initiatives:

- To separate operational and financial responsibilities (Section 3.3).
- The further application of logical metering arrangements (Section 3.4).

AEMO considers these last two to be more fundamental changes to the NEM design, requiring more detailed analysis to determine whether there is benefit in making these changes.

For each area, AEMO outlines the key opportunities identified to improve current arrangements, options, AEMO's comments, and stakeholder questions.

AEMO will consider stakeholder views to inform its view on whether there is a market benefit, the associated risks and costs, and alternative options, before assessing whether changes are likely to meet the National Electricity Objective (NEO).

3.1 The application of performance standards to a generating system or load in an exempt network

3.1.1 Current NEM arrangements

The National Electricity Law (NEL) and the NER require a person who owns, operates or controls a generating system connected to the grid to be registered with AEMO, unless exempt from doing so, and have a connection agreement with the relevant NSP. Registered Generators have NER obligations associated with the technical performance and compliance, bidding and dispatch, metering and settlements of electricity associated with their generating systems.

In assessing an application for registration as a Generator, AEMO must be satisfied that the generating system is capable of meeting or exceeding applicable technical performance standards.[15]

[15] Refer to NER clause 2.2.1(e)(3).

Performance standards are one of the principal tools AEMO uses to manage power system security, and are established between AEMO, the NSP and connection applicant during the connection process.[16]

The AER may exempt any person or class of persons from the requirement to register as a NSP or the operation of Chapter 5 of the NER, if the AER considers the exemption is not inconsistent with the NEO.

3.1.2 Issue

Where a person connects their generating system or load to the grid via an exempt network [17], it is unclear whether their performance standards are enforceable by AEMO and the AER. This could potentially reduce AEMO's ability to securely operate the power system.

A NSP is a "person who engages in the activity of owning, controlling or operating a transmission or distribution system and who is registered by AEMO as a Network Service Provider under Chapter 2".

Given that performance standards are defined by reference to the NSP, the NER do not appear to contemplate registrable performance standards at the point of connection of generation or load to an exempt network.

Some stakeholders have suggested that a back-to-back contractual arrangement between the exempted network owner and the connecting proponent could be applied to ensure the connecting proponent's performance standard is applicable to the connection point. However, this arrangement still does not allow AEMO and the AER to apply the NER compliance and enforcement powers in respect of any breach of the contractually agreed performance standards.

To address the issue in the short-term, the AER amended its Electricity Network Service Provider – Registration Exemption Guideline regarding the scope and criteria of the NR01 and NR02 exemption classes.[18] Where the total generation at the NEM connection point is 5 MW or more, an applicant for an NR01 or NR02 exemption class needs to confirm with AEMO that all necessary performance standards will apply and the generating system is unlikely to pose undue risk to power system security or reliability, prior to the AER making a decision.

3.1.3 Options

AEMO has identified the options to address this issue in Table 11.

Table 11 Options to clarify a performance standard applies to a Registered Participant connecting in an exempt network

ID	Options	Costs/Risks	Benefits
1	Amend the NER to ensure that relevant clauses of Chapter 5 (including 5.3.4A, 5.3.4B, 5.7.3, etc) and rule 4.14 apply to ensure plant connected to exempt networks by Registered Participants will have agreed access standards that apply as performance standards for the purposes of the NER.	• Costs of NER change.	• Ensures all appropriate technical requirements under Chapter 5 are applicable to plant. connecting in exempt network • No need to be a Registered Participant for the network.
2	Amend the definition of NSP to include the owners of exempt networks in appropriate cases, excluding NER Chapter 6A and 6.	• Cost of NER changes. • Risk of unintended consequences associated with ensuring all NER references (currently, over 1000) to Network Service Provider are	• Overcomes the definitional issue so performance standards are clearly applicable and enforceable. • No need to be a Registered Participant for the network.

[16] Where appropriate, a performance standard includes technical requirements for load and generation.

[17] An exempt network refers to a network that has been exempted by the AER from the requirement to be a Registered Participant or NER Chapter 5.

[18] AER, March 2018, Electricity Network Service Provider – Registration Exemption Guideline, pp. 50-51.

ID	Options	Costs/Risks	Benefits
		appropriate in context of amended definition.	
3	Amend the definition of connection agreement so it is not restricted to registered networks.	• Costs of NER change. • May not achieve intended outcome, as the connection agreement is only the outcome of the Chapter 5 process under which performance standards are determined. That process currently only applies to registered NSPs.	• Overcomes the definitional issue so that performance standards are clearly applicable and enforceable. • Minimal NER change. • No need to be a Registered Participant for the network.
4	May need to amend the NEL and NER to ensure the AER's exemption only relates to economic and access regulation, rather than the technical requirements of the NER.	• NEL and NER changes required to carve out responsibilities for exemption from registration and economic/access regulation. • Requires COAG Energy Council decision. Longer time required to make changes.	• Clearer and appropriate delineation of roles and responsibilities for AER and AEMO. • Overcomes the definitional issue so that performance standards are clearly applicable and enforceable. • No need to be a Registered Participant for the network.

3.1.4 AEMO's assessment

AEMO has received at least six enquiries regarding connecting generating systems and load in exempt networks and proponent interest continues in early design discussions with AEMO.

Given the increasing number of proposed connections to exempt networks, resolving this issue is considered a priority. AEMO intends to progress this matter in a rule change proposal by the end of this year, following further consultation with stakeholders, including the AER and AEMC.

Currently, the preferred option to address this is option 1 as set out in section 3.1.3. This option is selected because it would address the issue and is relatively simpler to implement.

3.1.5 Questions for stakeholders

Question 1: Are there other options to address the issue identified for connecting plant in an exempt network?

Question 2: Are there other costs, risks and benefits associated with the options presented? If so, please indicate what these are.

Question 3: Which option to address the issue is your preferred option? Why?

3.2 Providing NEM information to project developers

3.2.1 Current NEM arrangements

Under the NEL, AEMO has a statutory obligation to protect confidential information from unauthorised use or disclosure. AEMO can only disclose such information in limited circumstances, including where:

- AEMO is required or permitted to provide it under a law or the NER.

- The disclosee is one of the agencies listed in the NEL (ACCC, AER, AEMC etc).
- AEMO has the written consent from the person the information relates to.
- Disclosure is necessary for safety, security or the proper operation of the market[19].

The NER permit AEMO to provide certain information to Registered Participants, including Intending Participants.

Typically, the primary reason for proponents registering as an Intending Participant is to access information needed to build a generating system (e.g. network data) or to set up systems and processes prior to registering as a Market Customer (usually, retailer).Under NER rule 2.7, to become an Intending Participant, a person must apply to AEMO and AEMO must be reasonably satisfied that the person "…intends to carry out an activity in respect of which it must or may be registered as a Registered Participant."

3.2.2 Issue

One of the business models that has emerged is for developers to build generating systems and sell them prior to connection to the grid. In this circumstance, developers have no intention of owning or operating a grid-connected generating system. In these circumstances the developer will not meet the NER eligibility requirement for registration as an Intending Participant. This limits their ability to access NEM information needed to connect and build a generating system.

3.2.3 Options

AEMO has identified the options to address this issue in Table 12.

Table 12 Options to provide NEM information to project developers

ID	Options	Costs/Risks	Benefits
1	Delete NER rule 2.7 and replace with a requirement on AEMO to provide information to persons wishing to have access after being satisfied the information is used for the purpose of connecting plant to the national grid or access to AEMO market systems, and provide that the recipient is bound by the NER confidentiality requirements (Rule 8.6.1) as if it were a Registered Participant.	• Cost of NER change seeking to remove rule 2.7 and amending clauses dealing with information provided to Registered Participants (including Intending Participants), refer to NER clauses 3.13.3(k)(2) and (l). • Replacing existing known process for Intending Participants with developing a new process to provide access to network data and AEMO's PreProd system. • Potential reduced transparency of future market developments.	• Might provide a more flexible and accessible approach to sharing information with interested stakeholders.
2	Amend NER rule 2.7 to include that a person can register to become an Intending Participant for the purposes of building grid-scale resources, such as a generating system.	• Cost of NER change.	• Allows a person who is intending to build grid-scale resources access to the information required without the intention to become a Registered Participant. • The person would need to demonstrate that they are registering with the intent of developing plant to be connected to the grid, which is a NEM related activity.

[19] Refer to section 54 of the NEL.

3.2.4 AEMO's assessment

AEMO considers that the NER should allow AEMO to provide people with access to the information they need to develop or build grid-scale resources (such as a generating system, ESS or hybrid system) if they satisfy AEMO this is their intent. Table 12 sets out the identified options, AEMO considers the most appropriate approach is option 1 (amending the Intending Participant eligibility criteria). This amendment would preserve the Registered Participant status and associated NER confidentiality obligations of a developer receiving network information with minimal amendments, and will not affect other people seeking to register as an Intending Participant, e.g. a new retailer seeking early access to set up systems.

3.2.5 Questions for stakeholders

Question 1: Should a person intending to develop or build a generating system or ESS (and not subsequently register as a Generator) be allowed to register as an Intending Participant?

Question 2: What is the market benefit associated with allowing a person intending to develop or build a generating system (and not subsequently register as a Generator) to be an Intending Participant?

Question 3: Referring to section 3.2.3, are there other options to provide a person intending to develop or build a generating system (and not subsequently register as a Generator) with the necessary NEM data?

Question 4: Are there other costs, risks and benefits associated with the options presented? If so, please indicate what these are.

3.3 Separation of operational and financial responsibility

3.3.1 Current NEM arrangements

Currently the NER requires:

- Each connection point to have a single FRMP.
- Each connection point to have a NER compliant metering installation.
- Each metering installation to have a unique NMI[20].
- A Registered Participant to have a connection agreement with the NSP.

Under the NER, a person who owns, operates or controls each generating system must register with AEMO. This person is the Registered Participant and becomes the FRMP for the relevant connection point. The NER also allow an owner, operator or controller to be exempted from the requirement to be registered by AEMO if an Intermediary is appointed to act in its place as the Registered Participant.[21] In both cases, the Intermediary is responsible for compliance with all NER obligations relating to the operation, bidding, dispatch, network losses, settlement and prudential arrangements for the generating system (because it is the registered Generator for NER purposes).

Figures 6, 7, and 8 illustrate the current NER arrangements with a one-to-one relationship between a connection point and a FRMP.

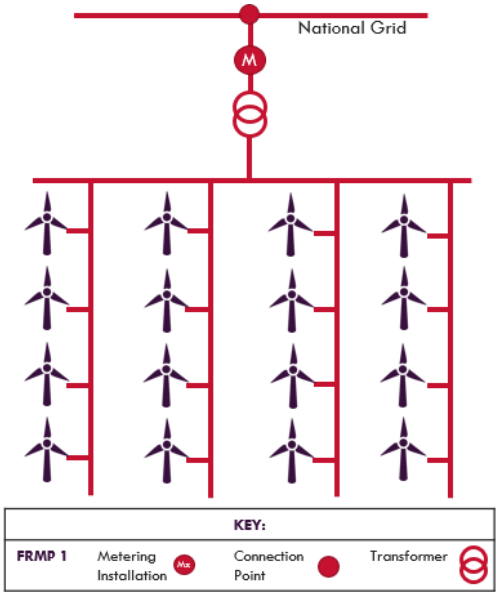
Figure 6 shows that the Registered Participant (also the FRMP) is responsible for the entire generating system, which is connected to the transmission or distribution network via a single connection point. There is a single FRMP and NER compliant metering installation associated with the connection point. Any financial arrangements that the proponent has with other parties or investors must be settled 'off-market'. In addition

[20] Refer to NER clause 7.2.1 and 3.15.3

[21] Refer to NER clause 2.9.3

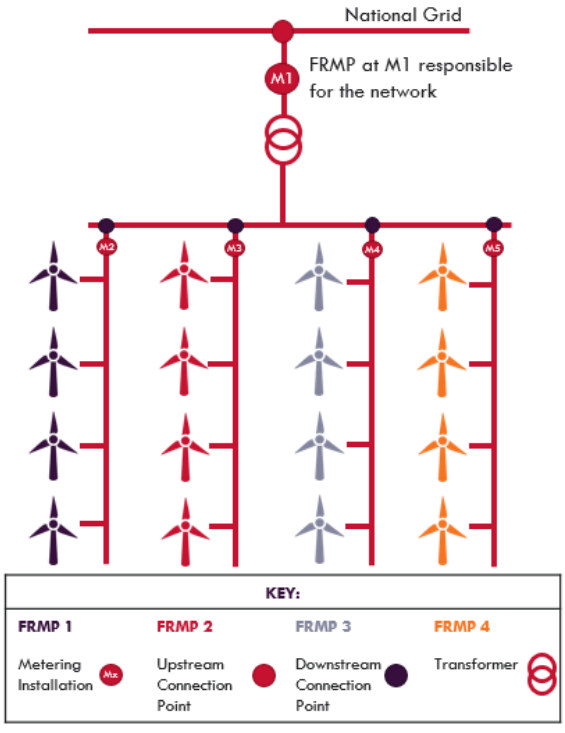
to the NER compliant metering installation, a proponent may choose to install additional meters (not necessarily NER compliant) to assist with its 'off-market' transactions, which AEMO does not settle.

Figure 6 Single Registered Participant (and FRMP) and connection point



Figures 7 and 8 illustrate how the existing NEM arrangements offer some flexibility in the treatment of the same physical generating system and how each 'cluster' could be settled 'on market'.

Figure 7 Multiple Registered Participants (and FRMPs) for each cluster in a 'private' network

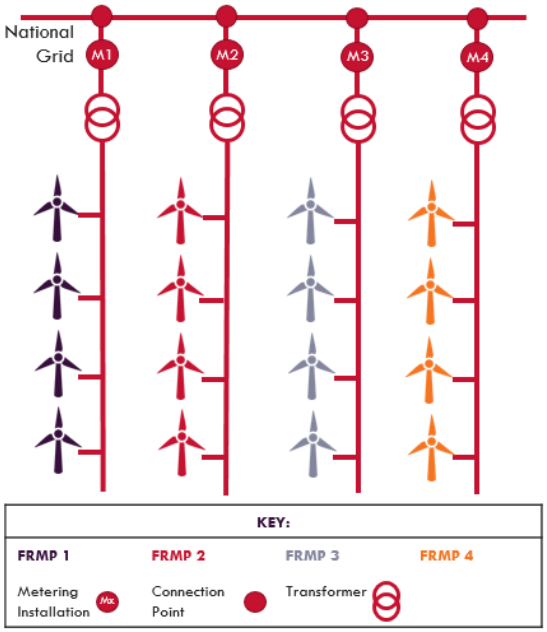


In Figure 7, a Registered Participant (also the FRMP) is responsible for the 'private' network connecting to the national grid at the 'upstream' connection point. The combined nameplate rating of the entire generating

system is greater than 30 MW. Note, this Registered Participant must have a NER compliant metering installation to account for the electricity and the network losses. The 'downstream' generating systems are connected to the 'private' network through a connection point, each must have a Registered Participant (also FRMPs), Performance Standard, NER compliant metering installation, SCADA, a separate distribution loss factor, bidding and dispatch, settlements and prudentials. In this situation, AEMO settles the electricity for each Registered Participant.

In Figure 8, a Registered Participant (also the FRMP) is responsible for each 'cluster', which is a separate generating system, these are connected to the grid through separate connection points. The combined nameplate rating of the entire generating system is greater than 30 MW. Each connection point must have a Registered Participant who is responsible for performance standard compliance, NER compliant metering installation, SCADA, bidding and dispatch, settlement and prudential requirements of the 'cluster'.

Figure 8 Multiple Registered Participants (and FRMPs) and connection points



Under each scenario in Figures 6, 7, and 8, the owner, operator or controller of the generating system could apply for an exemption from registration and appoint an Intermediary to register in their place, if that Intermediary is eligible for registration as the Generator for that system in its own right. The Intermediary would become the FRMP and responsible for all relevant NEM activities.

3.3.2 Opportunity

A number of stakeholders have suggested that changing the NEM arrangements to allow separate participants to assume responsibility for technical obligations (connection agreement, establishing and compliance with a performance standard, operational (bidding and dispatch)) and financial obligations in respect of generating systems would deliver market benefits.

Some stakeholders have indicated that entry into a Power Purchasing Agreement (PPA) with an off-taker[22] is a barrier to the development of new generation facilities, for participation in the NEM. This occurs because the larger the generation facility, the smaller the number of off-takers who are able to purchase the entire output. This may mean that multiple PPAs are required to fund a new facility.

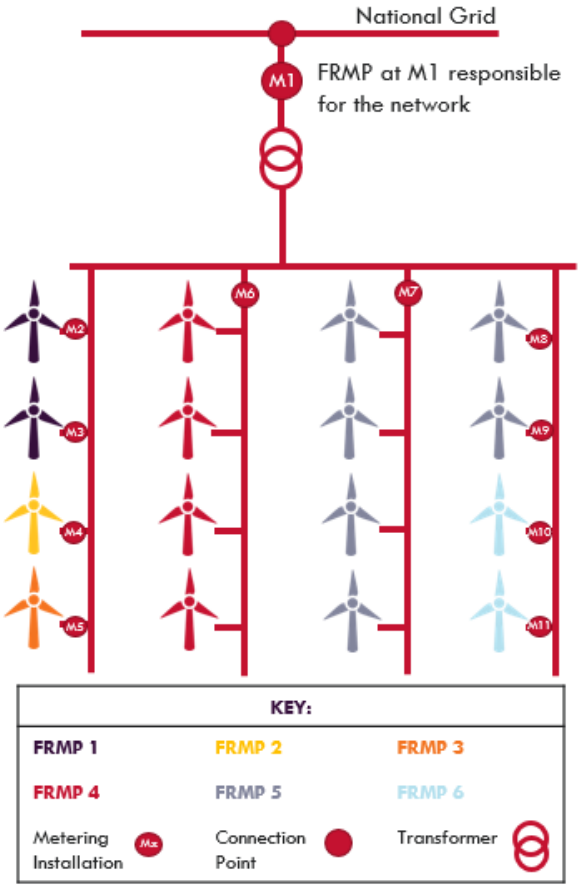
[22] In the context of this paper, an off-taker is a purchaser who enters into a PPA with a generator, for the sale and supply of energy. An PPA is normally negotiated prior to the construction of a facility, in order to secure future revenue and is a key instrument of project finance.

Off-takers are increasingly seeking to act as the Intermediary for generating systems, based on their entitlement to 'control' commercial operation. However, where an off-taker may only want to commit to a fraction of the facility output, this option can result in risk allocation that the parties are not well placed to manage, increasing counterparty risk.

Stakeholders have proposed that off-takers could be financially and operationally responsible (for dispatch and bidding) for some generating units within a facility without establishing separate connection points for those units. It has been submitted that greater flexibility and transferability of these arrangements between parties would increase the pool of investors. This in turn might be expected to increase the number of buyers and bidders into the NEM, facilitate new investment in generation and ESS assets and potentially reduce average spot prices.

Figure 9 demonstrates one possible approach to separating the operational and financial responsibility for a generating system.

Figure 9 Separate financial responsibility for generating system



In this example, it is assumed that there is a single Registered Participant for the entire facility, who is responsible for:

- Connection point to the grid, including the connection agreement.
- Compliance with performance standards.
- Maintenance of the facility[23].
- NER compliant metering installation (M1, at the connection point).

[23] This may include turbine maintenance, wind sector management, etc

- Allocation of electrical energy losses to multiple parties (off-takers) downstream of the connection point.
- Management of dispute resolution between off-takers in the facility.

Multiple parties would register with AEMO as Intermediaries (controllers) for their respective generating units and would be operationally and financially responsible for these. Each off-taker would also be separately settled by AEMO. They would be responsible for:

- Separate 'downstream' NER compliant metering installation(s) for each off-taker, illustrated as meters M2 to M11 in Figure 9.
- Bidding and dispatch of their registered generating units.
- Settlement and prudential requirements for the electricity purchased and sold (sent out) to the NEM from their respective units.

3.3.3 AEMO's assessment

AEMO is keen to facilitate changes that deliver market benefits in the long-term interests of consumers, consistent with the NEO. As set out in section 3.3.2, stakeholders have indicated that allowing the disaggregation of operational and financial responsibilities for a single generating system may open the market to new investment models that provide a business and market benefit.

AEMO is keen to further understand stakeholder views and any additional information on the potential market benefit and risks of these arrangements. Following this feedback, AEMO will form a view on whether these arrangements are likely to deliver market benefits outweighing the likely costs of implementation and ongoing monitoring.

Stakeholders are encouraged to consider the following points when providing feedback on this, including:

- NER, system and procedure changes would be required to implement this proposal, including, but not limited to, changes to NER Chapters, 3, 5, 7, and 10.
- At least one NER compliant metering installation would be required per off-taker and at the grid connection point.
- Each off-taker would be required to register with AEMO separately for their generating units and meet individual settlements and prudential requirements.
- The responsibilities and arrangements required if the off-taker had a default event, was suspended from NEM activities or wished to cease being a Registered Participant. In these circumstances, AEMO considers that the Registered Participant for the entire generating system (responsible for the performance standard and operations) would become responsible for the future activities from the generating unit or ESS. They would need to choose whether they took on the financial and bidding responsibility or physically disconnected the generating unit or ESS.
- The requirements needed if the Registered Participant of the entire generating system sells to another party. Potentially, the new owner, operator or controller may wish to continue operating using the same model or operate under any of the examples illustrated in Figures 6, 7, and 8.
- The appropriateness of whether the individual 'off-takers' should be responsible for dispatch of the 'downstream' generating units. For example, if there was a need to direct, AEMO's control room staff would need to individually direct the Registered Participant separately for each unit.

3.3.4 Questions for stakeholders

Question 1: What is the market benefit associated with allowing the separation of operational and financial responsibilities?

Question 2: What are the risks associated with allowing the separation of operational and financial responsibilities?

Question 3: Are there other models of separate operational and financial responsibilities that should be considered?

3.4 Logical metering arrangements

3.4.1 Current NEM arrangements

Section 3.3.1 sets out the NER requirements to have a separate NER compliant metering installation for each connection point, irrespective of whether it is a parent or child connection point that the Registered Participant is financially responsible for. These metering requirements reflect that electricity imported or exported needs to be accurately measured (and therefore valued) so that the Registered Participant (also the FRMP) can be accurately settled. Additionally, these arrangements maintain integrity of the settlement process (e.g. traceability of measurement and auditability).

Under NER clause 7.8.12(a), AEMO may determine that special arrangements are required to support the integrity of the collection and processing of metering data from nominated metering installations, referred to as special sites or technology related conditions. Originally, these arrangements were introduced where facilities were being retrofitted and a metering installation could not be installed. Further information on special sites can be found in the Special Sites and Technology Related Conditions within the NEM.[24] AEMO currently considers special metering arrangements on a case by case basis, where Registered Participants have investigated all other NER compliant metering arrangements and AEMO determines they are unsuitable.

3.4.2 Opportunity

AEMO is receiving more frequent requests from proponents to consider alternative metering arrangements that do not meet the special site conditions. Typically, their preference is to use logical metering arrangements to replace the need for a NER compliant metering installation.[25] Stakeholders have indicated two main reasons for this:

- To avoid the costs associated with installing a metering installation.
- Project planning and timing considerations associated with metering arrangements not being adequately considered in the facilities design.

As noted, under current NEM arrangements these alternatives are only considered in limited situations.

Several factors need to be considered when assessing whether logical metering arrangements provide a market benefit and in understanding the limitations, including:

- NER, system and procedure changes would be required to implement this proposal, including, but not limited to, changes to NER Chapters 7 and 10.
- Logical metering arrangements introduce components that may be based on assumptions (e.g. loss factor determination and incorrect application of the logical calculation) that may compromise the accuracy of energy market settlements. If logical metering arrangements were to become more commonplace, market participants would need to accept the consequence that the electricity metered for each of those connection points is less accurate than where a NER compliant metering installation is installed. AEMO and MDPs would need to develop suitable procedures and processes to monitor and manage the logical metering arrangements to maximise the integrity of the metering data input to market settlements. These would involve potentially material costs.
- The same Metering Coordinator (MC) and Metering Data Provider (MDP) is required for all NMIs in the facility. This is because, where a logical metering calculation is required, the MDP needs to have access to

[24] Available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Retail-and-metering/Metering-procedures-guidelines-and-processes

[25] The assembly of physical metering installations, calculations and processes to derive the metering data for a connection point that does not have a physical metering installation.

the meter data for all metering installations involved in the calculation. Otherwise, the MC is reliant on another party to provide it which would further complicate the calculation process. To assign the MDP to all the metering installations, the MC would need to be the same.

- How the electrical energy losses would be determined.
- MC and AEMO processes and systems would need to be in place for any changes to logical metering arrangements for the facility. If logical metering installations are more broadly used, AEMO and MCs would incur costs involved in establishing and maintaining them. For AEMO, it is necessary to consider these costs and the parties from whom the costs should be recovered.
- Allowing the use of logical metering arrangements to settle parts of a generating system typically appears to avoid the cost associated with setting up NER compliant metering installations. If this cost is to be avoided by a Registered Participant and there is an operational cost involved in setting up and maintaining logical metering installations. AEMO considers that this should be borne by Registered Participants who requested them.

AEMO seeks feedback on the questions in Section 3.4.4Error! Reference source not found. regarding the potential costs and market benefits of logical metering installation requirements for grid-scale business models.

Scenarios 1 and 3 demonstrate how logical metering arrangements could be used in the NEM.

Scenario 1

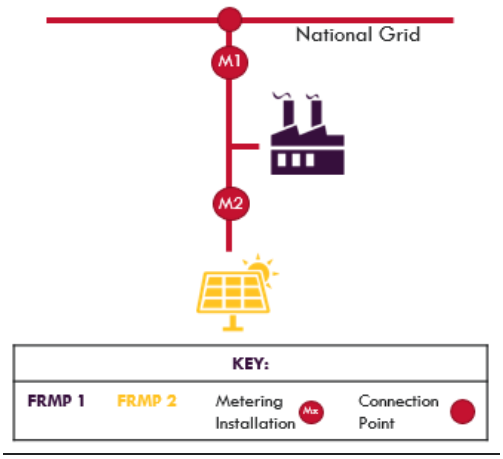
Scenario 1 is illustrated by Figure 10 and the following assumptions apply:

- The total nameplate rating of the generating system (where connecting to the grid) is more than 30 MW.
- There are two Registered Participants (also FRMPs), including:
  - Market Scheduled Generator for the thermal generating units.
  - Market Semi-Scheduled Generator for the solar units.
- Both Market Participants (also FRMPs) have separate connection points at the same physical location.
- The individual Market Participants would be settled separately and have their own prudential requirements.

Using a logical metering arrangement, settlement of energy occurs as follows:[26]

- FRMP1 = M1 - M2. This is a logical calculation.
- FRMP2 = M2 energy.

Figure 10 Potential use of logical metering arrangements – scenario 1



[26] As there is no transformer in this scenario, these equations do not need to be corrected for transformer losses.

Scenario 2

Scenario 2 is illustrated by Figure 11 and the following assumptions apply:

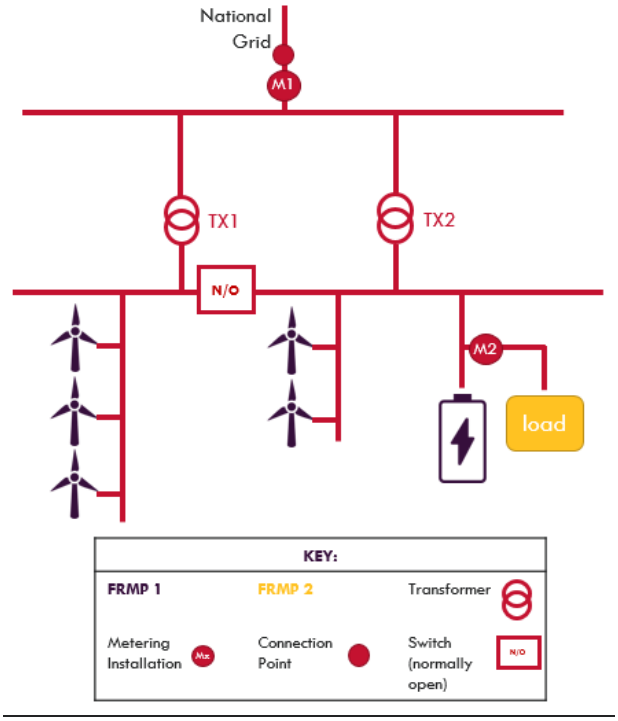
- The total nameplate rating of the generating system (where connecting to the grid) is more than 30 MW and the battery is at least 5 MW.
- There are two Registered Participants (also FRMPs), including:
- Market Scheduled Generator for the battery and wind generating units.
- Market Customer for the load.
- Both Market Participants (also FRMPs) have separate connection points at the same physical location.
- The individual Market Participants would be settled separately and have their own prudential requirements.

Using a logical metering arrangement, settlement of energy occurs as follows:

- FRMP1 = M1-M2. This is a logical calculation.
- FRMP2 = M2 energy.

Note that the calculations above for FRMP 1 and 2 will need to be adjusted for electrical energy losses, including transformer losses, to the connection point. The logical calculation will also need to account for different operating states (for example, different switching arrangements, transformer outages).

Figure 11 Potential use of logical metering arrangements – Scenario 2



Scenario 3

Scenario 3 is illustrated by Figure 12. This scenario is similar to Figure 9, explored in Section 3.3.1, except this scenario details a 'full metering' approach to measuring the output from multiple FRMPs for a single generating system. Figure 12 illustrates how the metering of electricity could be achieved using logical metering calculations. The following assumptions apply:

- The total nameplate rating of the generating system (where connecting to the grid) is more than 30 MW.

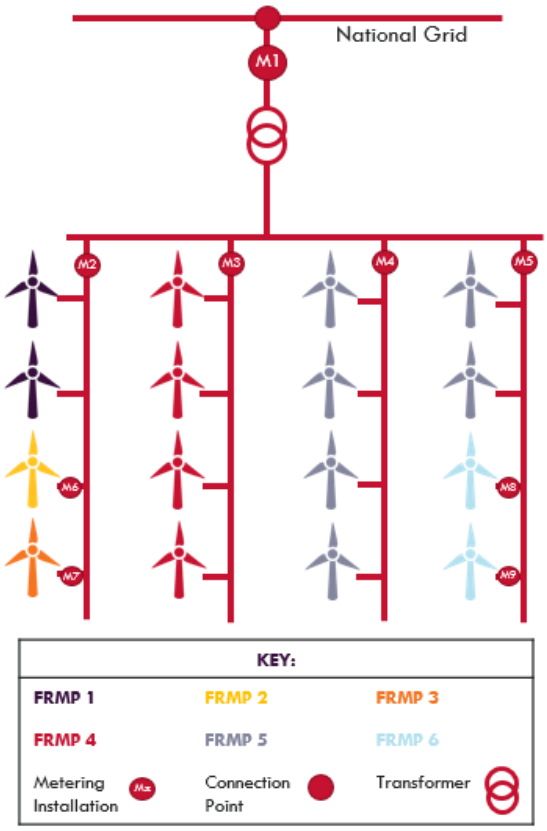
- There would be six Market Participants (also FRMPs) for the generating system, each being registered as a Market Generator and classified as semi-scheduled generating units.
- All Market Participants (also FRMPs) have separate connection points (or identifiers) at the same physical location.
- All Market Participants would be settled separately and have their own prudential requirements.

Using a logical metering arrangement, settlement of energy occurs as follows:

- $FRMP1 = M2 - (M6 + M7)$
- $FRMP2 = M6$
- $FRMP3 = M7$
- $FRMP4 = M3$
- $FRMP5 = M4 + M5 - (M8 + M9)$
- $FRMP6 = M8 + M9.$

Note that the calculations, above, for FRMP 1 and 2 will need to be adjusted for electrical energy losses, including transformer losses, to the connection point.

Figure 12 Potential use of logical metering arrangements – scenario 3



As described in Section 3.3.2, a single Market Participant is responsible for the entire facility and would be responsible for allocation of electrical energy losses to multiple parties (off-takers) downstream of the connection point (i.e. the losses between the $M2$ to $M9$ and the connection point ($M1$)). There are two approaches that could be taken to calculating those losses:

1. Place a meter ($M1$) as close as practicable to the connection point to measure electrical energy losses between the connection point and generation assets. These may be attributable to the different FRMPs based on distance from the connection point and output.

2. Use an additional logical calculation to reference the output from each FRMP to the connection point by adjusting for losses.

3.4.3 AEMO's assessment

At this time, AEMO needs more comprehensive views from a broad range of stakeholders on the risks and market benefits of using logical metering installations to consider whether these changes are likely to meet the NEO and should be pursued.

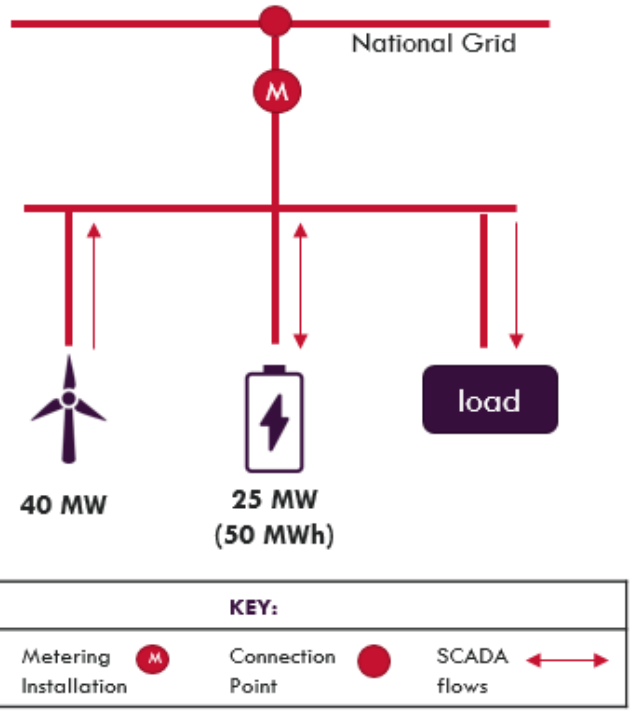
3.4.4 Questions for stakeholders

Question 1: What is the market benefit associated with using logical metering arrangements?

Question 2: What are the risks associated with allowing the use of logical metering arrangements?

Question 3: If logical metering arrangements are permitted to be used instead of a NER compliant metering installation, who should pay for this? Please identify any cost recovery arrangements that you consider appropriate.

A1. Summary of 'hybrid' system registration and participation – now, aggregating the entire facility and ESS category



	Registration category	ESS Participation in dispatch	Stakeholder Benefit	Stakeholder challenges
Now	• Market Generator – wind farm, classified as semi-scheduled generating unit – battery (export), classified as scheduled • Market Customer – Battery (import), scheduled load – Load (no need to be scheduled	Separate bid/offer for: • Wind farm generation (export). • Battery generation (export). • Battery load (import).	• ESS can participate.	• Costs and process involved in registering in two categories • bid/offer three DUIDs
Aggregating the entire facility	• Bi-directional Resource Provider	Separate offer for: • Entire facility (import/export)	• Facility could participate as one asset • Participate in central dispatch as a single (bi-directional) facility	• Costs involved in providing an aggregate offer • Offer import and export using one DUID
ESS category only	• Market Generator – wind farm, (semi-scheduled generating unit) • Market ESS – Battery (scheduled generating unit) – Market Customer (scheduled load) – Load (not scheduled)	Separate bid/offer for: • Wind farm generation (export) • Battery (import/export)	• ESS could participate as one asset – registered and dispatched as one • Avoids possibility of conflicting import and export targets for battery	• Costs involved in registering in two categories • bid/offer import and export using two separate DUIDs

A2. ESS single offer for generation and load

The following example is for a standalone ESS with a registered minimum capacity of -200 MW, a maximum capacity of 250 MW and a storage capacity of 350 MWh.

Notes:

- The new variables that would be required for an ESS offer are highlighted in red. A description of these variables is in Table 7.
- NEMDE absolutes all bid band MW quantities before solving
- NEMDE solver adds the aggregated band MW dispatched to an offset of the absolute sum of all negative MW quantity bands (AVAIL) in the raw bid for constraint purposes. The offset should be equal to the registered minimum capacity (i.e. maximum charge) that is provided under NER Schedule 3.1. In the example below, the aggregated band MW dispatched are offset by -200MW for each period
- There must be at least 1 negative quantity and 1 positive band MW quantity for each period
- There must be a breakpoint of 0 for each period. The breakpoint may be in any band, except bands 1 and 10. This breakpoint is required, due to the way MLFs are applied. A different MLF is required for the load and generation side of the asset. If a price band contains an offer that cuts across load and generation, then two MLFs would need to be applied, which is not possible in this model.

Max and min state of charge (SOC) are expressed in MWh at the facility and Rate of Change (ROC) Up and down are in MW/min at POC. All other values are expressed in MW at POC.

A2.1 Raw bids

Price Bands

PB 1	PB 2	PB 3	PB 4	PB 5	PB 6	PB 7	PB 8	PB 9	PB 10
-959.27	-71.65	-0.69	27.42	58.48	100.10	125.50	182.65	302.98	13399.40

Band Availability

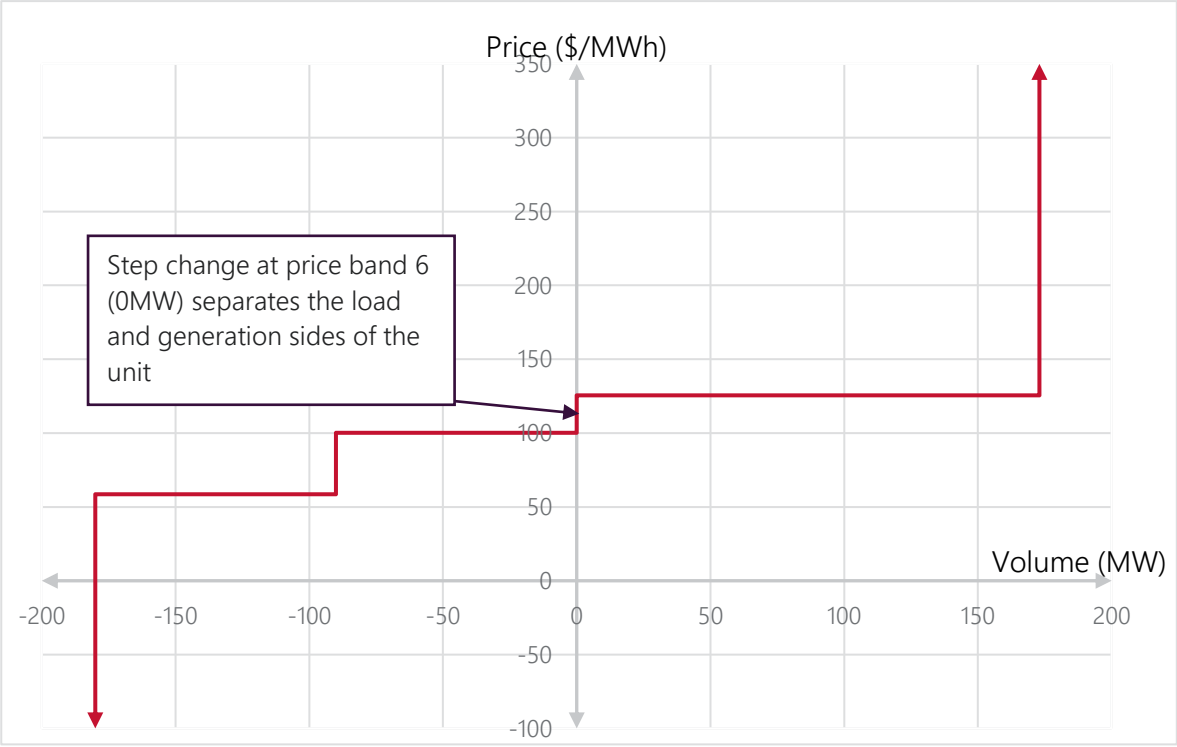
PERIOD ID	MAX CHARGE AVAIL	MAX DISCHARGE AVAIL	ROC UP	ROC DOWN	PASA MAX CHARGE AVAIL	PASA MAX DISCHARGE AVAIL	MIN SOC	MAX SOC	AVAIL1	AVAIL2	AVAIL3	AVAIL4	AVAIL5	AVAIL6	AVAIL7	AVAIL8	AVAIL9	AVAIL10
1	-100	250	6	8	-200	250	0	350	-20	0	0	0	-90	-90	173	0	0	77
2	-200	180	6	8	-200	250	0	350	0	-20	0	0	-90	-90	173	0	0	77
3	-200	0	6	8	-200	250	0	350	0	-20	0	-90	-90	0	173	0	0	77
4	-200	250	6	8	-200	250	0	350	0	-20	0	-90	-90	0	173	0	0	77
5	-200	250	6	8	-200	250	0	350	0	-20	0	0	-180	0	61	0	112	77
6	-200	100	6	8	-200	250	0	300	0	-20	0	0	-180	0	61	0	112	77
7	-200	250	6	8	-200	250	0	300	0	-20	-180	0	0	0	0	0	0	250
8	-100	250	6	8	-200	250	0	300	0	-20	-180	0	173	0	0	0	0	77
9	-100	250	6	8	-200	250	0	300	0	-20	-80	-100	0	0	173	0	0	77
10	-100	250	6	8	-200	250	0	300	0	-20	-80	-100	0	0	173	0	0	77

A2.2 Aggregated bids

The greyed-out bands are unattainable for that respective trading interval, due to the reduced max avail discharge (periods 2, 3 and 6) and discharge (periods 1, 8, 9 and 10)

PERIOD ID	MAX CHARGE AVAIL	MAX DISCHARGE AVAIL	ROC UP	ROC DOWN	PASA MAX CHARGE AVAIL	PASA MAX DISCHARGE AVAIL	MIN SOC	MAX SOC	BAND1	BAND2	BAND3	BAND4	BAND5	BAND6	BAND7	BAND8	BAND9	BAND10
1	-100	250	6	8	-200	250	80	350	-180	-180	-180	-180	-90	0	173	173	173	250
2	-200	180	6	8	-200	250	80	350	-200	-180	-180	-180	-90	0	173	173	173	250
3	-200	0	6	8	-200	250	80	350	-200	-180	-180	-90	0	0	173	173	173	250
4	-200	250	6	8	-200	250	80	350	-200	-180	-180	-90	0	0	173	173	173	250
5	-200	250	6	8	-200	250	80	350	-200	-180	-180	-180	0	0	61	61	173	250
6	-200	100	6	8	-200	250	80	300	-200	-180	-180	-180	0	0	61	61	173	250
7	-200	250	6	8	-200	250	80	300	-200	-180	0	0	0	0	0	0	0	250
8	-100	250	6	8	-200	250	80	300	-200	-180	0	0	173	173	173	173	173	250
9	-100	250	6	8	-200	250	80	300	-200	-180	-100	0	0	0	173	173	173	250
10	-100	250	6	8	-200	250	80	300	-200	-180	-100	0	0	0	173	173	173	250

A2.3 Graphical representation: ESS offer for period 1



Glossary

This document uses terms and abbreviations that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified.

Term/abbreviation	Definition
ACCC	Australian Competition and Consumer Commission.
AEMC	Australian Energy Market Commission.
AER	Australian Energy Regulator.
CoGATI	AEMC's Co-ordination of Generation and Transmission Investment Review.
DER	Distributed Energy Resources.
DUID	dispatchable unit identifier.
ESS	Energy Storage System.
FCAS	frequency control ancillary services.
FRMP	financial responsible Market Participant.
grid-scale	Amount of capacity (in megawatts (MW)) available for generation.
'hybrid' system	A system connected to the national grid and includes ESS coupled with a generating system and/or load.
logical metering arrangements	The assembly of physical metering installations, calculations and processes to derive the metering data for a connection point that does not have a physical metering installation.
MASS	Market Ancillary Services Specification.
MC	Metering Coordinator.
MDP	Metering Data Provider.
MLF	marginal loss factor.
MSGA	Market Small Generation Aggregator.
NEL	National Electricity Law.
NEM	National Electricity Market.
NEMDE	National Electricity Market Dispatch Engine.
NER	National Electricity Rules.
NMI	national metering identifier.
NSP	Network Service Provider.
POC	point of connection.

Term/abbreviation	Definition
PPA	power purchase agreement.
ROC	rate of change.
SCADA	supervisory control and data acquisition.
SOC	state of charge.
stand-alone ESS	An individual ESS that is connected to the national grid.
TUoS	transmission use of system.
Virtual power plant (VPP)	VPPs broadly refer to an aggregation of resources, coordinated using software and communications technology to deliver services that have traditionally been performed by a conventional power plant.
VRE	variable renewable energy.