Integrating Energy Storage Systems

High Level Design

December 2021

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

Executive summary

Introduction

On 2 December 2021, the Australian Energy Market Commission (AEMC) made a Final Determination on the Integrating Energy Storage Systems (IESS) Rule change, seeking 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.

Beyond the improved integration of storage and hybrid resources, the Rule also takes a significant step toward a technology agnostic two-way market model for the NEM. These changes anticipate, and help prepare the NEM for, future steps being envisioned through the Energy Security Board's (ESB) Post-2025 Market Design work.

Objective

This high-level design (HLD) document outlines proposed arrangements for the implementation of the IESS rule change, aiming to achieve the following;

- Outline AEMO's system and operational changes, in order to allow for efficient planning and cost-minimisation of the IESS implementation body of work.
- Enable participants and other stakeholders to understand and plan for system, process and operational changes as required to implement the Rule Change.
- Provide an opportunity for feedback from industry on proposed arrangements for the implementation of the IESS rule change, while remaining compliant with the new Rule.

IESS Design

A new participant category – the Integrated Resource Provider (IRP) will be used by participants with bi-directional units (e.g. storage), but will also be able to classify generating units and load (scheduled and retail), thereby representing a universal participation option. This will be accompanied by a new unit type – the bidirectional unit (BDU). 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, with the Small Generation Aggregator (SGA) role being moved into the IRP category (SGA will no longer exist as a category, although the label Small Resource Aggregator (SRA) is used). SRA's 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 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 introduced, this being used for systems where multiple technology types (e.g. solar and a battery) share common equipment such as an inverter. Flexibility in classification of coupled production units will be provided for, 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. The same functionality as exists under the current two-DUID model will generally be available, that is scheduled

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

BDUs will be able to submit up to 20 energy bid bands (10 for load-side capacity, and 10 for 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), AEMO may still require conformance on an individual unit basis (not aggregated). Accordingly, a so-called Individual Compliance (IC) Flag will be included with the dispatch instruction sent to each DUID, and 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 and the IC Flag.

The Rule updates non-energy cost recovery (NECR) calculations, so that there is no dependency upon registration category for calculation of these payments, and so that there is no 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, but the Rule does not make significant changes in these areas.

Finally, the Rule also 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. This, along with the changes to participant categories and unit classifications will require significant changes to AEMO and NEM procedures and documents.

Implementation

Implementation of the changes under the IESS Rule will be delivered through a baseline and a final release.

- 31st March 2023: delivery of a 'baseline' release containing new registration and dispatch models. This release will give effect to any transitional rules.
- 3rd June 2024: delivery of a 'final' release containing the full implementation of the IESS rule change. AEMO estimates that 30 months is required for full implementation, including a market trial for a period of four months prior to go-live.

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1. Introduction

Background and Context

On 2 December 2021, the Australian Energy Market Commission (AEMC) made a Final Determination on the Integrating Energy Storage Systems (IESS) Rule change, making sweeping changes to registration and dispatch arrangements particularly for storage resources and hybrid systems. Changes and clarifications also apply to non-energy cost recovery (NECR) arrangements, performance standards for storage and hybrid systems, and finally to enhance participation options for small resources, including small batteries.

In sum, the Rule change does not just make significant changes to accommodate storage and hybrid systems, but represents a significant conceptual shift toward a technology agnostic trader-services model[2]. These changes anticipate, and help prepare the National Electricity Market (NEM) for, future steps being contemplated through the Energy Security Board's (ESB) Post-2025 Market Design work.

Purpose of this Document

This document presents a high-level design of the IESS Final Rule arrangements, aiming to;

- Outline the Australian Energy Market Operator's (AEMO) system and operational changes, in order to allow for efficient planning and cost-minimisation of the IESS implementation body of work.
- Enable participants and other stakeholders to understand and plan for system, process and operational changes required due to the Rule change.
- Provide an opportunity for input from industry on how some aspects of the IESS changes should be planned and progressed (while remaining compliant with the new Rule).

Document Outline

This document is structured as follows:

- Registration and Participation arrangements are presented in Section 2, including a new and overarching participant category – the Integrated Resource Provider (IRP) and a new resource type – the Bidirectional Unit (BDU). This section also considers classification of hybrid and DC-coupled systems and arrangements by which small generating units and storage may access Frequency Control Ancillary Service (FCAS) markets.
- Bidding and dispatch arrangements for both grid-scale storage and hybrid systems (including access to aggregate conformance) are presented in Section 30.
- 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 Non-Energy Cost Recovery calculations – are discussed in Section 60.
- Retail and Metering-related changes are discussed in Section 70.
- Implementation of the new arrangements (under Baseline and Final releases) is presented Section 80.

The following Appendices are also included:

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

[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.

2. Registration and Classification

2.1 New Integrated Resource Provider Category

The Integrated Resource Provider (IRP) is a new participant category introduced by the IESS rule change, which will be able to take on a range of roles that are currently separated. While a primary driver of this category is to facilitate the inclusion of bi-directional resources (such as batteries and other forms of storage), this participant 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). Hence, 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.

As a result of the introduction of the IRP participant category, participants with grid-scale storage resources will no longer need to register in two categories – i.e., rather than being both a Generator and a Market Customer, they will (be required to) participate as an IRP. Scheduled storage resources will then be able to be bid and dispatched under a single DUID. To do so, a new resource type will be used, called a bidirectional unit (BDU); bidding and dispatch arrangements for scheduled BDUs are described in Section 0.

Existing participants with resources which fit the bidirectional unit requirements will be required to transition into the IRP category, and in most cases, re-classify their units using the BDU unit type – e.g., grid scale batteries will be classified as scheduled BDUs, rather than a scheduled generating unit and a scheduled load. However, 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, as occurs currently.

Table 1 indicates the range of classification options available to an Integrated Resource Provider, and also provides examples of how each classification could be used.

Another new unit type is the small bi-directional unit (Small BDU), which can be used for small storage resources, and which will accompany the existing small generating unit term. However, the existing Small Generation Aggregator (SGA) category will not exist, and such participants will be transitioned into the new IRP category, using a label of Small Resource Aggregator. Note that with the exception of Small Generation Aggregators, existing participant categories will continue to exist much as they do currently.

As an IRP can classify several different unit types, they will need to ensure that it is appropriately accredited to participate in respect of those 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'.

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

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
		Classifications											
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

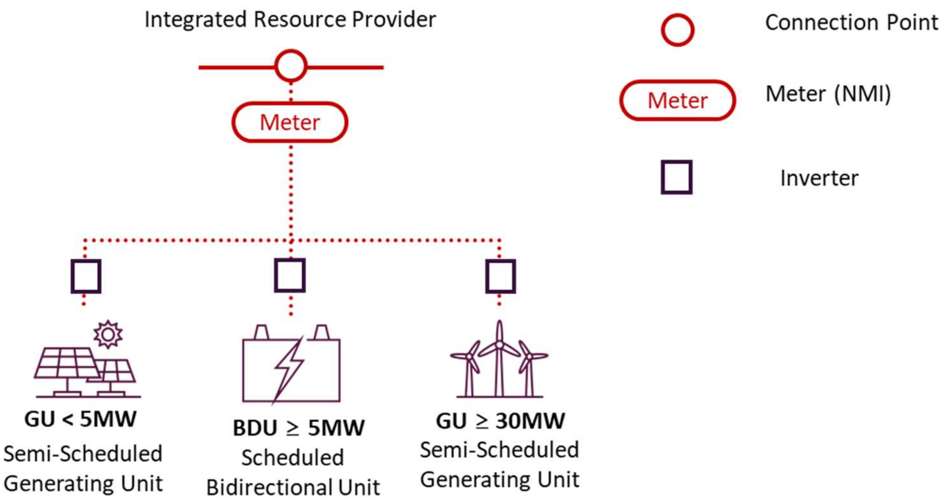
2.2 Hybrid and DC-Coupled Systems

Participants will be required to use the IRP category for hybrid integrated resource systems[4] comprised of multiple technology types behind a connection point. Figure 1 shows classification of generating and bi-directional units within an example hybrid integrated resource system, (there is no shared equipment such as inverters that would qualify the resources as a coupled production unit). Note that as the total capacity of the group of generating units (i.e., the wind and solar resources) exceeds 30 MW, the figure shows both the wind and the solar being classified as semi-scheduled generating units, despite the latter having a capacity of less than 5 MW.

The following broad arrangements will apply to hybrid systems (further detail is available in Section 3.2):

- 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). This means that classification will – in most cases – 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 bidirectional unit 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.
- Conformance with dispatch instructions could however 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 these form a hybrid system, and dispatch conformance would be 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 (see Section 3.2 for 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 modes, these being i) only the battery is operating, ii) only the solar farm is operating and iii) both the battery and the solar farm are operating.

Figure 1 Example of classification of units in a hybrid Integrated Resource System.



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

Further detail on participation and dispatch arrangements for hybrids is included in Section 3.2. DC-coupled systems are – like hybrid systems – 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, it will then not generally be necessary to differentiate between power flows from different resources behind the same inverter, and as such, greater flexibility in classifying such resources can be provided for. 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, and would be able to choose (subject to AEMO policy) to classify such a system as either being a single scheduled BDU (even including VRE) or a single semi-scheduled generating unit (subject to restrictions). Alternatively, it could also classify 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: Will participate in the same manner as stand-alone battery classified as a BDU – that is, the solar will not be able to access semi-scheduled provisions e.g., such as AEMO determining a Unconstrained Intermittent Generation Forecast (UIGF) and 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: 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 a (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. Hence individual conformance is likely to be required less frequently.

Finally, where the coupled production unit is below 5 MW in aggregate capacity, it could participate as a non-scheduled bidirectional unit, i.e., the unit would not participate in the central dispatch processes.

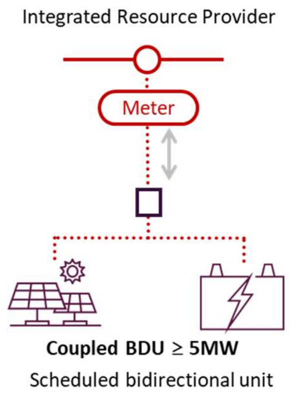
Table 2

Table 2 on the following page outlines classification and participation options for a solar-battery coupled production unit example. Note that forecasting, constraints, and other processes for coupled production units will need to take into account both the inverter capacity and the capacity of the individual technologies using the inverter.

Table 2 Classification of coupled production units.

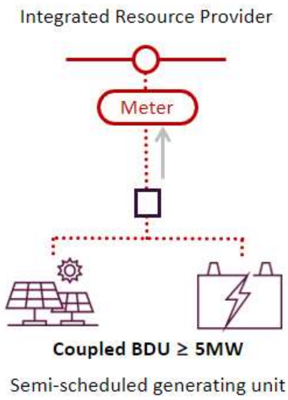
Scheduled bidirectional unit

For a coupled production unit with a capacity of 5 MW or larger, the participant may use a scheduled bidirectional unit 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, and 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, and the system will not be able to consume from the grid, other than for auxiliary load. AEMO will produce a UIGF for the system. Market Participants can optionally provide a UIGF self-forecast for use in dispatch.

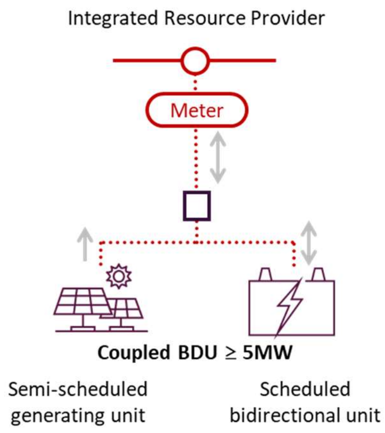


Scheduled bidirectional unit and semi-scheduled generating unit

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

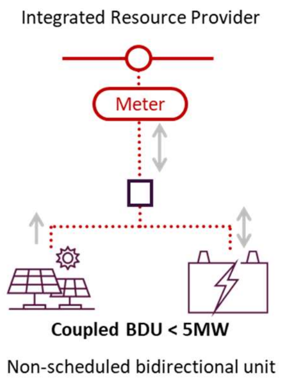
- a production-only bid with up to 10 bid bands in respect of the semi-scheduled generating unit, and
- a bidirectional bid with up to 20 bid bands in respect of the scheduled bidirectional unit.

The battery will be able to consume from the grid. AEMO will produce a UIGF for the semi-scheduled generating unit. Market Participants can optionally 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

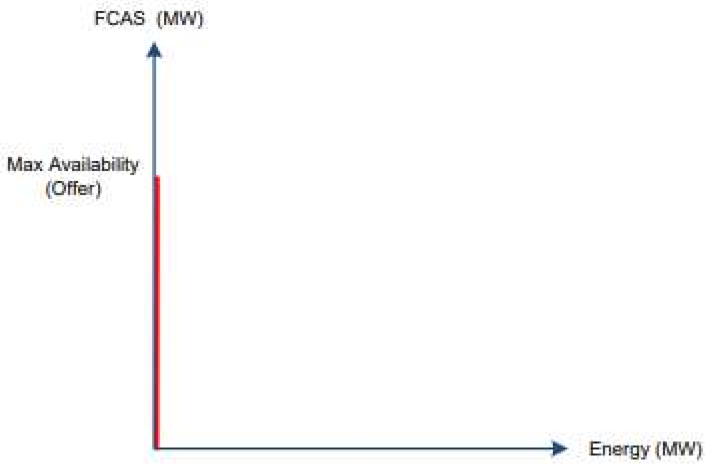
Under the new rule Small Resource Aggregators will – using the Integrated Resource Provider category – be able to participate in the FCAS markets with a portfolio of small generating units and/or small bidirectional units. To do so, they will classify the plant at their small resource connection point as an ancillary service unit, subject to meeting the requirements in the Market Ancillary Service Specification (MASS) and the NER in respect of the services they will provide.

Note that in order to qualify to provide regulation FCAS, an ancillary service unit[5] 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 prohibit small resources from providing regulation FCAS, and the remainder of this Section 2.3Error! Reference source not found. pertains to contingency FCAS only.

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

As for 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 2(see AEMO's *FCAS Model in NEMDE* document[6]). Further, as NEMDE will not co-optimise energy and FCAS for these units, the participant will need to ensure that they are operated such that the enabled quantity of FCAS is available to be deployed.

Figure 2 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. Small Resource Aggregators with ancillary service units will not be required to install more sophisticated SCADA systems in order to provide these measurements. Instead, AEMO is exploring alternative systems or processes by which these measurements can be provided to AEMO while avoiding prohibitive barriers to entry for these small units. SGAs must still comply with the measurement requirements specified in the MASS.

Note that 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

[5] 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).

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

maximum enablement would be less than the full range, due to limitations on droop settings as discussed for scheduled bidirectional units in Section 3.1.3.

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

2.3.2 Transitional Arrangements

In addition, transitional rules will allow Market Small Generation Aggregators to participate in FCAS markets in respect of their small generating units. This will be implemented with the baseline release (31st March 2023). Compared with 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 Rules.

Under the interim arrangements and for the purposes of ancillary service load classification, Market Small Generation Aggregators 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, and – upon approval - 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 National Electricity Rules 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 effective date of the IESS rule, the participant would continue to be taken to be an Ancillary Service Provider, but will be registered as an IRP and not an SGA (this transition to an IRP will occur for all SGAs, regardless of whether they are an Ancillary Service Provider). Similarly, small generating unit connection points which are classified as an ancillary service load will also be taken 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 to use a new term - the ancillary service unit classification, an umbrella term which can be used by generating units, loads, bidirectional units, and plant, subject to meeting the MASS. Again, this is a more universal participation model that allows for a future two-sided market. All other aspects of the current arrangements will remain as they are (other than being consolidated).

The current 6 MW limit on aggregation of generating units as one semi-scheduled generating unit (current Rules clause 2.2.7())) 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 scheduled units (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 new Rule will require transition of participants in the following cases:

- Participants with existing grid-scale storage units will be required to transition to the new Integrated Resource Provider 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.
- The SGA participant category will no longer exist, existing SGAs will be transitioned to the Integrated Resource Provider category (with the label of Small Resource Aggregator).

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, and these participants will not incur additional fees, not need to demonstrate performance standard capability or need to re-negotiate performance standards.

AEMO will determine a process and timeframes through which the transitioned registration and classification arrangements will apply. There may be changes to participant bidding and dispatch systems required for scheduled BDUs, as discussed further in Section 3, and AEMO will work with participants to reduce the impact of these insofar as possible.

Seeking Feedback

AEMO is seeking feedback from affected participants on considerations that could facilitate the transition to the IRP category and bidirectional unit type.

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

In cases where, in the future, storage is retrofitted to an existing generating system, this will require review and possibly renegotiation of the generation performance standards and connection agreements due to the change in physical resources within the system.

3. Dispatch

3.1 Bidding and Dispatch of Scheduled Bidirectional Units

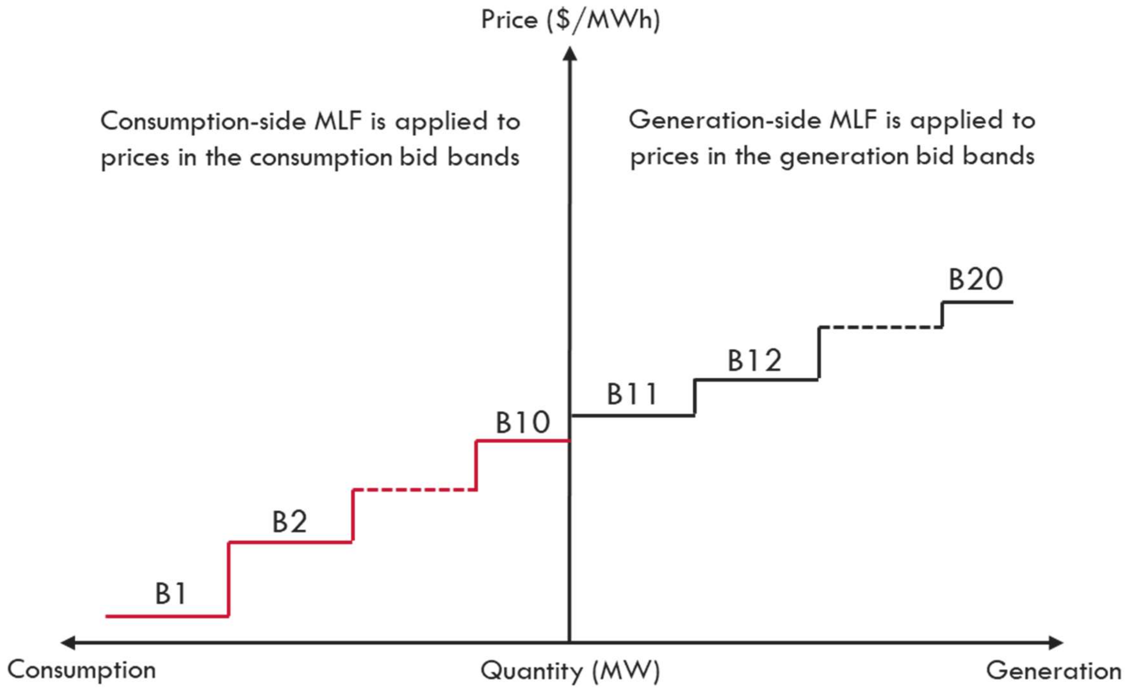
The introduction of the bidirectional unit classification will enable storage units to submit a single bid, and to receive a single dispatch instruction, in comparison with current arrangements where bidding and dispatch is in respect of a scheduled generating unit and a scheduled load. This will also apply to bidding for FCAS services, 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.

Note that hybrid systems with multiple units will bid and be dispatched separately for each unit, with more detail in Section 3.2. 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 3Figure 3). 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, while recognising certain attributes of BDUs, as described in the remainder of this section.

Figure 3 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, and 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 on). 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), and this is acceptable as long as these bands do not both have non-zero quantities in any particular 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. As long as 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

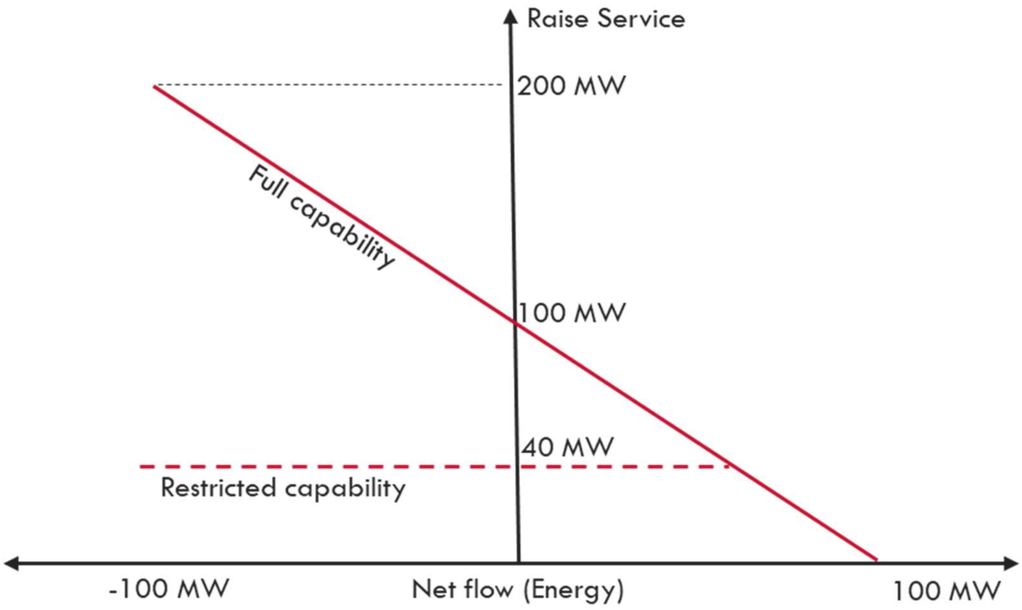
Bidding for FCAS in respect of a scheduled BDU that is an ancillary service unit will allow for up to 10 bid bands for each service – the same as for other ancillary service units. As FCAS enablement is in a positive direction only, there is no bidirectional nature to these products, and treatment of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

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. In order 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 4 for a raise service.

Figure 4 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 it the raise service was to be fully deployed, it would move from consuming at 10 MW, to producing 30 MW).

These restrictions will only need to be applied to contingency services, as deployment of contingency services is decentralised in nature (i.e., units independently measure frequency and deploy the service). 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 will also apply 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, that is an up ramp rate and a down ramp rate for both the generation and the consumption side of the BDU, or 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 their bidding and dispatch systems to accommodate this change. As described in Section 0, AEMO will run a market trial to facilitate this. As part of consultation on this document, AEMO is also seeking feedback from participants in order to understand the likely scale and drivers of costs incurred in updating their bidding and dispatch systems.

Seeking Feedback

For participants which will be required to update bidding and dispatch systems in order to use the new dispatch arrangements for scheduled bidirectional units, AEMO is seeking to understand the changes required by participants

3.2 Dispatch of Hybrid and DC-Coupled Systems

Under the Rule Change, 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 in order to firm the output of VRE resources. This section provides an overview of how the arrangements will be applied. Appendix A2 also describes a range of different hybrid and DC-coupled 'use cases'.

Note that the ability to use aggregate conformance will be made available in the baseline 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 conformance will be available and performance standards will be defined at the unit level, but will be measured at the connection point.

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.

The mechanics of aggregate conformance will be as follows. Each scheduled resource in a hybrid system will be dispatched separately, and will receive a so-called Individual Compliance Flag (IC Flag), as part of the dispatch instruction. This flag may be active or inactive. When active for a DUID, that DUID will be required to conform individually. AEMO will typically 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.

The UIGF and Semi-Dispatch Cap (SDC) arrangements will still apply to semi-scheduled generating units in hybrid systems. Where the SDC Flag is set, semi-scheduled generating units are capped at their dispatch target, but can use aggregate conformance for that cap, subject to the IC Flag.

Conformance could be with a dispatch target or a dispatch cap, and this will depend on 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 (e.g., if the SDC Flags are active). However, if a scheduled unit is included in the aggregated set, conformance is always with a target. In general, a unit must bid and be dispatched in order to be included in aggregate conformance. However, non-scheduled production will be taken into account – 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 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 take into account 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 available headroom for the battery under aggregate conformance.

Aggregate conformance itself will not materially impact causer pays arrangements. Under the IESS Rule Change, frequency impacts will continue to be determined at the DUID level, but currently causer pays effectively allows for netting of these impacts. However, it should be noted that these arrangements may change under the separate Primary Frequency Response Incentive Arrangements Rule Change.[7]

For hybrid systems, there will also be a need to consider the application of MLFs for different technologies, (as well differentiating between flow direction for BDUs). Different technologies behind a single connection point may typically produce or consume energy at different times of day or under different system conditions, and as such it would be appropriate to allow for application of technology-specific MLFs. AEMO will be able to do so in dispatch, but where multiple units use a single meter, an aggregate MLF will need to be used for metering and settlement functions, as it will not be possible to differentiate flows from each technology (see Section 0 for further discussion).

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, and units in these systems are formally termed coupled production units. These are a relatively novel configuration for the NEM, and while this section describes AEMO's view of how such systems will be treated, it is expected that 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.

- For 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. They will need to meet other requirements for scheduled BDUs, for example:
    - to provide (and demonstrate the ability to provide) seven-day forecasts of availability,
    - to bid and re-bid according to those forecasts
    - to conform with dispatch targets.

  These requirements will apply even if intermittent generation is included in the scheduled unit.
- For 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.
- For 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. Note that non-intermittent capacity (e.g., battery capacity) exceeding 5 MW would generally be required to be scheduled (not included in a semi-scheduled or non-scheduled classification), though application for consideration of an exemption can be made. NER clauses 2.2.3(c) and 3.2.8(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 such as power system security.

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

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.

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 will require further consideration with respect to processes for forecasting, constraints and bidding. This is 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, it will be the participant's responsibility 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.[8]

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

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

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 is correct, the cost of making these changes would not be justified. However, AEMO is seeking to understand from industry whether there are participants intending to use such as classification, and whether there are significant benefits over using separate classifications for such a system.

Seeking Feedback

Does industry see value in being able to use a single semi-scheduled generating unit classification for more than one variable renewable energy resource type (e.g., wind, solar) that are a coupled production unit? If so, what are the advantages over using a separate semi-scheduled generating unit for each resource?

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") to be dispatched up/down. Other constraints – such as thermal

[8] 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.

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 change 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 compliance. 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.

4. System Operations

Under the IESS 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 Compliance 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 in order to integrate BDUs, and hybrid and DC coupled systems. Reserve level declaration guidelines may be updated, in order 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 bidirectional units, hybrid systems, and also for 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 take into account impacts on enablement availability from other units in the hybrid system.

AEMO will be able to support dual sets of ramp rates for scheduled bidirectional units, 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 bidirectional units. Effectively, this means that forecasting arrangements will be unchanged, as scheduled load is not currently included in the Electricity Statement of Opportunities and Projected Assessment of System Adequacy processes. However, forecasting of intermittent resources in coupled production units will need to take into account both inverter capacity and intermittent capacity, as described below.

5.2 Operational Planning

AEMO undertakes and publishes a number of forecasting and operational planning studies broadly referred to as a Projected Assessment of System Adequacy (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. It is important to note that 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, and is published monthly. 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 uses a three-week horizon and is published weekly. Participants will submit their available capacity for each 30-minute period and daily energy constraints (if relevant) in respect of their scheduled BDUs units.

Note that 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 “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, and 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 take into account that multiple technologies share the same inverter capacity. For example, where VRE shares an inverter with a battery, it may be that the inverter capacity is sized smaller than the maximum combined generation of the solar and battery on the DC side.

Beyond these changes to integrate bidirectional units, the Rule leaves considerations for energy limited resources to a future Rule Change. It is likely that AEMO may, in the future, require improved visibility of storage unit’s state-of-charge in order to effectively include these units within operational planning processes that run close to real-time. However, this is not being progressed directly under the IESS work stream.

6. Settlements and Prudential Requirements

6.1 Non-Energy Cost Recovery

Non-energy cost recovery covers costs that arise due to a number of 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, as well as due to 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 change will alter the framework for non-energy cost recovery, which will now be calculated on the share of gross measurements of consumed and sent-out energy, for all participants categories. These measurements will be recorded as data streams for Adjusted Consumed Energy (ACE) and Adjusted Sent Out Energy (ASOE).

To facilitate this change, recovery of non-energy costs 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, and will not be netted at the connection point (this currently occurs for units other than grid-scale batteries). This will align NECR with a future service-based approach, and put all participants on an equal footing. However, recovery will not include energy 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 on the following page summarises the current and updated non-energy cost recovery changes.

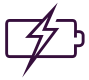
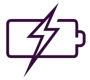
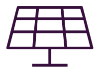
Table 5 Current and future non-energy cost recovery arrangements

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

Error! Reference source not found. 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.

Changes between existing and future NECR arrangements are primarily expected to impact Market Customers and SGAs, who have been able to net exported and imported energy. Note that batteries will have much the same arrangements, but may will likely have a smaller allocated share of the total non-energy costs, due to changes to other participants.

It is important to highlight that 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 change 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 off classification for IRPs. Conceptually, the calculation for a storage participant will remain the same, as the MCL will take into account load exposure less generation exposure.

Causer pays arrangements will not undergo material change under the Rule change (other than accounting for the new categories/classifications).[9] 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.

[9] 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 BDUs 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.

In order to incorporate SGAs into the IRP category changes to NMI classification in the MSATS system will be made to identify NMIs that are small generating units/small BDUs at the point of initial classification. Processes will similarly update existing NMIs.

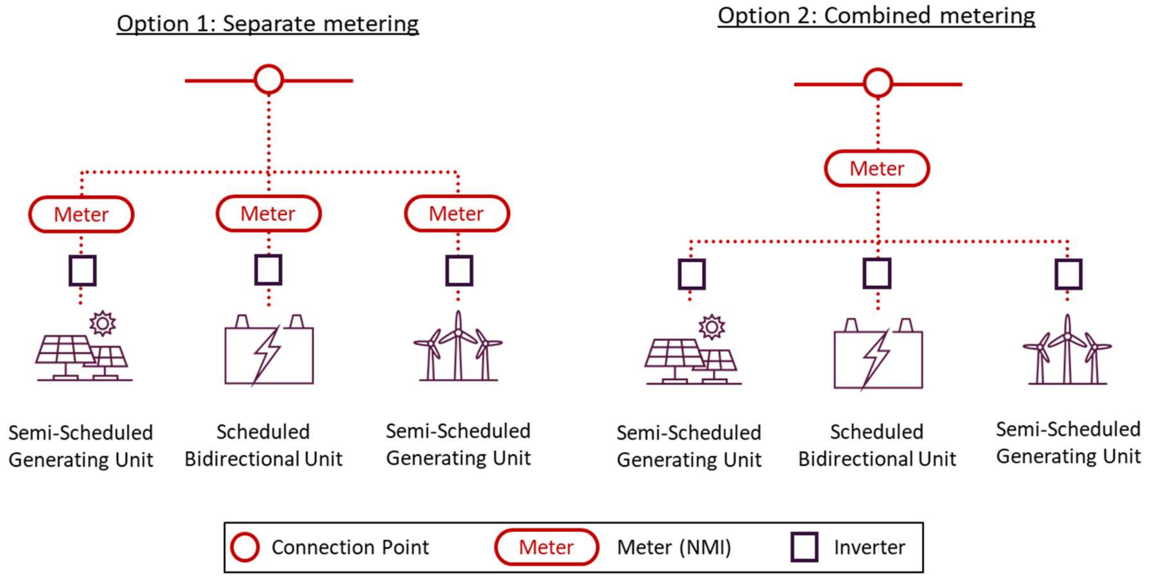
7.2 Metering and Telemetry

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. Bidirectional units will have a single (bi-directional) National Metering Identifier (NMI) and Transmission Node Identifier (TNII), as opposed to current arrangements in which storage units have separate NMIs due to being classified as a scheduled generating unit and a scheduled load.

Regarding hybrids, there will be flexibility in metering requirements to match physical infrastructure and the proponent's intent for the energy and services of the site to be traded separately or in aggregate. Figure 5Figure 5 indicates two possible metering options for a hybrid system, that is to either use a single meter for each unit, or to separately meter each unit.

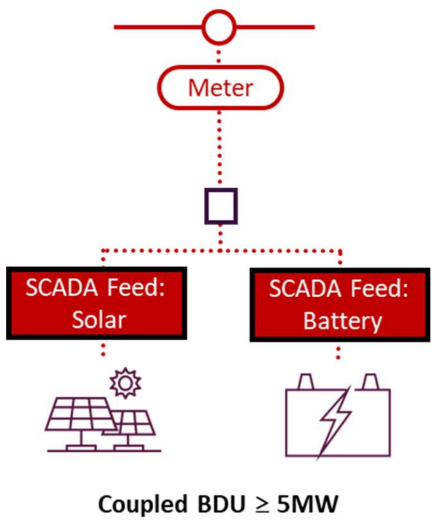
While both are acceptable, it should be noted that where a single meter is used in respect of multiple units, it will not be possible to apply separate loss factors for those units for the purposes of metering and settlement functions, as the energy flows will not be distinguishable. To be clear, such 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 5 Example metering and telemetry arrangements for hybrid systems.



It is also important to clarify 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 bidirectional unit 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 is demonstrated in Figure 6Figure 6, 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 (see also Section 2.2 and Table 2).

Figure 6 Separate SCADA feeds for each technology resource in a scheduled coupled production unit.



8. Implementation

8.1 Indicative Timelines

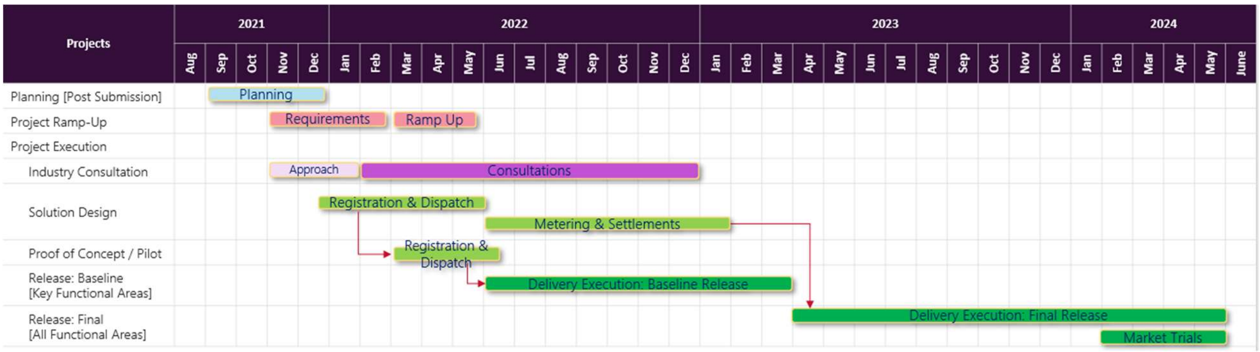
As evidenced through this HLD document, implementation of the IESS rule change will require amendments to large portions of market systems, business processes and procedures, including:

- 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 is completion of the Global Settlements rule change (go-live in May 2022), with the metering solution in turn being a key input to the settlements changes that underpin the Rule change implementation.

AEMO has commenced detailed planning for IESS implementation, which will occur over a 2.5-year period from publication of the Final Determination in December 2021 (Figure 7 and Table 7Table 7). Delivery of the new arrangements will occur in two stages, that is a baseline release scheduled for 31st March 2023, and a final release scheduled for 3rd June 2024, following a four-month market trial.

Figure 7 Indicative Implementation Timeline



The baseline release will deliver:

1. Aggregate conformance for hybrid systems
2. Participation in FCAS markets for Small Generation Aggregator portfolios.

The baseline release will also develop the Registration and Dispatch aspects, but these will remain dormant until the Final Release, when they will be integrated with Settlement and Metering aspects.

AEMO is also planning an industry consultation process regarding affected procedures and other documents to achieve and align with the projects implementation deadlines (see Appendix A1).

Table 7 IESS Implementation - Key Dates

Activity	Date
Draft determination	16 September 2021
Final determination	2 December 2021
Baseline Release	31st March 2023
Market Trials	February – May 2024
Final Release	3rd June 2024

A1. Procedures and Documents

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

While a number of these documents will only require changes that are directly consequential on the rule, the sheer number of those changes still makes this a significant task, and in many cases consultation on these changes will be required.

The following new procedures and documents will be required as a result of the rule change:

- IRP registration, classification of BDUs and units in hybrid systems, including coupled production units - procedures, guides, fact sheets and application forms. Procedures 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

Existing documents that are expected to require material or consulted changes across AEMO business areas are shown in Table 8. This table does not provide an exhaustive list but aims to convey the scale of change required.

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 9Table 9 (on hybrid systems) and Table 10Table 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[10] 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.

[10] The Individual Compliance (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.

		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	Aggregated conformance would hinder – but not preclude - provision of FCAS, because: • solar and battery headroom aren't interchangeable. • forecast errors need to be incorporated in the battery FCAS trapezium. I.e., availability for enablement is reduced.
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	FCAS availability could be assessed separately, but use most restrictive trapezium angle. Participant has to manage SOC for FCAS offers.
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 and #3.
5		Classification	Scheduled load, semi-scheduled GU and a scheduled BDU

	Scheduled load, 30+ MW solar (or wind) and 5+ MW battery	Constraints	As for #1. Load will be on LHS of constraints as it is scheduled.
		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 and #3. Constraining solar while accessing the load may be required.
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

	(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.
9		Classification; Constraints; Aggregate Conformance;	As for #8.

	DC-coupled solar, wind and battery (Thresholds subject to AEMO policy)	Real Time Operations; FCAS	
		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

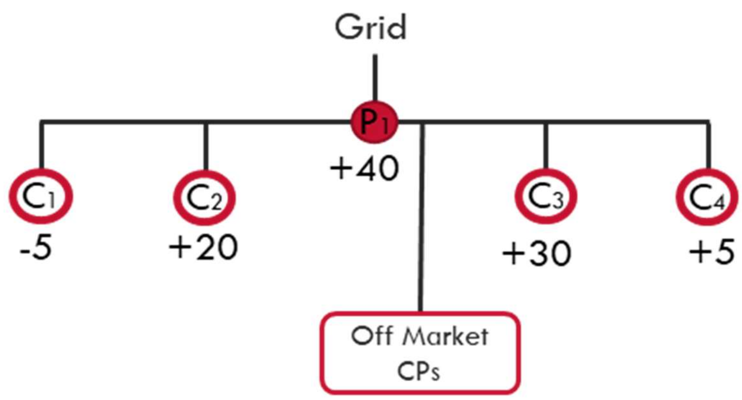
With the changes to non-energy cost recovery, it is important that design and implementation do not result in 'double-charging' in embedded network, where the same energy flow may be recorded at both a parent NMI, and a child NMI. To ensure that each unit of energy is accounted for once - and only once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

Consider recovery of non-energy costs in the embedded network shown in Figure 8. This figure 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. Consider recovery of contingency raise (on share of adjusted sent out energy, ASOE) and contingency lower (on share of adjusted consumed energy, ACE).

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 8 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 non-energy cost recovery 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.

Also note that 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.