Integrating Energy Storage Systems

High Level Design

July 2022

Important notice

PURPOSE

AEMO has prepared this document to provide information about the design of AEMO processes and systems to implement and support new market and power system arrangements under the Integrating Energy Storage Systems Final Rule Determination.

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VERSION CONTROL

Version	Release date	Changes
1.0	15/12/2021	Initial consultation version
2.0	07/07/2022	Final version

Executive summary

Introduction

On 2 December 2021, the Australian Energy Market Commission (AEMC) made the Final Rule (Rule) on Integrating Energy Storage Systems (IESS), to better integrate storage and hybrid systems into the National Electricity Market (NEM). Under the Rule, there will be significant changes to registration and dispatch arrangements, as well as in areas such as non-energy cost recovery, performance standards and participation options for aggregation of small resources, including batteries.

Further, the Rule takes a significant step toward a technology agnostic two-way market model for the NEM. The Rule anticipates and helps prepare the NEM for the future steps being envisioned through the Energy Security Board's (ESB) Post-2025 Market Design initiative.

Objective

This high-level design (HLD) document outlines the proposed arrangements to implement the Rule, by:

- Outlining AEMO's system and operational changes, to allow for efficient planning and cost-minimisation of the IESS implementation.
- Enabling participants and other stakeholders to understand and plan for system, process and operational changes as required to implement the Rule
- Providing the opportunity for industry feedback on the proposed arrangements to implement the Rule in a compliant manner.

IESS Design

The new participant category – the Integrated Resource Provider (IRP) – will be used by participants with bi-directional units including storage (BDU) , and will also be able to classify generating units and load (scheduled and retail), thereby representing a universal participation option.

The new unit type – the BDU – means that participants with existing grid-scale bidirectional resources will transition to the IRP category, and their units will be re-classified as scheduled BDUs, unless the resource is not capable of linear transition from charge to discharge (e.g., pumped hydro energy storage).

The classification of small resource connection points[1] will correspond to the existing classification of small generating units,. The Small Generation Aggregator (SGA) role will be moved into the IRP category (SGA will no longer exist as a category, although the label Small Resource Aggregator (SRA) is used). SRAs' portfolios of small generating units and small BDUs will also be able to participate in Frequency Control Ancillary Service (FCAS) markets, subject to requirements of the National Electricity Rules (NER) and the Market Ancillary Service Specification (MASS).

Units within hybrid systems will bid and be dispatched separately, but will be able to use aggregate conformance, e.g., to firm variable renewable energy (VRE) resources. A coupled production unit will be used for systems where multiple technology types (e.g. solar and a battery) share common equipment (eg. an inverter). The classification of coupled production units will be flexible, including both resources as a single scheduled BDU or single semi-scheduled generating unit. Alternatively, the different resources may use separate classifications.

The creation of the IRP and BDU allows storage resources to bid and be dispatched under a single DUID. Generally, the same functionality as exists under the current two-DUID model will be available, meaning that scheduled BDUs will be able to submit up to 20 energy bid bands (10 for load-side capacity and 10 for

[1] Connection points that only connect small generating unit(s) and/or small BDU(s).

generation-side capacity) and will have dual marginal loss factors and dual availabilities. For each market ancillary service, 10 bid bands will be available, consistent with other ancillary service units.

While scheduled and semi-scheduled units in hybrid systems will bid and be dispatched under separate DUIDs, dispatch conformance will be assessed against an aggregated dispatch target – allowing, for example, storage to firm wind or solar output. Under certain system conditions (for example, where system strength constraints limit solar exports), however, AEMO may nonetheless require conformance on an individual unit basis (not aggregated). Accordingly, an Individual Conformance (IC) Flag will be included with the dispatch instruction sent to each DUID – when the flag is active, that DUID will be required to conform with its individual dispatch target. New or revised Power System Operating Procedures will provide instructions and guidelines on the application of aggregate conformance, as well as the IC Flag, as discussed in Section 3.2.1 below.

The Rule updates non-energy cost recovery (NECR) calculations, so that there is neither dependency upon registration category for calculation of these payments, nor netting of load and generation between separate connection points for these calculations. Calculations will simply be calculated based on two gross measurements – Adjusted Consumed Energy (ACE) and Adjusted Sent Out Energy (ASOE).

More broadly, storage resources under the new classification options will be integrated into systems and processes for areas such as operational forecasting and planning, system operations, settlements and prudential requirements, noting however that the Rule does not make significant changes in these areas.

Finally, the Rule updates NEM language and terminology to be less technology specific and to better accommodate the increasingly two-way nature of flows in the power system.

In conclusion, the IESS design features which are set out above will require significant changes to AEMO and NEM procedures and documents.

Implementation

The changes under the Rule will be implemented through:

- An Initial Release on 31t March 2023, which will contain new registration and dispatch models, as well as give effect to any transitional rules.
- A Final Release on 3 June 2024, which will finalise the full implementation of the Rule. AEMO estimates that 30 months is required for full implementation, including a market trial period prior to go-live.

Contents

1. Introduction

Background and Context

The AEMC's Rule makes sweeping changes to registration and dispatch arrangements, particularly for storage resources and hybrid systems. However, the changes and clarifications also apply to NECR arrangements, performance standards for storage and hybrid systems and participation options for small resources, including small batteries.

Accordingly, the Rule makes significant changes to accommodate storage and hybrid systems, but also represents a significant conceptual shift toward a technology agnostic trader-services model[2]. The Rule anticipates and helps prepare the NEM for the future steps being contemplated through the ESB's Post-2025 Market Design initiative.

Purpose of this Document

This document sets out the high-level design of the Rule's implementation arrangements, by:

- Outlining AEMO's system and operational changes, to allow for efficient planning and cost-minimisation of the IESS implementation.
- Enabling participants and other stakeholders to understand and plan for system, process and operational changes as required to implement the Rule
- Providing the opportunity for industry feedback on the proposed arrangements to implement the Rule in a compliant manner.

Document Outline

This document is structured as follows:

- Registration and Participation arrangements are presented in Section 2, including the new, overarching participant category – the IRP – and – the new resource type – the BDU. This section also considers classification of hybrid and DC-coupled systems and arrangements by which small generating units and storage may access FCAS markets.
- Bidding and dispatch arrangements for both grid-scale storage and hybrid systems (including access to aggregate conformance) are presented in Section 3
- System Operations impacts are discussed in Section 4
- Forecasting and Operational Planning process impacts to integrate the new resource types are presented in Section 5
- Settlements and Prudential Requirements – particularly for updates to NECR calculations – are discussed in Section 6
- Retail and Metering-related changes are discussed in Section 7
- Implementation of the new arrangements (under initial and final releases) is presented Section 8.

In addition:

- Appendix A1 presents the scope of required changes to procedures, guides and other documents.

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[2] This includes a significant update to NEM terminology to have greater technology neutrality and to recognise the increasing 'two-way' nature of the NEM. A description of terminology changes is available in the AEMC's Final Determination (Appendix G).

- Appendix A2 presents arrangements for a range of possible hybrid system 'use cases'.
- Appendix A3 provides a non-energy cost recovery example for an embedded network.
- Appendix A4 lists abbreviations used throughout this document.

2. Registration and Classification

2.1 New Integrated Resource Provider Category

The IRP will be able to take on a range of roles that are currently separated. A primary reason to establish the IRP category is to facilitate the inclusion of bi-directional resources (such as batteries and other forms of storage). However, this category will also be able to classify units within hybrid systems, DC-coupled units[3], aggregated portfolios as well as generating units, scheduled load and even retail load (end user connection points). Accordingly, this category approaches a "universal" participant type. New types of resource classifications will also be created to facilitate this model, as described later in this section.

Consequently, as an IRP, a participant with grid-scale storage resources will no longer need to register in the two categories of Generator and Market Customer. Scheduled storage resources will then be able to be bid and dispatched under a single DUID, by virtue of the new BDU resource type. Section 3.1. describes the bidding and dispatch arrangements for scheduled BDUs.

Existing participants with resources which satisfy the BDU requirements must transition into the IRP category, and in most cases, re-classify their units using the BDU unit type – for example, grid scale batteries will be classified as scheduled BDUs, rather than as a scheduled generating unit and a scheduled load. However, as occurs currently, the units which are otherwise bidirectional in nature but are not capable of continuous transition from charging to discharging (e.g., pumped hydro energy storage) will continue to bid and be dispatched under separate scheduled load and scheduled generating unit classifications and DUIDs.

Table 1 indicates the range of classification options available to an IRP and provides examples of how each classification could be used.[4]

Another new unit type is the small BDU (Small BDU). The Small BDU can be used for small storage resources, and will accompany the existing small generating unit term. However, the existing SGA category will not exist. Accordingly, SGAs will be transitioned into the new IRP category, using the label of Small Resource Aggregator. Otherwise, except for SGAs, the existing participant categories will continue to exist, much as they do currently.

Because an IRP can classify several different unit types, an IRP will need to ensure that it is appropriately accredited to participate in respect of the relevant classifications. For example, where an IRP wishes to classify another end user's connection point as a market connection point, it must hold a Retail Authorisation (or be exempted).

[3] Formally called 'coupled production units'.

[4] This information reflects the Rule as written, noting that AEMO is clarifying with the AEMC whether it is appropriate to require < 30 MW BDUs to be semi-scheduled or to allow > 30 MW of generating and BD unit at the connection point to be non-scheduled.

Table 1 Classification options and examples under the Integrated Resource Provider category.

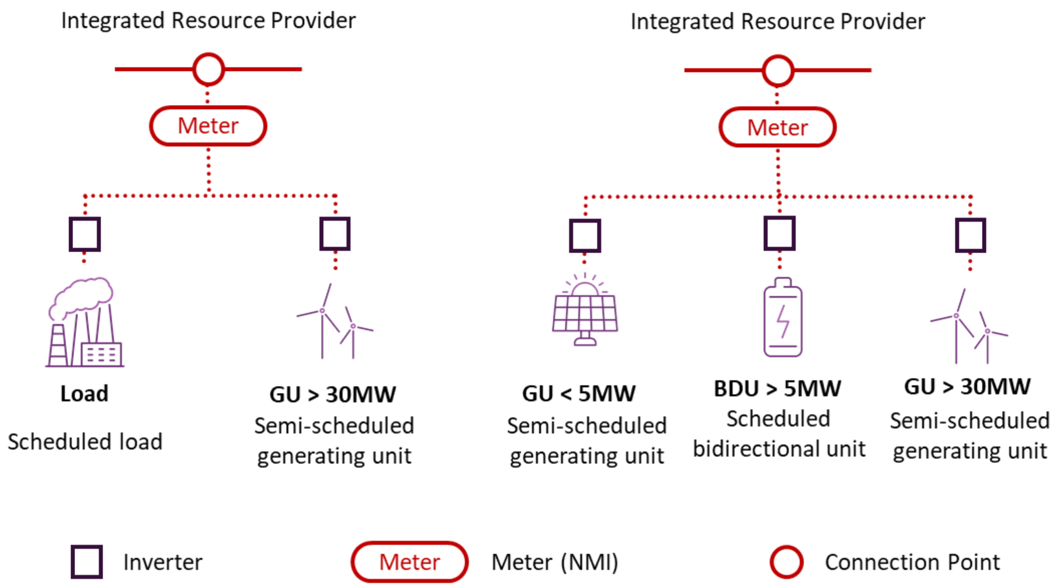
		Classifications											
Resource	Description	Scheduled GU	Semi-scheduled GU	Non-scheduled GU	Scheduled BDU	Non-scheduled BDU	Scheduled load	Market GU	Non-market GU	Market BDU	Non-market BDU	Market CP	Example
Generating unit (GU)	≥ 30 MW GU	✔						✔					50 MW synchronous generating system with all output sold to the market
	≥ 30 MW GU and intermittent		✔					✔					50 MW wind farm with all output sold to the market
	< 30 MW GU and not exempt			✔				✔					20 MW solar farm with all output sold to the market
	< 30 MW GU, not exempt and located at a Market Customer's CP			✔					✔				Registered 20 MW generating system internal to a manufacturing plant with all output sold to the retailer at the connection point
Bidirectional unit (BDU)	≥ 5 MW BDU and linear				✔					✔			8 MW battery storage facility with all output sold to the market
	≥ 5 MW BDU and non-linear	✔					✔			✔			8 MW pumped hydro storage facility with all output sold to the market
	≥ 5 MW BDU and coupled				✔					✔			20 MW solar farm comprised of 10 x 2 MW DC-coupled PV-BESS units, that consume from the grid and all output sold to the market
	≥ 5 MW BDU, coupled and partly intermittent		✔		✔					✔			20 MW solar farm comprised of 10 x 2 MW DC-coupled PV-BESS units. Consumes from the grid, and all output sold to the market.
	≥ 5 MW BDU, coupled, partly intermittent. No grid consumption		✔							✔			20 MW solar farm comprised of 10 x 2 MW DC-coupled PV-BESS units. No grid-consumption, and all output is sold to the market (inclusion of non-intermittent capacity subject to AEMO policy).
	< 5 MW BDU and not exempt					✔				✔			4 MW battery unit in a registered hybrid IRS. All output sold to the market.
	< 5 MW, BDU not exempt and located at a Market Customer's CP					✔					✔		4 MW battery unit in a registered hybrid IRS, internal to a manufacturing plant with all output sold to the retailer at the connection point
Plant	Excluding generating plant connected at a market connection point						✔						20 MW data centre that participates in central dispatch
Small resource connection point	CP only connects small GU(s) and/or small BDU(s)											✔	4 MW battery system aggregated by an IRP (Small Resource Aggregator)
Connection Point	CP supplies end user and/or connects exempt production unit(s)											✔	5kW battery system located 'behind the meter' at a consumer's premises

2.2 Hybrid and DC-Coupled Systems

Participants will be required to use the IRP category for hybrid integrated resource systems[5] which are comprised of multiple technology types behind a connection point. Figure 1 shows example classifications of loads, generating units and BDUs within hybrid systems, (there is no shared equipment such as inverters that would qualify the resources as a coupled production unit). In Figure 1:

- The configurations are not intended to limit the types of hybrid use cases or to exclude (for example) scheduled generating units or other combinations. Appendix A2 also describes a range of different hybrid use cases.
- In the right-hand example, as the total capacity of the group of generating units (i.e., the wind and solar resources) exceeds 30 MW, both the wind and the solar generating units are classified as semi-scheduled generating units, even though the latter has a capacity of less than 5 MW.
- Hybrid systems will be able to include non-scheduled resources (e.g., non-scheduled load, non-scheduled BDU or non-scheduled generating unit). However, only scheduled resources (which includes semi-scheduled generating units) could be included in aggregate dispatch conformance calculations.

Figure 1 Two examples of hybrid configurations and classifications.



Broadly, the following arrangements will apply to hybrid systems3.2):

- Classification, bidding and scheduling occur at the resource (i.e., unit) level (each resource in the hybrid system will bid and be dispatched under a separate DUID). Accordingly, in most cases, classification will occur similarly to the equivalent resources using separate connection points. For example, a 50 MW solar farm with a 20 MW battery in a hybrid system with a single connection point would be classified as a semi-scheduled generating unit and a scheduled BDU respectively.
- Where possible, constraints will be applied to the net flow from all resources within the hybrid system, except where a constraint is in respect of a particular unit within the system. For example, a system strength constraint would typically be applied to a particular unit, but a thermal transmission limit would apply to flow from all units in the hybrid.

[5] A person may register as either an IRP or Generator with respect to a hybrid generating system.

- However, conformance with dispatch instructions could occur at the system level – e.g., a battery could firm output from a solar or wind farm. This would occur through the linking of the separate DUIDs in AEMO's systems to acknowledge that these DUIDs form a hybrid system, with dispatch conformance being monitored across the aggregate. However, AEMO would be able to require individual conformance at specific times, e.g., if a solar farm in a hybrid system contributes to a system strength constraint (Section 3.2 sets out more detail).
- Performance standards would be defined at the unit level, but measured at the connection point. Performance standards will be determined for each possible mode of operation of the system. For example, a solar-battery system will have three operational modes, being: (1) battery only; (2) solar farm only; and (3) both battery and solar farm .

Section 3.2 provides further detail on participation and dispatch arrangements for hybrids. DC-coupled systems – like hybrid systems – are systems which consist of multiple technology types e.g., a solar and battery system. However, the term "DC-coupled" refers to multiple technology types using shared equipment, such as a single inverter for two distinct technologies. From a power system constraints perspective, generally, a differentiation will be unnecessary between power flows from different resources behind the same inverter. Accordingly, greater flexibility in classifying such resources can be accommodated. Where such resources share equipment such as an inverter, they are referred to as coupled production units in the NER.

A proponent of such an integrated resource system with coupled production units would register as an IRP. The proponent would be able to choose (subject to AEMO policy) either to classify:

- the system as a single scheduled BDU (even including VRE) or a single semi-scheduled generating unit (subject to restrictions); or
- each resource separately e.g., a battery as a scheduled BDU and a VRE resource as a semi-scheduled generating unit.

Using the example of a solar-battery system, restrictions will be applied to classifications as follows:

- Single scheduled BDU: The BDU will participate in the same manner as stand-alone battery which is classified as a BDU. Accordingly, the solar farm will not be able to access semi-scheduled provisions, such as AEMO determining an Unconstrained Intermittent Generation Forecast (UIGF) or the associated ability to generate below the dispatch target as a result of energy resource availability.
- Single semi-scheduled generating unit: Other than for auxiliary load, the system would not be able to consume energy from the grid, and bids will be limited to 10 generation bands. AEMO will determine an UIGF which applies to all resources in that classification. AEMO will develop a policy regarding limitations on inclusion of non-intermittent resources in a semi-scheduled classification. This policy is likely to follow existing exemption guidelines (namely, a 5 MW limit on non-intermittent capacity) and may also limit registered capacity to be that of the intermittent capacity.
- Separate classifications, e.g., scheduled BDU and semi-scheduled generating unit: The units would bid and be dispatched separately. In practice, there would be little-to-no distinction between a coupled production unit which has multiple classifications and an (uncoupled) hybrid system, as the two coupled units would bid and be dispatched separately, but still have access to the aggregate conformance provisions. However, the use of a common inverter for multiple units (of different technology) means it would be less likely for a constraint to apply to an individual unit. Accordingly, individual conformance is likely to be required less frequently.

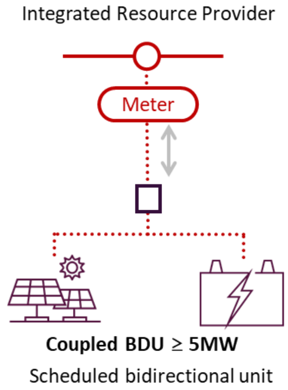
Finally, where the coupled production unit is below 5 MW in aggregate capacity, the unit could participate as a non-scheduled BDU – that is, the unit would not participate in the central dispatch processes.

Table 2 outlines the classification and participation options for a solar-battery coupled production unit. The forecasting, constraints and other processes for coupled production units will need to consider both the inverter capacity and the capacity of the individual technologies using the inverter.

Table 2 Classification of coupled production units.

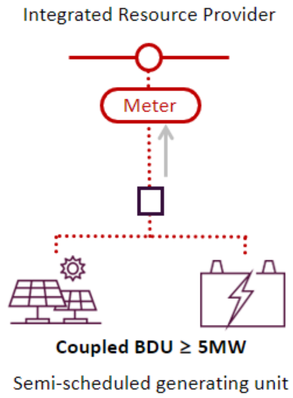
Scheduled bidirectional unit

For a coupled production unit with a capacity of 5 MW or larger, the participant may use a scheduled BDU classification in respect of the combined solar-battery resource. It will submit one bidirectional bid, with up to 20 bid bands. It will need to forecast both the solar and battery consumption and production, then incorporate this into its bid. AEMO will not produce a UIGF for the solar resource.



Semi-scheduled generating unit

For a coupled production unit with a nameplate rating of 5 MW or more, the participant may use a semi-scheduled generating unit classification in respect of the combined solar-battery resource, subject to an AEMO policy (to be developed). It will submit one uni-directional (production only) bid, with up to 10 bid bands. The system will not be able to consume from the grid, other than for auxiliary load. AEMO will produce a UIGF for the system. Optionally, the participant can provide a UIGF self-forecast for use in dispatch.

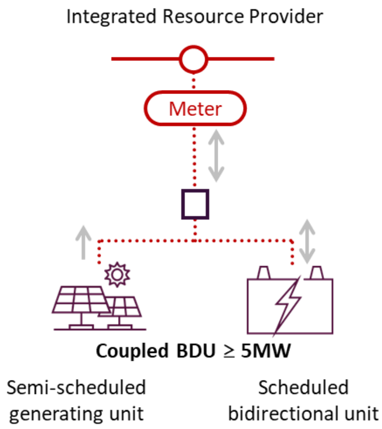


Scheduled bidirectional unit and semi-scheduled generating unit

For a coupled production unit with a nameplate rating of 5 MW or more, the participant may use two classifications – a semi-scheduled generating unit in respect of the solar resource, and a scheduled bidirectional classification in respect of the battery storage resource. It will submit

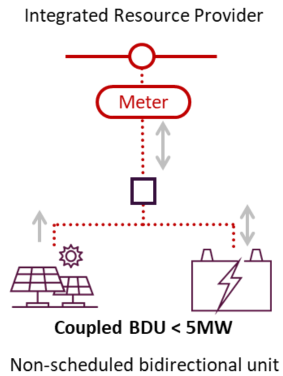
- a production-only bid with up to 10 bid bands in respect of the semi-scheduled generating unit; and
- a bidirectional bid with up to 20 bid bands in respect of the scheduled bidirectional unit.

The battery will be able to consume from the grid. AEMO will produce a UIGF for the semi-scheduled generating unit. Optionally, the participant can provide a self-forecast for the semi-scheduled generating unit.



Non-scheduled bidirectional unit

For a coupled production unit with a nameplate rating less than 5 MW, the participant may use a non-scheduled bidirectional unit classification. It will not participate in central dispatch.



2.3 Small Generating Units and Small Bidirectional Units

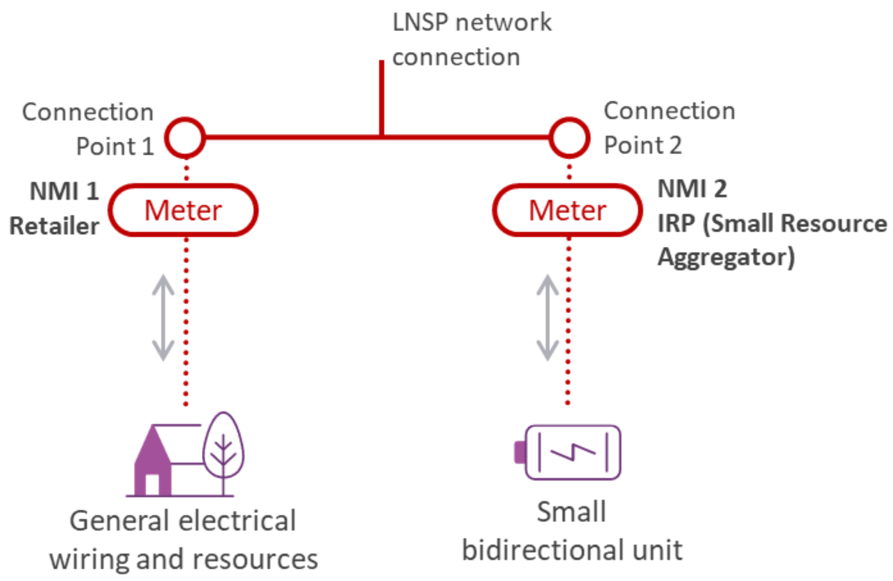
2.3.1 Enduring Arrangements

The Rule:

- Replaces SGAs with the IRP category and a new Small Resource Aggregator label.
- Clarifies that aggregation will extend to BDUs as well as generating units.

Small resource connection points will refer to connection points which connect one or more small generating units or small BDUs. Small Resource Aggregator is a label – such a participant will be required to register as an IRP.

Figure 2 IRP (Small Resource Aggregator) example



Under the Rule Small Resource Aggregators – using the IRP category – will be able to participate in the FCAS markets with a portfolio of small generating units and/or small BDUs. To do so, they will classify the plant at their small resource connection point as an ancillary service unit, subject to meeting the requirements in the MASS and the NER in respect of the services which they will provide.

In order to qualify to provide regulation FCAS, an ancillary service unit[6] must have a centrally-determined level of generation or consumption (in megawatts), which requires the unit to be scheduled or semi-scheduled. This requirement will preclude small resources from providing regulation FCAS.

The remainder of this section relates to contingency FCAS only.

The portfolio of ancillary service units will be able to apply to aggregate and bid and be dispatched in FCAS markets as a single ancillary service unit, if they are connected within a single region and are operated by a single person.

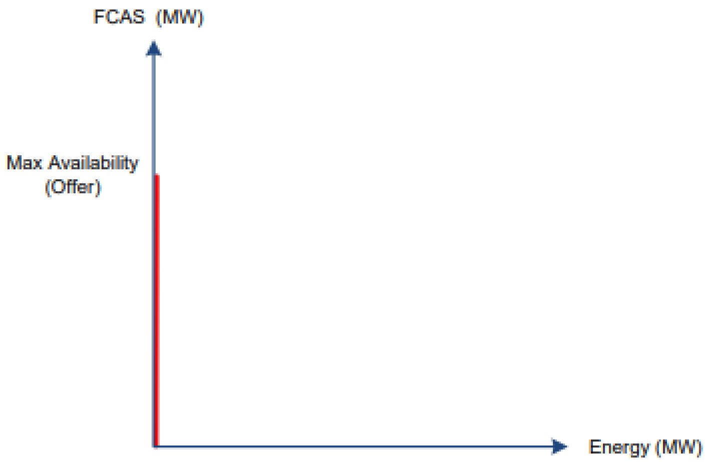
As under the current SGA framework, small generating units and small BDUs will not participate in central dispatch for energy, regardless of whether they are participating in FCAS markets. As the NEM Dispatch Engine (NEMDE) will not dispatch these units for energy, the unit's FCAS trapezium will be taken to be a vertical line, as in Figure 3 (AEMO's *FCAS Model in NEMDE* document provides more detail[7]). Further, as

[6] The MASS currently uses the term 'ancillary service facility', but this terminology will change to use 'ancillary service unit' in line with the consolidation to the latter term (see Section 2.4).

[7] https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/fcas-model-in-nemde.pdf?la=en

NEMDE will not co-optimise energy and FCAS for these units, the participant will need to ensure that it is operated such that the enabled quantity of FCAS is available to be deployed.

Figure 3 FCAS bid trapezium for small resources classified as an ancillary service unit.



AEMO verifies the deployment of contingency FCAS by enabled providers in response to a change in Local Frequency using locally recorded measurements of frequency and power flows. SGAs must comply with the measurement and data provision requirements which are specified in the MASS.

While a battery which is a small BDU and ancillary service unit would be able to provide raise and lower services over the full operating range (that is, maximum consumption to maximum production), its maximum enablement would be less than the full range, due to limitations on droop settings as discussed for scheduled BDUs in Section 3.1.3.

Finally, due to this and other initiatives under the ESB Post 2025 initiative, there will be opportunities to evolve the MASS to better integrate the provision of FCAS by the new types of resources, e.g., distributed and/or small resources.

2.3.2 Transitional Arrangements

In addition, the transitional rules will allow Market Small Generation Aggregators to participate in FCAS markets in respect of their small generating units. This allowance will be implemented with the initial release (31st March 2023). In contrast to the enduring arrangements described above, the main differences in the interim arrangements will be how the pathway by which the connection point for the small generating units is classified to provide market ancillary services under the NER.

Under the interim arrangements, for the purposes of ancillary service load classification, a Market Small Generation Aggregator will be deemed to be a Market Customer in respect of the connection point at which the small generating unit is located. It will then be able to apply to AEMO for approval to classify the connection point as an ancillary service load. Upon approval, it would be taken to be an Ancillary Service Provider.

Again, AEMO will assess applications to classify a connection point for a small generating unit as an ancillary service load having regard to the NER and the MASS. It is not expected that changes to the MASS will be required for these transitional arrangements.

Regarding transition to the enduring arrangements, from the Rule's effective date, the participant would continue to be taken to be an Ancillary Service Provider, but will be registered as an IRP, instead of an SGA (this transition to an IRP will occur for every SGA, regardless of whether it is an Ancillary Service Provider). Similarly, small generating unit connection points which are classified as an ancillary service load will be taken also to be classified as an ancillary service unit – a consolidated classification discussed in the next section – from the Effective Date.

2.4 Consolidative Registration Changes

Ancillary service generating units and ancillary service loads will be consolidated under a new umbrella term – the ancillary service unit classification – which can be used by generating units, loads, bidirectional units and plant, subject to satisfying the MASS. Again, this is a more universal participation model, which allows for a future two-sided market. All other aspects of the current arrangements will remain as they are.

The current 6 MW limit on aggregation of generating units as one semi-scheduled generating unit (current NER 2.2.7(i)(2) will no longer apply. Minimum ramp rates will be unified for scheduled units, with no dependency upon classification or aggregation method. The minimum ramp rate for a scheduled unit (whether a generating unit, bidirectional unit or load) will be the lower of 3 MW or 3% of capacity.

2.5 Transition of Existing Participants and Connection Agreements

The Rule will require the transition of:

- Participants with existing grid-scale storage units to the new IRP category. Existing grid-scale storage resources will also need to transition to the scheduled BDU classification, unless they are incapable of continuous transition between charging and discharging, in which case they will continue to use separate scheduled load and scheduled generating unit classifications.
- Existing SGAs to the IRP category (with the label of Small Resource Aggregator), given that the SGA participant category will no longer exist.

In both cases, as there are no changes to physical systems, it is expected that transition to the IRP category will be relatively streamlined. While relevant Participants would need to apply for transition to the scheduled BDU classification:

  - AEMO will help facilitate this as part of a readiness effort.
  - These participants will neither incur additional fees, nor need to demonstrate performance standard capability, nor need to re-negotiate performance standards.

AEMO will determine a process and timeframes through which the transitioned registration and classification arrangements will apply.

NER 11.145.2(c) requires an Existing IRS Participant[8] to apply to AEMO to register as an IRP no later than 3 September 2024 and to classify each BDU or generating unit accordingly.

NER 11.145.3(b) requires a New IRS Participant – which includes a person who submits a new registration application before 3 June 2024, then consequentially becomes registered – to obtain AEMO's approval to classify a BDU or generating unit accordingly prior to and with effect from 3 June 2024.

There may be changes to participant bidding and dispatch systems which are required for scheduled BDUs, as discussed further in Section 3. AEMO will work with participants to reduce the impact of these changes, as far as possible.

AEMO will also determine whether any additional transition arrangements are required to formalise aggregate conformance and connection point performance standards for existing hybrids.

In respect of the future cases where storage is retrofitted to an existing generating system, the generation performance standards and connection agreements will need to be reviewed and possibly renegotiated, due to the change in physical resources within the system.

[8] An existing IRS participant is a registered participant of a transitioning generating system, or a registered participant who becomes registered as a generator during the transition period (between 9 December 2021 and 3 June 2024), as defined in NER 11.145.1(a).

3. Dispatch

3.1 Bidding and Dispatch of Scheduled Bidirectional Units

The introduction of the BDU classification will enable:

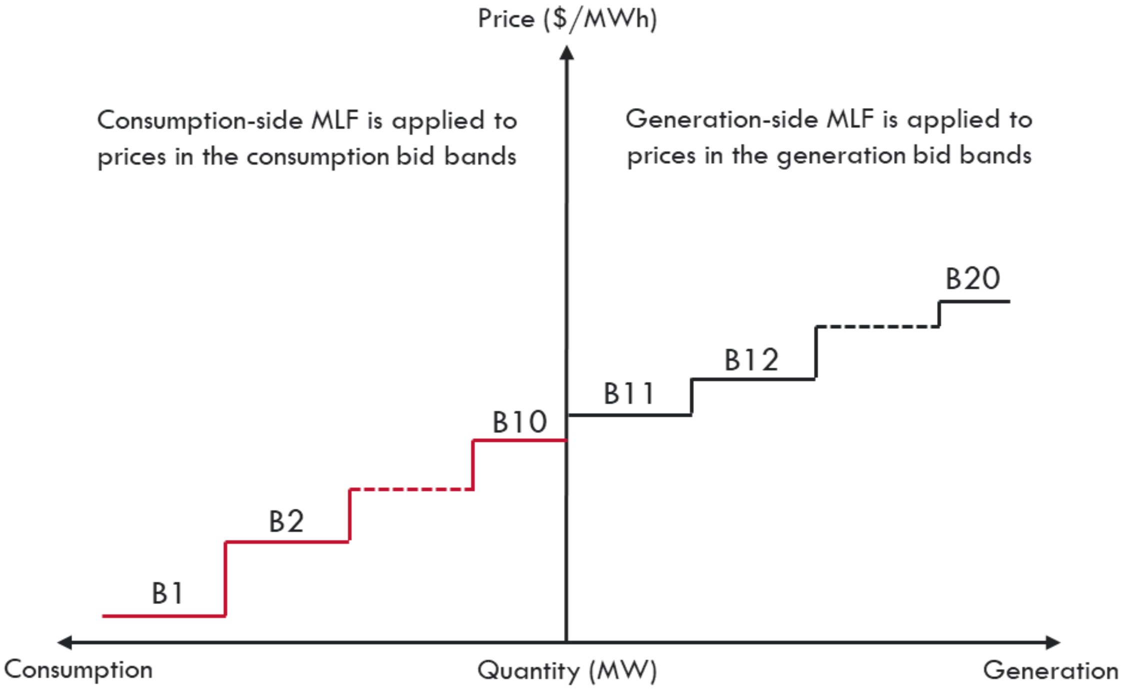
- Storage units to submit a single bid and to receive a single dispatch instruction, in comparison with the current arrangements, where bidding and dispatch is in respect of a scheduled generating unit and a scheduled load.
- FCAS services to be similarly bid, where currently, FCAS bids are in respect of an ancillary service generating unit or an ancillary service load. With the consolidation to the universal ancillary service unit classification, FCAS bids will be submitted in respect of the one ancillary service unit.

The hybrid systems with multiple units will bid and be dispatched separately for each unit (Section 3.2 provides more detail) Further, resources such as pumped hydro energy which are bidirectional in nature, but which have a dead-band within which they cannot continuously operate, will continue to submit separate generation and consumption bid sets using two units and DUIDs, as this simplifies implementation within NEMDE.

3.1.1 Bidding for energy

Up to 20 bid bands will be available to be submitted in respect of a scheduled BDU, with these being restricted to a maximum of 10 bands for capacity on the consumption side, and 10 bands on the generation side (Figure 4). Like bids from existing unit types, prices in bid bands are required to be monotonically increasing with available MWs. AEMO will apply a bid validation to enforce this requirement, while recognising certain attributes of BDUs, as described in the remainder of this section.

Figure 4 Up to 20 bid bands for scheduled BDUs.



The validation would ensure that bids are monotonically increasing across the combined consumption and generation bands, so that consumption and generation quantities cannot be simultaneously selected at a single energy price. BDUs will have separate marginal loss factors (MLFs) applied to the consumption and generation bands, so this validation must be enforced on the bids *after* they have been adjusted for their MLF, in order that the bid prices are valid when referred to the relevant regional reference node (RRN).

The bid price at the regional reference node (RRN) is calculated as

$$P_{RRN} = P_{CP}/LF$$

where

P_{RRN} and P_{CP} are the prices referenced to the RRN and the connection point, respectively

LF is the relevant (consumption or generation-side) loss factor

To demonstrate the effect of the loss factor adjustment, consider a BDU with marginal loss factors of LF_G = 0.99 and LF_C = 0.98 on the generation and consumption bands respectively. Table 3 shows how a consumption-side bid price may be less than a generation-side price at the connection point, but greater when adjusted by the loss factor to apply at the RRN. The validation will ensure that bid prices remain monotonically increasing after adjustment by the MLF.

Table 3 Valid and invalid BDU bids after adjustment by the respective MLFs.

	First generation bid band price		**Last consumption bid band price**	
	At connection point	**Adjusted to RRN**	**At connection point**	**Adjusted to RRN**
Invalid bid	$300/MWh	$300/0.99 = $303.03/MWh	$299/MWh	$299/0.98 = $305.10/MWh
Valid bid	$300/MWh	$300/0.99 = $303.03/MWh	$295/MWh	$295/0.98 = $301.02/MWh

Only bid bands with non-zero quantities will be assessed in the validation, and the validation will consider each interval independently. This will allow participants to adjust bid quantities throughout the day as conditions change – for example, a price at which a participant wishes to sell energy at one time of the day may later be a price at which the participant wishes to buy energy (under the expectation that prices will be even higher later). The validation will allow this, as it will be applied interval-by-interval on bands with non-zero capacity only, as in Table 4. Here, Band 9 (consumption side) is priced greater than band 12 (generation side), which this is acceptable if these bands do not both have non-zero quantities in any dispatch interval (DI).

Table 4 An example of allowable overlapping generation and consumption-side bids, where the quantity offered is for consumption (negative) or generation (positive) at that price.

DI	**Band 1**	**Band 2 …**	**Band 8**	**Band 9 …**	**Band 12**	**Band 13 …**	**Band 19**	**Band 20**
Prices	-$999	-$300	$29	$149	$30	$150	$1000	$15000
…	…	…	…	…	…	…	…	…
15:00	-100	-50	-50	-50	0	0	50	100
15:05	-100	-100	-50	0	0	50	0	100
15:10	-100	-150	0	0	50	50	50	0
…	…	…	…	…	…	…	…	…

3.1.2 Dispatch instructions

Scheduled BDUs will receive a single (bidirectional) dispatch instruction representing the net flow to be achieved. Conventionally, this value would be positive where the unit is being dispatched to discharge, and negative where it is being dispatched to charge.

AEMO understands that some storage resources may be capable of simultaneously charging and discharging, and it may be profitable to do so in order to be paid for their energy conversion losses when the energy price is negative. Consider a storage resource which must consume 11 MWh of energy for every 10 MWh that it can later discharge, i.e., the losses on the 11 MWh are 1 MWh.

In this situation, the BDU is simultaneously charging and discharging, but it will only receive a single (net) dispatch target. It should therefore structure its bids so that 1 MW conversion loss is dispatched, i.e., its single dispatch target would be -1 MW. If the net consumption of 1 MW is then physically achieved, the unit will be considered conforming. The NEM power system will "see" 1 MW of consumption from a conformance view, regardless of how this is achieved by the storage resource.

3.1.3 Bidding for Frequency Control Ancillary Services

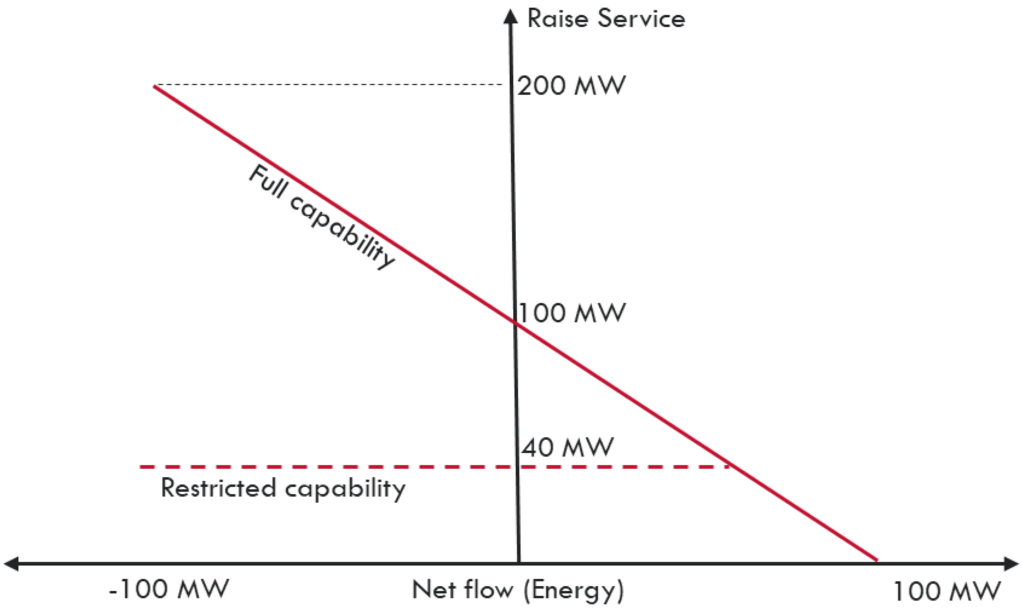
Bidding for FCAS in respect of a scheduled BDU that is an ancillary service unit will allow for up to 10 bid bands for each service – the same as for other ancillary service units. As FCAS enablement is in a positive direction only, there is no bidirectional nature to these products, and treatment of FCAS bids and enablement for BDUs will be similar to other units.

The FCAS trapezium for a scheduled BDU will be similar to that used by other units which are not bidirectional, in that it will be constructed in terms of parameters such as Enablement Min, Enablement Max, Low Breakpoint and High Breakpoint. However, these parameters will be able to be specified in respect of capacity on the consumption (negative) or generation (positive) side of the unit (subject to the technical envelope specified at the time of registration for that provider).

However, technologies such as batteries may be limited to a maximum contingency FCAS enablement that is less than the BDU's physical capability, due to the rapid response capability of batteries. Any limitations on the maximum enablement would arise due to the application of power system constraints to droop settings, and *not* because only 10 bid bands are available. The remainder of this section explains the basis for this approach.

The bi-directional nature of a battery means its potential capacity to deploy FCAS is double the nameplate capacity, e.g., consider a storage unit which can move from -100 MW (charging), to +100 MW (discharging), i.e., 200 MW in total. The potential maximum enablement quantity is then 200 MW. To ensure power system stability constraints are not adversely impacted by droop settings, AEMO may need to limit the maximum contingency enablement to some lesser value – for example 40 MW, as shown in Figure 5 for a raise service.

Figure 5 Restricted Contingency FCAS Enablement



This restriction will only limit the capacity of the raise service which the unit can be enabled for. It will still be able to provide the raise service regardless of whether it is dispatched to consume or produce energy (subject to submitted minimum and maximum enablement values). Further, there will be no restrictions at the point of 0 MW net flow, i.e., the BDU could be enabled for 40 MW of a raise service even if it were currently consuming at 10 MW (so that if the raise service was to be fully deployed, it would move from consuming 10 MW, to producing 30 MW).

These restrictions will only need to be applied to contingency services, as the deployment of contingency services is decentralised in nature (i.e., units independently measure frequency and deploy the service). These restrictions do not need to be applied to regulation FCAS enablement, because setpoints for regulation are centrally determined. Therefore, the maximum regulation enablement for the 100 MW battery in the example above could potentially be 200 MW.

3.1.4 Availability, Ramp Rates and MLFs for Bidirectional Units

Scheduled BDUs will have dual MLFs applied – one to their generation-side bids and the other to their consumption-side bids. This application will also be the case in metering and settlement.

For scheduled BDUs, participants will submit two capacity availabilities (in MW) – one to indicate capacity to consume energy, and the other for capacity to produce energy. This will enable the availabilities to differ where required – e.g., if the storage reservoir is full, a unit will have zero availability to consume, but its full capacity may be available to discharge.

Participants will also submit dual sets of ramp rates in respect of scheduled BDUs, comprising an up ramp rate and a down ramp rate for both the generation and the consumption side of the BDU, which amounts to four ramp rates in total. The use of two sets of ramp rates under one DUID will need to be accommodated in NEMDE implementation. For example, where – in a dispatch interval – a BDU is dispatched to transition from consuming at -5 MW to generating at 10 MW, this implies that two separate ramp rates should apply – one from -5 MW to 0 MW, and the other from 0 MW to 10 MW. Participants using separate ramp rates may also need to consider this in their SCADA systems, as there are times when dispatch processes use the SCADA ramp rate, as opposed to the ramp rates provided in bids.

3.1.5 Implementation and impacts on existing storage units

AEMO will implement the changes described in this section so that NEMDE will optimise one DUID and determine one dispatch instruction for each scheduled BDU. Participants with existing bidirectional resources would need to ensure that their bidding and dispatch systems can accommodate this change. As described in Section 8, AEMO will run a market trial to facilitate the satisfaction of this requirement.

3.2 Dispatch of Hybrid and DC-Coupled Systems

Under the Rule, DC-coupled systems will be able to register and participate as either scheduled, semi-scheduled, or use multiple classifications. Participants with hybrid systems will – subject to some exceptions – be able to use aggregated conformance to firm the output of VRE resources. This section provides an overview of how the relevant arrangements will be applied. Appendix A2 also describes a range of different hybrid and DC-coupled use cases.

The ability to use aggregate conformance will be made available in the initial release in March 2023 (see Section 8 on implementation timing).

3.2.1 Hybrid systems

Resources in hybrid systems will be classified separately, and will bid and be dispatched separately. However, aggregate dispatch conformance will be available and performance standards will be defined at the unit level, although they will be measured at the connection point. In this regard, hybrid systems are not limited to scheduled bidirectional units paired with VRE, but extend to include, for example:

- Scheduled load with a semi-scheduled generating unit.
- Scheduled generating units with a semi-scheduled generating unit.
- Two intermittent technologies (wind and solar) as semi-scheduled generating units.
- Combinations with three or more technologies.

Figure 1 and Appendix A2 provide more examples of the possible combinations, as well as their treatment.

Aggregate conformance allows assessment of conformance with dispatch targets at the hybrid system level, rather than the unit level. AEMO may still require unit level conformance, but only under particular conditions. Currently, the Rule expressly allows only aggregate conformance from a bi-directional hybrid. However, this restriction is the subject of discussions with the AEMC and may be included within an AEMO implementation amendments rule change proposal. This section assumes all hybrids may be accommodated within aggregate conformance.

The mechanics of aggregate conformance will be as follows. Participants will elect, typically during the registration process, whether they wish to use or opt out of aggregate dispatch conformance. Each scheduled resource in a hybrid system will be dispatched separately, and will receive the IC Flag as part of the dispatch instruction. The IC Flag may be active or inactive, depending on whether the resource is using aggregate dispatch conformance, and, if so, whether a situation for individual conformance has arisen. When active for a DUID, that DUID will be required to conform individually. Typically, AEMO will set the IC Flag to be active where a particular unit is restricted by a particular constraint – e.g., if solar exports must be constrained for system strength. All units not on individual conformance may use aggregate conformance. For example, in a wind-solar-battery hybrid, if only the solar IC Flag is active, the wind and battery may still use aggregate conformance.

Conformance could be with a dispatch target or a dispatch cap, as determined by the classification of the relevant units in the conformance set. Where there are only semi-scheduled generating units in the aggregated set, conformance is with a dispatch cap. However, if a scheduled unit is included in the aggregated set, conformance is always with a target. Non-scheduled production will be considered – e.g., a hybrid system with a 3 MW non-scheduled battery could exceed its aggregate conformance cap by 3 MW.

As each resource in a hybrid system will use a separate DUID, constraints can be applied individually where required (see Section 3.2.4).

Use of aggregated conformance would not prevent bidding and being enabled for FCAS by units within a hybrid system. Each unit would bid and be enabled for FCAS separately (if registered/qualified to do so). However, the ability to use aggregate conformance means FCAS trapeziums would need to consider other units within the system when determining headroom for enablement. For example, a battery in a battery-solar hybrid system could provide FCAS, but solar forecast errors could reduce the available headroom for the battery under aggregate conformance.

Aggregate conformance itself will not materially impact causer pays arrangements. Under the Rule, frequency impacts will continue to be determined at the DUID level, but currently causer pays effectively allows for netting of these impacts. However, these arrangements may change under the separate Primary Frequency Response Incentive Arrangements Rule Change.[9]

3.2.2 DC-Coupled Systems

DC-coupled systems are generating or integrated resource systems with multiple plant types (e.g., solar and a battery) which share common equipment such as a single inverter. The units in these systems are formally termed coupled production units. These are a relatively novel configuration for the NEM. While this section describes AEMO's view of how such systems will be treated, further examination may be required as such systems enter the NEM.

Coupled production units will be able to use either a single scheduled BDU or a single semi-scheduled generating unit classification, or could use separate classifications for each technology within the system. Depending on the classification, the following arrangements for participation will apply.

- A single scheduled BDU classification – The participant will be able to use a single DUID and bid with 20 bands, much like a stand-alone battery. The participant will need to meet other requirements for scheduled BDUs, for example to:
    - Provide (and demonstrate the ability to provide) seven-day forecasts of availability.
    - Bid and re-bid according to those forecasts.
    - Conform with dispatch targets.

  These requirements will apply even if intermittent generation is included in the scheduled unit.
- A single semi-scheduled generating unit classification – The participant will not be able to use any battery load to consume from the grid, and only 10 generation-side bid bands will be available (i.e., under one DUID). AEMO will forecast the unit, and Market Participants can optionally provide a self-forecast for use in dispatch.
- Multiple classifications – e.g., one scheduled BDU and one semi-scheduled generating unit – Units would bid and be dispatched separately, and have access to aggregate conformance, as for a hybrid system which is not a coupled production unit.

Coupled production units which meet criteria to be exempt from registration may be non-scheduled. Generally, non-intermittent capacity (e.g., battery capacity) exceeding 5 MW would be required to be scheduled (not included in a semi-scheduled or non-scheduled classification), although application for consideration of an exemption can be made. NER 2.2.3(c) and 3.8.2(e) will continue to be applied so that AEMO can place scheduling obligations on units to – for example – participate in central dispatch, where it is deemed necessary for reasons including power system security.

For coupled production units using a single classification, bidding, constraints and dispatch will also be for a single DUID, and so the IC Flag and individual conformance will not generally be applicable.

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[9] https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements

Coupled production units will have multiple 'capacities', in the sense that there will be an overarching inverter capacity, but also capacities of each technology (e.g., wind, solar or battery capacity) behind the inverter. This multiplicity will require further consideration with respect to processes for forecasting, constraints and bidding. This consideration is required because the inverter capacity could be 'saturated' by the individual power flows from the energy resources behind that inverter.

Finally, participants with coupled production units under a single classification would still be able to provide FCAS if they wish to. As AEMO will not be forecasting any VRE which is registered under a scheduled BDU, the participant will be responsible to ensure that it only bids to be enabled for quantities which are physically achievable.

3.2.3 Forecasting for single semi-scheduled generating units

Forecasting arrangements for coupled production units participating as a semi-scheduled generating unit will need to be considered. As any battery capacity is likely to be relatively small (typically under 5 MW), batteries would not be accounted for in weather-based forecasts, but the forecasting models being trained from SCADA feeds would be expected to adjust for the battery profiles in addition to the VRE.[10]

It is also conceivable – but perhaps unlikely in practice – that multiple intermittent resources could be DC-coupled. Consequently, if a single semi-scheduled generating unit was to include more than one VRE source (e.g., wind and solar), then AEMO envisages that:

- Separate energy conversion models (ECMs) would be required for each VRE source, with systems changes being required to aggregate these into a single UIGF.
- Market portal changes would be required for information provision to the Projected Assessment of System Adequacy (PASA) and Pre-Dispatch processes. This is because, under these requirements currently, participants must provide *either* a number of turbines or a number of inverters which are available. Combined VRE under one DUID would require both to be provided.

AEMO is not aware of any industry intention to use a single semi-scheduled classification in respect of multiple coupled intermittent technologies (coupled wind and solar). To the extent that this understanding is correct, the cost of making these changes would not be justified. Therefore, AEMO's current position is that it will not facilitate the registration of a single semi-scheduled generating unit that includes more than one VRE source.

3.2.4 Application of constraints to hybrid systems

In operating the power system, AEMO applies various types of constraints, including to limit power flow on transmission lines and to ensure sufficient levels of services such as system strength, voltage support and inertia are available, in the right locations. Some of these constraints (e.g., system strength) require constraining specific units (Unit Level Constraint) to be dispatched up/down. Other constraints – such as thermal constraints on transmission lines – apply equally to power flow from any unit/technology in the same generating or integrated resource system (System Level Constraint).

When formulating and applying constraints with respect to scheduled or semi-scheduled units, the intent of the Rule is that AEMO will apply constraints to the net flow from the hybrid system, unless the constraint must be applied to a particular DUID. In the latter case, where a constraint is active, the IC Flag will be activated (set to a value of one) for that DUID, but remaining units in the hybrid without an active IC Flag may still use aggregate conformance. In other words, individual conformance will not be required due to a binding constraint which applies only to the net power flow from all relevant units, rather than from a particular unit.

[10] The magnitude of any forecast errors by not specifically forecasting the batteries is thought to be similar to what occurs (and is managed without major issues) in some connection points which are located far from the generating units, resulting in (unforecasted) losses of 1 – 2 MW. If batteries exceeding 5 MW were to be allowed in a single semi-scheduled classification, this assumption would need to be revisited.

4. System Operations

Under the Rule, updated and/or new power system operating procedures will be required particularly in order to provide instructions and guidelines regarding the application of aggregate conformance and the new Individual Conformance Flag for hybrid systems (see Section 3.2 and Appendix A2 for a description of these arrangements). Section A1 of this document also provides wider discussion of the scope of procedural change.

RTO control room tools will also be reviewed and updated to integrate BDUs, and hybrid and DC coupled systems. Reserve level declaration guidelines may be updated, to incorporate state-of-charge and energy limits of scheduled BDUs.

In operating the power system, AEMO will need to be able to apply directions to resources within hybrid systems. Where AEMO issues a direction for a scheduled resource in a hybrid integrated resource or generating system, the directed resource would be required to comply with that direction as if it were a stand-alone resource, i.e., it should not comply in aggregate only.

FCAS dispatch processes and trapezium calculations will be updated for BDUs, hybrid systems, and portfolios of small generating units/small BDUs. As discussed in Section 3.2, where a unit in a hybrid system is participating in FCAS markets and is using the aggregate conformance provisions, FCAS enablement will need to consider impacts on enablement availability from other units in the hybrid system.

AEMO will be able to support dual sets of ramp rates for scheduled BDUs – that is, one set of up/down ramp rates for the consumption side, and another set for the generation side. As scheduled BDUs could be dispatched to transition from charging to discharging within an interval, which would imply that two ramp rates apply, AEMO will implement functionality to ensure that both ramp rates are respected.

5. Forecasting and Operational Planning

5.1 Forecasting

Demand definitions used for planning (both operational and longer term) and scheduling processes will not include load from scheduled loads and scheduled BDUs. Effectively, therefore, forecasting arrangements will be unchanged, as scheduled load is not currently included in the Electricity Statement of Opportunities and PASA processes. However, forecasting of intermittent resources in coupled production units will need to consider both inverter capacity and intermittent capacity, as described below.

5.2 Operational Planning

AEMO undertakes and publishes several forecasting and operational planning studies – broadly referred to as a PASA – which consider different levels of details and time horizons.

While the IESS rule change does not significant direct changes to the various PASA studies, BDUs and hybrid/coupled systems will need to be integrated into PASA processes and systems. In addition, there will be other changes to PASA process through the ST PASA rule change and any future rule changes.

The MT PASA considers a three-year horizon. Participants will submit a daily PASA availability (for both consumption and generation) and weekly energy constraints (if relevant) in respect of their scheduled BDUs, as occurs for other energy constrained scheduled generating units or loads.

The ST PASA considers a three-week horizon. Participants will submit their available capacity for each 30-minute period and daily energy constraints (if relevant) in respect of their scheduled BDUs units.

AEMO also publishes a Pre-Dispatch PASA (PD PASA), which is run every 30-minutes and covers the periods from the currently dispatched interval, through to the end of the last trading day for which bid submission has closed. However, arrangements for the PD PASA may change under the Updating Short Term PASA rule change.

For coupled production units, where an intermittent resource has been classified as a scheduled BDU, the participant will need to forecast and otherwise incorporate the intermittent resource within the information provided to AEMO for the PASA processes. In other words, the participant will have to meet all the obligations which apply in respect of a scheduled BDU which does not contain intermittent capacity. In addition, AEMO will not produce an Unconstrained Intermittent Generation Forecast for that intermittent resource.

Forecasting of intermittent resource availability in coupled production units will also need to consider that multiple technologies share the same inverter capacity. For example, where VRE shares an inverter with a battery, the inverter capacity could be sized smaller than the maximum combined generation of the solar and battery on the DC side.

Beyond these changes to integrate BDUs, the Rule leaves considerations for energy limited resources to a future rule change. In future, AEMO will likely require improved visibility of a storage unit's state-of-charge to effectively include these units within operational planning processes which run close to real-time. However, this matter is not being progressed directly under the IESS work stream.

6. Settlements and Prudential Requirements

6.1 Non-Energy Cost Recovery

NECR covers costs that arise in respect of:

- Several services and regulatory mechanisms which ensure the secure and reliable delivery energy, e.g., costs of market ancillary services, network support and system restart ancillary services.
- Interventions and the application of the administered price cap.

Currently, these costs are recovered according to formulas based on participant category, which can provide an incentive to register in one category over another.

The Rule will change the framework for NECR. NECR will now be calculated on the share of gross measurements of consumed and sent-out energy, for all participant categories. These measurements will be recorded as data streams for Adjusted Consumed Energy (ACE) and Adjusted Sent Out Energy (ASOE).

To facilitate this change, NECR will be from so-called Cost Recovery Market Participants (CRMPs), with the following categories being defined as being CRMPs:

- Market Generators.
- Integrated Resource Providers.
- Market Customers.

Consumed and sent-out energy:

- Will be measured separately for all market participant categories.
- Will not be netted at the connection point (this currently occurs for units other than grid-scale batteries).

This approach will align NECR to a future service-based approach and will place all participants on an equal footing. However, this approach will apply where energy is produced and consumed onsite – e.g., if a solar production unit directly supplies a behind-the-meter load, then this *would* be netted.

The two new data streams – ACE and ASOE – will be available in May 2022 once global settlements is implemented. Remaining accumulation meters will continue be settled on net flows until they are replaced with smart meters. Table 5 summarises the current and updated NECR-related changes.

Table 5 Current and future non-energy cost recovery arrangements

Area	Recovery item	NER Reference	Current recovery arrangements	New recovery arrangements
Market Ancillary Services	Contingency raise	3.15.6A(f1)	MG and MSGA based on generated energy and small generated energy	CRMPs based on ASOE
	Contingency lower	3.15.6A(g1)	MCs based on consumed energy	CRMPs based on ACE
	Regulation	3.15.6A(i)	MGs, MSGAs and MCs with appropriate metering for contribution factors, and MCs for the residual on the basis of consumed energy	CRMPs with appropriate metering/SCADA for contribution factors, and other CRMPs for the residual
Non-Market Ancillary Services	Network support control ancillary services (NSCAS)	3.15.6A(c8) and 3.15.6A(c9)	MCs based on adjusted gross energy	CRMPs based on ACE
	System restart ancillary services (SRAS)	3.15.6A(d) and 3.15.6A(e)	Half from MGs (generated energy) and MSGAs (small generated energy), and half from MCs (consumed energy)	CRMPs based on ASOE (half) and based on ACE (half)
Interventions	Direction – energy	3.15.8(b)	MCs on adjusted gross energy	CRMPs based on ACE
	Direction – FCAS (applies to each FCAS services)	3.15.8(g)	MGs, MSGAs and MCs on generated energy, small generated energy and consumed energy	CRMPs based on ASOE and ACE
	Reliability and emergency reserve trader (RERT)	3.15.9(e)	MCs based on AGE, excluding their loads for which they submitted a dispatch bid	CRMPs which did not submit a dispatch bid, based on ACE
	Market suspension	3.15.8A(b)	MCs based on AGE	CRMPs based on ACE
Other	Administered price cap or administered floor price compensation	3.15.10(b)	MCs based on AGE	CRMPs based on ACE

6.1.1 Non-Energy Cost Recovery Examples

Table 6 demonstrates how ASOE and ACE are calculated and applied for various resource configurations. Under the new NECR arrangements, these costs will be recovered in proportion to each CRMP's contribution to consumed and sent-out energy. For example, for the contingency lower service, which is to be recovered on consumed energy, the total consumed energy is 20 "units" in Table 6. As the Retailer has a total consumed energy of 3 units, it would pay 15% of the Contingency Lower costs.

Table 6 Non-energy cost recovery examples

Responsible Participant	Retailer	Generator	Market Customer	IRP with stand-alone bidirectional unit	IRP as an Small Resource Aggregator	Retailed with child and parent connection point
Units/load description	3 retail loads (separate connection points)	Scheduled generating unit	Large industrial load with BTM solar	Battery (scheduled BDU)	Battery (small BDU) and solar (small GU)	Embedded network with parent and child connection points (parent CP) (child CP)
Gross import/Gross export	+5 -1 -2	+10	-5 (note that the load consumes 8 but BTM solar supplies 3)	-4	-1 +5	-7 (including -4 from the child CP)
Sent out energy (ME+)	5	10	0	0	5	0 0
Consumed energy (ME-)	-3	0	-5	-4	-1	-3 -4
Comments	Under current arrangements, consumed energy is -2 (i.e. negative and implying a payment for contingency lower)	10	Behind the meter flows *would* be netted	Unchanged from existing arrangements (but has a smaller share of total)	These flows are not netted	Subtractive metering would apply, so that although an import of 7 occurs at the parent CP, the import of 4 at the child CP reduces this at the parent CP

Importantly, subtractive metering will be used for parent/child connection points, so that the child energy is not charged at both the child and parent connection points (which would otherwise be double charging).

6.2 Prudential Calculations and Causer Pays

While the Rule does not introduce direct changes to prudential requirements, these will need to be updated to accommodate BDUs. Calculating Maximum Credit Limits (MCLs) is currently based on registration category, but would need to be based on classification for IRPs. Conceptually, the calculation for a storage participant will remain the same, as the MCL will consider load exposure less generation exposure.

Causer pays arrangements will not undergo material change under the Rule (other than accounting for the new categories/classifications).[11] While causer pays is (and will continue to be) assessed at the DUID level, the impacts on frequency (and hence causer pays payments) are able to be netted at a portfolio level. These arrangements will apply for separate DUIDs within a hybrid system, for example, so that causer pays charges are effectively assessed at the hybrid level.

6.3 Participant / Market Fees

It is proposed that AEMO's market fee determination be reviewed to ensure that it is consistent with the new model that reflects consumed and sent out energy, rather than participant category.

6.4 Unaccounted For Energy (UFE) allocation methodology

The retail settlements process provides a local area based UFE value for each settlement interval. This is currently allocated to each FRMP's distribution connected market loads associated with the local area, with a single allocation value (UFEA) determined by the FRMP's proportion of total load in the trading interval.

In this regard, under the Rule, the following formula in NER 3.15.5(c) will apply:

UFEA = UFE x (DME/ADMELA)

Where

DME is the DLF adjusted consumption energy of the FRMP assigned to the local area

ADMELA is the total of all DLF adjusted consumption energy of the FRMP assigned to the local area

These newly calculated values relate to all distribution connected market connection points (and not market load connection points as previously). This means that generators in the distribution system will now be attributed a proportion of UFE based on their auxiliary load. All consumption values are measured as gross consumption, not net consumption values.

AEMO's retail settlements processes will be updated to reflect these calculations.

[11] Separately there may be changes to Causer Pays through the Primary Frequency Response Incentive Arrangements Rule Change: https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements

7. Retail and Metering

7.1 Retail Access for IRPs

AEMO provides the Market, Settlements and Transfer Solution (MSATS) system, which is a retail data system that stores data for each NEM connection point. MSATS will need to incorporate IRPs, as they will be able to classify both retail load and small resource connection points. Therefore, new functionality will allow IRPs to be treated similarly to retailers. They should be able to be nominated as the Financially Responsible Market Participant (FRMP) for a connection point by a customer and have access to facilities such as:

- National Metering Identifier (NMI) standing data and visibility of roles associated with a NMI (e.g., roles such as meter data provider).
- NMI discovery.
- Metering and customer switching processes.
- Appointment of a metering co-ordinator.

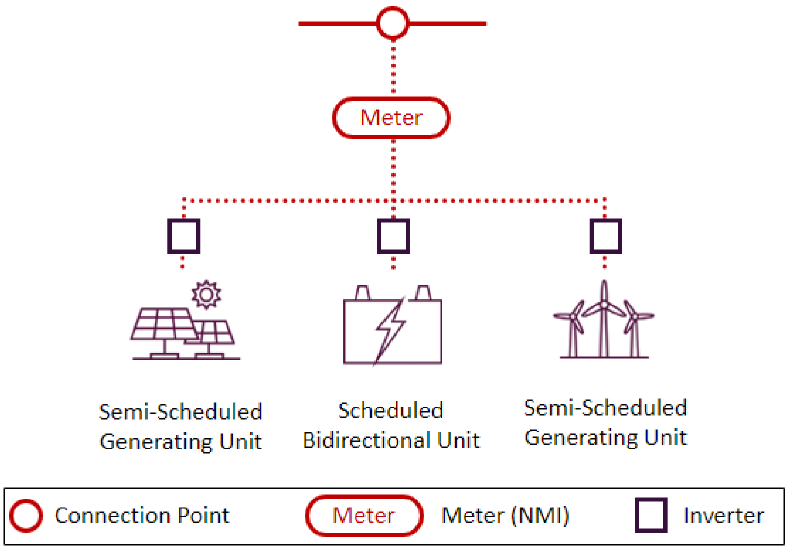
To incorporate SGAs into the IRP category, changes to NMI classification in the MSATS system may be made to identify NMIs that are small generating units/small BDUs at the point of initial classification. Currently, AEMO is reviewing the value of new NMI classification codes with industry through the Electricity Retail Consultative Forum (ERCF). Processes will similarly update for existing NMIs.

7.2 Metering and Telemetry

Existing NEM metering and telemetry obligations will apply to the new scheduled BDU classification. Scheduled BDUs will be required to have a SCADA connection and to provide data to AEMO and Network Service Providers. BDUs will have a single (bi-directional) NMI and Transmission Node Identifier (TNI), as opposed to current arrangements in which storage units have separate NMIs, as a consequence of them being classified as a scheduled generating unit and a scheduled load.

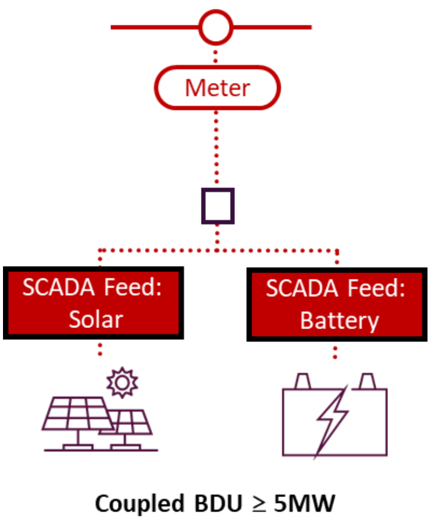
Hybrid systems would only have a single meter and NMI. It is not possible to apply separate loss factors for those units for the purposes of metering and settlement functions, as the energy flows are not distinguishable. To be clear, such a metering setup *would* allow for application of different MLFs to exports and imports (e.g., from a bidirectional unit), but not between export/import flows from two different technologies, e.g., where a battery and a solar could each be exporting.

Figure 6 Example of a hybrid system with a single Meter (NMI)



It is also important to clarify the expected SCADA requirements for systems with coupled production units. Each resource which participates in central dispatch will likely require a separate SCADA feed, even in coupled production units in which there is a single scheduled BDU which incorporates intermittent capacity. The purpose of this requirement would be to provide AEMO with appropriate situational awareness, rather than for specific forecasting purposes. This attribute is demonstrated in Figure 7, where the requirement could apply to a coupled production unit classified as a scheduled BDU, a semi-scheduled generating unit, or both a scheduled BDU and a semi-scheduled generating unit (Section 2.2 provides further information).

Figure 7 Separate SCADA feeds for each technology resource in a scheduled coupled production unit.



8. Implementation

8.1 Indicative Timelines

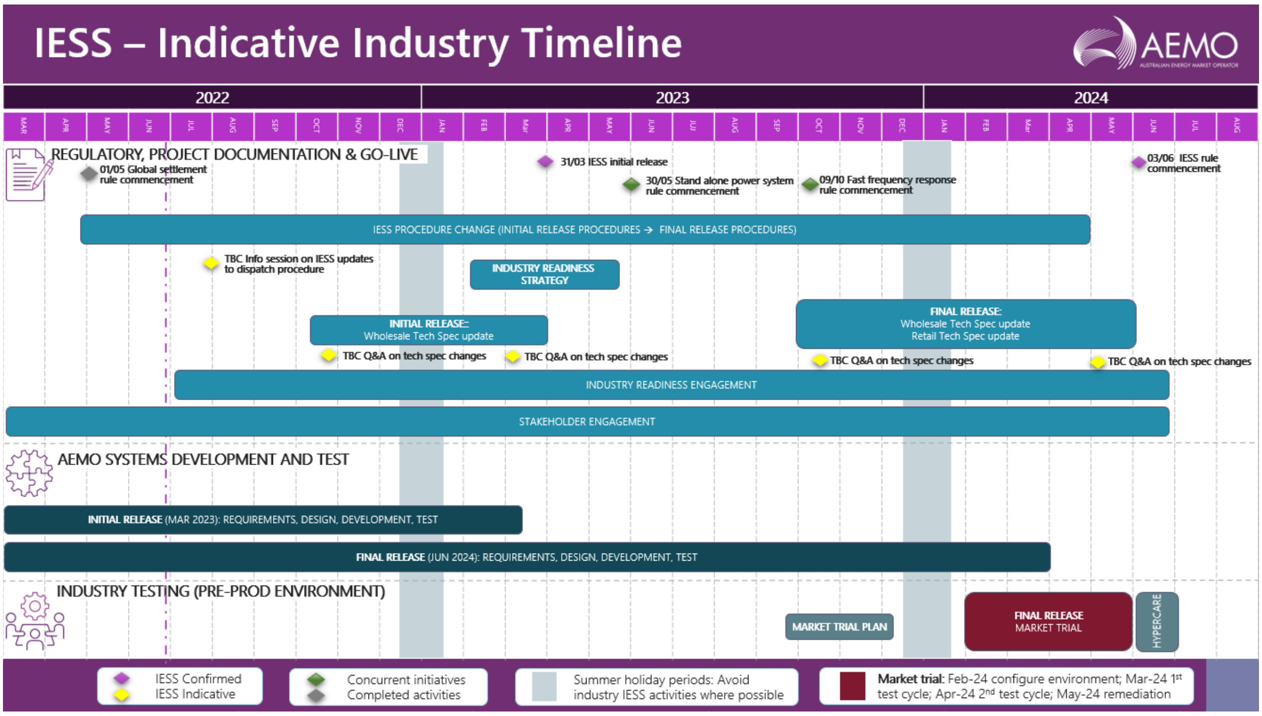
The implementation of the Rule will require significant changes to AEMO's market systems, business processes and procedures, including:

- Registration: Implementation of the IRP category and downstream systems integration.
- Dispatch and system operations: Facilitation of bidding under a single DUID for scheduled BDUs, and aggregate conformance arrangements for hybrid generating systems.
- Settlements and retail: Changes to settlement calculations, metering and retail systems as well as integration of the wider IESS reforms into settlement and prudential processes and systems.

A dependency of the metering solution was completion of the Global Settlements rule change with successful go-live in May 2022. This metering solution is a key input to the settlements changes that underpin the Rule implementation.

AEMO has commenced detailed planning for IESS implementation (Figure 8), which will occur over a 2.5-year period from publication of the Final Determination in December 2021. The delivery of the new arrangements will occur in two stages (Table 7) – being the initial release scheduled for 31 March 2023 and the final release scheduled for 3 June 2024, following the market trial.

Figure 8 IESS indicative implementation timeline



The initial release will deliver:

1. Aggregate conformance for hybrid systems.
2. Participation in FCAS markets for SGA portfolios.

The initial release will also develop the registration and dispatch aspects for AEMO's systems, but these will remain dormant until the final release, when they will be integrated with IESS changes for settlement and metering.

AEMO is also conducting an industry consultation process for affected procedures and other documents to achieve and align with the IESS implementation deadlines (Appendix A1).

Table 7 IESS Implementation - Key Dates

Activity	Date
Draft determination	16 September 2021
Final determination	2 December 2021
Initial release	31 March 2023
Market Trials	Q2 2024
Final release	3 June 2024

A1. Procedures and Documents

As the Rule makes significant revisions to registration and classification arrangements, as well as updates to terminology to have greater technology neutrality, there will be a significant volume of procedures, guidelines and other documents which require changes.

While a number of these documents will require only changes that are directly consequential to the Rule, the sheer number of those changes makes this a significant task nonetheless. In many cases, consultation on these changes will be required.

The following procedures and documents will be required as a result of the Rule:

- IRP registration, classification of BDUs and units in hybrid systems, including coupled production units - procedures, guides, fact sheets and application forms. A process for transfer of existing participants and reclassification for bidirectional units may also be needed.
- Bidding under single DUID for scheduled BDUs.
- Power system operating procedures for the application of aggregate conformance to hybrid units.

The existing documents which are expected to require material or consulted changes across AEMO business areas are shown in Table 8. Table 8 does not provide an exhaustive list, but instead aims to convey the scale of the changes which are required. There are likely to be up to 100 documents that require major and minor consultation, or at least industry awareness. These documents are listed in greater detail in the accompanying implementation straw-person to this HLD. The changes to these documents will be managed through the IESS Working Group's procedure stream.

Table 8 Scope of changes to procedures, guidelines and other documents

Area	Document(s)
Registration	Registration information resource and guidelines, including the Guide to generator exemption and classification of generating units Application forms, application and transfer guides, fact sheets and registration documents relating to the Generator, Customer, Demand Response Service Provider, Small Generation Aggregator and Trader categories
Metering and Retail	Retail Electricity Market Procedures – Glossary and Framework Metrology Procedure: Part A National Electricity Market Metrology Procedure: Part B Metering Data Validation, Substitution and Estimation Exemption Procedure MSATS Procedures: CATS Procedure Principles and Obligations Operating Procedure MSATS CATS History Model Operating Procedure MSATS – NMI Discovery Questions and Answers
B2B Procedures (IEC)	B2B Procedure Customer and Site Details Notification Process B2B Procedure Service Order Process B2B Guide
Settlement and Prudentials	NEM Settlements Estimation Guide

	Settlements Guide to Ancillary Service Payments and Recovery NEM Direction Compensation Recovery Credit Limit Procedures NEM Direction Compensation Recovery
Electricity Market Monitoring	Schedule of Constraint Violation Penalty Factors SO_OP_3705 Dispatch Pre-Dispatch Process Description Market Suspension Compensation Methodology SO_OP_3707 Procedures for issue of directions and clause 4.8.9 instructions SO_OP_3708 Non-market ancillary services
Systems Performance and Commercial	Market Ancillary Service Specification Forward Looking Loss Factor Calculation Methodology Regulation FCAS Contribution Factor Procedure Intervention Pricing Methodology FCAS Model in NEMDE SO_OP_3717 Procedure for the exercise of the reliability and emergency reserve trader
Operational Forecasting	SO_OP_3710 Power system operating procedures - load forecasting
Operational Planning	ST PASA Process Description SO_OP_3718 Outage Assessment SO_OP_3719 Procedure for submitting recall information of scheduled generator outages
Forecasting	MT PASA Process Description ESOO & Reliability Forecast Guidelines ISP Methodology
Network Development	Power System Model Guidelines Generator Performance Standards Template

A2. Hybrid and DC-coupled use cases

Table 9 (on hybrid systems) and Table 10 (on systems with coupled production units) outline the treatment of various hybrid and DC-coupled configurations, with respect to classification, constraints, dispatch, forecasting, conformance and participation in FCAS markets.

Table 9 Hybrid system use cases

#	Resources	Topic	Arrangements
1	30+ MW Solar (or wind) with 5+ MW Battery	Classification	Semi-scheduled generating unit (GU) and a scheduled bidirectional unit (BDU).
		Constraints	Aggregate conformance can occur in the absence of an individual binding constraint on either DUID. Individual constraints can be applied to each DUID when required (signified by setting the "Individual Conformance" (IC) flag[12] for a DUID in a dispatch interval).
		Dispatch and Forecasting	Solar: Receives a dispatch instruction comprising a MW target, an SDC flag and an IC Flag. If solar is in a binding constraint or its dispatch target is less than its UIGF then its semi-dispatch cap (SDC) will be set to one. Otherwise, the solar receives UIGF as dispatch target and the SDC is zero. Battery: Bids and receives a dispatch instruction comprising a MW target and a new IC flag.
		Aggregate Conformance	Aggregated conformance: Hybrid operator can vary each DUID's dispatch to meet the aggregated dispatch target when both DUIDs are marginally dispatched or to meet constraints that are applied in aggregate (other than constraints applied to a particular DUID – i.e., other than times the IC flag is applied). In other words, for each hybrid system and dispatch interval there will be a so-called "aggregate conformance set" of units for which aggregate conformance applies, with the units in this set potentially varying from interval to interval if AEMO requires particular units to comply individually. Aggregate Target or Aggregate Cap: If there is a binding solar-only or battery-only constraint, then the "Individual Conformance" flag for the relevant DUID(s) is set. Solar must cap at its dispatch target and the battery must meet its dispatch target. If there are no solar-only or battery-only binding constraints, then the "Individual Conformance" flag for both DUIDs is reset (not active) and the combined solar and battery output must meet their aggregated dispatch target. For solar, the SDC flag is then ignored.

[12] The Individual Conformance (IC) flag is a new flag, similar in use to the semi-dispatch cap flag in that it is sent out to applicable DUIDs as part of each dispatch instruction. When active, the DUID will be required to comply individually with its dispatch instruction for that interval, and it is not included in the aggregate compliance set for the hybrid system for which it is a part of.

#	Resources	Topic	Arrangements
		Real Time Operations	If the solar Individual Conformance Flag is active (e.g., system strength or network constraints), it cannot generate above its cap to offset load of the battery. AEMO could dispatch the battery if solar is constrained to zero (e.g., system strength), if they are registered separately and each have a DUID.
		FCAS	AEMO are developing arrangements for a DUID to provide FCAS while also participating in aggregated dispatch conformance. These proposed arrangements will be released in a separate issues paper, for stakeholder feedback. In respect of the battery, the participant has to manage SOC for FCAS offers.
2	Solar and wind (30+ MW combined) and 5+ MW battery	Classification	Two semi-scheduled GUs and a scheduled BDU.
		Constraints	As for #1. Battery, wind and solar can use the same constraint when aggregated conformance applies, e.g., W + S + B < X.
		Dispatch and Forecasting	As for #1. AEMO would require technology specific SCADA feeds to train/operate forecasting models.
		Aggregate Conformance	As for #1. Aggregate conformance will apply for all resources not on individual conformance, e.g., one resource might be on individual conformance, but others could still use aggregated conformance.
		Real Time Operations; FCAS	As for #1.
3	30+ MW synchronous unit with retrofitted 5+ MW battery	Classification	Scheduled GU and scheduled BDU.
		Constraints	Same as #1.
		Dispatch and Forecasting	Each unit bids and receives separate dispatch instructions, including their IC Flag.
		Aggregate Conformance	Could use aggregated conformance target if the system is a genuine hybrid (except when AEMO requires individual conformance). But if all units are scheduled, then existing aggregation rules apply.
		Real Time Operations	If needed, AEMO can manage constraints and dispatch of batteries/synchronous plant as for #1.
		FCAS	As for #1.
4	30+ MW synchronous unit, 30+ MW solar (or wind) and 5+ MW battery.	Classification	Scheduled GU, semi-scheduled GU and a scheduled BDU.
		Constraints; Dispatch and Forecasting; Aggregate Conformance; Real-Time Operations; FCAS	As for #1.
5	Scheduled load, 30+ MW solar (or wind) and 5+ MW battery	Classification	Scheduled load, semi-scheduled GU and a scheduled BDU.
		Constraints	As for #1. Load will be on LHS of constraints as it is scheduled.

#	Resources	Topic	Arrangements
		Dispatch and Forecasting	Load, battery and solar bid and receive separate dispatch instructions (like #1).
		Aggregate Conformance	As for #1 (including the load).
		Real Time Operations; FCAS	As for #1.
6	Uncontrollable load, 30+ MW solar (or wind) and 5+ MW battery	Classification	End user connection point, semi-scheduled GU and scheduled BDU. Note that it would not be possible to classify the connection point as a Wholesale Demand Response Unit, because it is a non-exempt integrated resource system that is scheduled, despite there being non-scheduled load at the connection point.
		Constraints	As for #1, but Load is included on RHS of constraint as it is "region load".
		Dispatch and Forecasting	As for #1 but load is non-scheduled.
		Aggregate Conformance	Aggregate conformance can apply to everything except the non-scheduled load.
		Real Time Operations	As for #5.
		FCAS	As for #1.
7	30+ MW solar, 30+ MW wind and a battery (< 5 MW)	Classification	Two semi-scheduled GUs and a non-scheduled battery.
		Constraints	As for #2, except that the battery will be on the RHS of constraints. For a battery < 5 MW, the NSP is responsible for system strength limit equations.
		Dispatch and Forecasting; Aggregate Conformance	As for #6.
		Real Time Operations	As for #5.
		FCAS	NA.

Table 10 DC-coupled system use cases

#	Use Case	Topic	Comments
8	DC-coupled solar and battery	Classification	Classification options: 1. Scheduled BDU

#	Use Case	Topic	Comments
	(Equivalently, wind instead of solar)		2. Semi-scheduled GU* 3. Multiple classifications: scheduled BDU and semi-scheduled GU. * There will be limitations on non-intermittent (e.g., storage etc) capacity in a semi-scheduled classification subject to AEMO policy
		Constraints	Constraints apply to the production system if it is classified under one DUID. If there are multiple DUIDs, arrangements for use case #1 in Table 9 apply. Using the same inverter means that solar and battery generation are the treated as being identical from a physics/power flow perspective (e.g., for system strength).
		Dispatch and Forecasting	Scheduled BDU Participate as a scheduled BDU – e.g., 20 bid bands, no UIGF, provide forecast as for scheduled unit (Availability). AEMO would require that the participant demonstrate it is capable of forecasting the solar and battery over the following seven days, and reflects these in its bids/rebids. Semi-scheduled GU Participate as for a (non-hybrid) semi-scheduled unit – will receive UIGF as dispatch instruction, and cannot charge battery from the grid. MW SCADA data used to train forecasting models will include activity of the battery. When the unit is constrained the forecast will be a weather-based forecast which will ignore the activity of the battery. When the unit is not constrained, the battery activity may impact the active power-based forecast (MW SCADA). Multiple classifications Battery with capacity equal to or greater than 5 MW is a scheduled BDU (20 bid bands and receives a dispatch instruction). Solar is semi-scheduled, receives dispatch instruction as for #1. If the battery capacity is less than 5 MW, it would be a non-scheduled BDU.
		Aggregate Conformance	Aggregate conformance applies as per #1 if there are multiple DUIDs. Not relevant for single DUID options.
		Real Time Operations	Real time management of plant will depend on classification choice. i.e., what procedures are relevant to that classification. Single DUID If the system is constrained for system strength, the solar and battery may generate and charge if the inverter does not exceed any constraints. Multiple DUIDs As per #1 in Table 9 if there are multiple DUIDs.
		FCAS	Similar to #1 in Table 9, though specific arrangements depend on classification choice. While this will be explored further, AEMO's envisages that FCAS can be provided under DUIDs which have met the prevailing requirements (as per the Market Ancillary Service Specification). To do so the participant would need to ensure it can provide the enabled amount, or it would be considered non-compliant.

#	Use Case	Topic	Comments
9	DC-coupled solar, wind and battery (Thresholds subject to AEMO policy)	Classification; Constraints; Aggregate Conformance; Real Time Operations; FCAS	As for #8.
		Dispatch and Forecasting;	Scheduled BDU As for #8. Semi-scheduled GU As for #8. Note that AEMO cannot currently combine AWEFS/ASEFS forecasts into single DUID forecast and to do so would require changes to systems. AEMO is seeking feedback on this issue (see Section 3.2.3). Multiple classifications As for #8. AEMO would require technology specific SCADA feeds to train/operate forecasting models.

A3. Non-energy costs in embedded networks

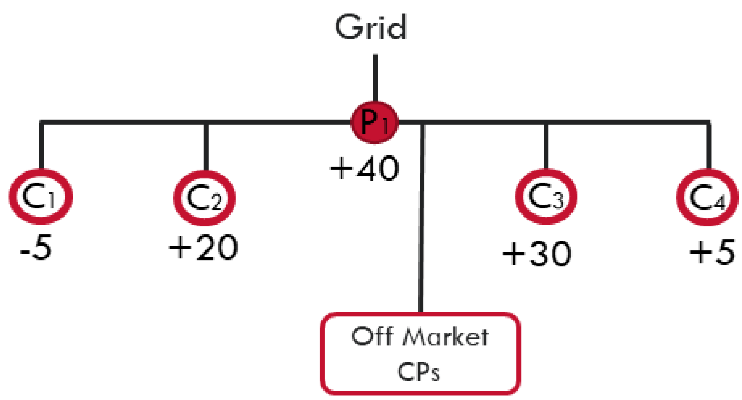
With the changes to NECR, it is important that design and implementation do not result in 'double-charging' in embedded networks, where the same energy flow may be recorded at both a parent NMI and a child NMI. To ensure that each unit of energy is accounted for once – and only once – when recovering non-energy costs, subtractive accounting will be used. The following example demonstrates outcomes in embedded networks.

Figure 9 enables the consideration of NECR in an embedded network. Figure 9 shows the meter read at each NMI, where a positive value denotes energy that is sent-out to the grid, and a negative value denotes energy which is being consumed from the grid. Figure 9 enables the consideration of recovery of contingency raise (on share of adjusted sent out energy, ASOE) and contingency lower (on share of adjusted consumed energy, ACE).

The relevant arrangements would be as follows:

- The FRMPs in respect of the C_2, C_3 and C_4 connection points will be charged for contingency raise costs on their share of the region's total ASOE, that is based on the +20, +30 and +5 data streams respectively. If the region's total sent out energy is +100, this would be 20%, 30% and 5% of the total amount to be recovered.
- The FRMPs in respect of the C_1 connection point will be charged for contingency lower costs on its share of the region's total ACE, that is the -5. If the region's total consumed energy is -100, this would be 5% of the total amount to be recovered.
- The FRMP in respect of the P_1 would be charged for these services after subtracting of the ACE and ASOE in respect of the four child connection points. That is, its meter read adjusted for this subtraction would be -10 (= +40 – (-5 +20 +30 + 5) = +40 - 50), which is the ACE due to its off-market CPs. This would result in a charge of 10% of the region's contingency lower costs.

Figure 9 Meter readings in an example embedded network.



Under these calculations, there is no netting of consumption and generation across NMIs – each of the FRMPs for the four child CPs is charged for NECR, as if it were connected directly to the grid. The FRMP for the parent connection point is also charged based on what its meter read would have been, if those child NMIs did not exist in the embedded network. In summary, there is no netting or double charging of energy, and there is no double counting of energy flows.

If – for example – the C_1 and C_4 CPs were in respect of the same FRMP, this FRMP would still be charged for recovery of both contingency raise and contingency lower on the +5 and -5 respectively, as netting across connection points (whether child or parent) will not occur.

A4. Abbreviations

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

Abbreviation	Term
ASL	Ancillary service load
ASU	Ancillary service unit
B2B	Business to business
B2M	Business to market (AEMO)
BDU	Bidirectional unit
BESS	Battery energy storage system
DC	Direct current
DUID	Dispatchable unit identifier
ECM	Energy conversion model
EMS	Energy management system
FCAS	Frequency control ancillary service
FRMP	Financially responsible market participant
IESS	Integrating energy storage systems
IRP	Integrated resource provider
IRS	Integrated resource system
MSATS	Metering settlement and transfer solution
MT PASA	Medium term projected assessment of system adequacy
NEM	National electricity market
NEMDE	NEM dispatch engine
NER	National electricity rules
PASA	Projected assessment of system adequacy
PMS	Portfolio management system
SCADA	Supervisory control and data acquisition
SGA	Small generation aggregator
SGU	Small generating unit
SOC	State of charge

Abbreviation	Term
SRA	Small resource aggregator
ST PASA	Short term projected assessment of system adequacy
UIGF	Unconstrained intermittent generation forecast
UFE	Unaccounted For Energy
VRE	Variable renewable energy