SCHEDULING AND DISPATCH PROGRAMME

Overview of SDP Solution for Battery Units

20 December 2024

Glossary

APC	Active Power Control
ASU	Associated Supplier Unit
CHCC	Castlereagh House Control Centre (Belfast)
CLAF	Combined Loss Adjustment Factor
COD	Commercial Offer Data
DAM	Day Ahead Market
DASSA	Day Ahead System Services Auction
EDIL	Electronic Dispatch Instruction Logger
EMS	Energy Management System
FAQ	Firm Access Quantities
FASS	Future Arrangements for System Services
LTS	Long Term Scheduling
MEC	Maximum Export Capacity
MIC	Maximum Import Capacity
MMS	Market Management System
MO	Market Operator
MPI	Market Participant Interface
MW	Megawatt
NCC	National Control Centre (Dublin)
NIV	Net Imbalance Volume
PBOA	Bid Offer Acceptance Price
PMEA	Price of the Marginal Energy Action
PN	Physical Notification
QBOA	Bid Offer Acceptance Quantity
RA	Regulatory Authority
RTC	Real Time Commitment
RTD	Real Time Dispatch
SCADA	Supervisory Control and Data Acquisition
SDP	Scheduling and Dispatch Programme

SO	System Operator
TOD	Technical Offer Data
TSC	Trading and Settlement Code
TSO	Transmission System Operator
TSSU	Trading Site Supplier Unit

Executive Summary

The Scheduling and Dispatch Programme (SDP) aims to improve and enhance technology and capability of the scheduling and dispatch process in the control centres on the island of Ireland. One of the initiatives of the SDP is the integration of battery units into the balancing market, with the goal of significantly increasing the value and efficient utilisation of these units.

As the number of battery units has increased over recent years, with more continuing to connect to the power system, a solution was put in place by the TSOs to accommodate batteries as quickly as possible in advance of making the required system changes. Under these arrangements, batteries are registered and modelled as multi-fuel generator units. However, this solution presents many challenges and limitations on the use of battery units and their participation in energy markets.

Initiative 2 of the Scheduling and Dispatch Programme (SDP_02) offers solutions to many of the challenges and limitations of the current solution. Battery units will be able to participate more fully in the Ex-Ante markets and submit negative Physical Notifications (PNs). TSOs will have more visibility of a battery unit's state of charge. This information will help to determine whether Physical Notifications submitted by Participants are feasible. TSOs will be able to issue negative Dispatch Instructions (DIs) and the Instruction Profiler will be able to profile these and calculate Bid Offer Acceptance Quantities (QBOAs) in the negative range in both pricing and settlement.

Although Initiative 2 of the Scheduling and Dispatch Programme offers solutions to many of the challenges and limitations of the existing solution, it is recognised that it is not the complete solution and the TSOs are seeking to identify a longer term solution via the "enduring storage" initiative under the Balancing Market Reform element of the TSOs' Strategic Market Programme. The enduring solution will enable inclusion of Battery Units in scheduling and dispatch processes, in a manner that facilitates more efficient utility of these storage assets. Optimisation of storage units is not currently possible, and instead a "follow PN" approach will be adopted. This is outlined in further detail throughout the document.

Initiative 2 has been developed in consultation with Regulatory Authorities (RAs) and market participants. The TSC modification proposal was initially presented to the modifications committee in October 2023. Based on additional workshops, the original modification proposal was reviewed, and an updated proposal was drafted which was recommended for approval in December 2023. Following feedback from RAs and industry stakeholders, an updated proposal was resubmitted to

the modifications committee for consideration in April 2024 where it was voted to be recommended for approval.

This document gives an overview of the SDP solution and how it has been developed, including the TSOs' policy on the scheduling and dispatch of battery units following delivery of the Scheduling and Dispatch Programme. This is in addition to the Trading and Settlement Code modification Mod_02_24, which includes details of registration, data submission, pricing and settlement, but does not include details of scheduling and dispatch processes.

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1. Introduction

1.1. Background and Purpose of this Document

In support of Irish and Northern Irish Government renewables targets for the electricity sector, EirGrid, SONI and SEMO have undertaken to define and implement a set of initiatives to allow them to operate the system under conditions of 80% renewable electricity and 95+% system non-synchronous penetration (SNSP) on an instantaneous basis. A number of these initiatives relate to how the system is scheduled and dispatched, and in conjunction with related changes required to support compliance with the Clean Energy Package, have been grouped together into the Scheduling & Dispatch Programme (SDP).

Initiative 2 (SDP_02) within this programme encompasses battery integration. Its objective is to facilitate more effective use of batteries in scheduling and dispatch processes and systems. With increasing intermittent generation, energy storage is an ever-growing important source of flexibility and stability to the electrical system, while also providing system services capabilities in Ireland and Northern Ireland. The changes included in this initiative will allow market participants and the control centres to realise more value from battery units, and better align with their operating characteristics. The SDP solution will allow batteries to be included in registration, data submission, scheduling, dispatch, pricing, settlement and reporting in a more appropriate manner than currently, reflecting their unique characteristics and in particular their energy limited nature. Due to vendor's system limitations, it is not currently possible to fully optimise the use of battery units across a time period based on technical or commercial characteristics in scheduling processes. An enduring solution for battery units which is part of the TSOs' Strategic Market Programme will provide a more efficient utility from battery units in the future.

The purpose of this document is to describe the process around how the changes were designed, with industry, and the TSOs' policy for operation of battery units following delivery of the Scheduling and Dispatch Programme. This is in addition to the Trading and Settlement Code modification Mod_02_24, which includes details of registration, data submission, pricing and settlement, but does not include details of scheduling and dispatch processes. A concise version of this document will be made available in advance of SDP Tranche 1 go-live.

1.2. What is the "problem" that the SDP_02 solution/Mod_02_24 is intending to address

One of the key queries from the RAs with respect to Mod_02_24 was with respect to the "problem" to be solved being unclear. This is summarised in Table 1 below:

#	Summary	Description
1	Current systems do not support batteries	Full functionality for "Battery Storage Units" was not delivered as part of the I-SEM Programme. In particular, this means: • Batteries cannot submit negative Physical Notifications (PNs). • TSOs cannot schedule battery units appropriately in both the charging and discharging ranges. • TSOs cannot issue negative Dispatch Instructions (DIs). • TSO Operational Scheduling tools have no visibility of state of charge. • Batteries cannot declare Minimum Output (i.e. availability to charge). • Bid Offer Acceptance Quantities (QBOAs) cannot be calculated in negative range, cannot be settled correctly.
2	Value from batteries cannot be realised	The TSOs and Participants are not currently realising maximum value from battery resources. Market participation will continue to be limited by the points discussed in point #1. e.g. the inability to register as a Battery Storage Unit, submit negative Physical Notifications, schedule or dispatch in the charging range, and price and settle accordingly. Participation in and revenue from energy markets will continue to be limited for these units. This may have an impact on investment decisions which may affect the system's ability to reach renewables targets.
3	Operational experience requires change in approach for batteries	Operational experience has shown that Control Centre Engineers would benefit from new Commercial Offer Data fields (Operational Maximum and Minimum Storage Quantity) which will be delivered as part of SDP_02. This will give information on whether Physical Notifications submitted by Participants are feasible with respect to the unit's state of charge, and as a result whether it is possible to schedule and dispatch the unit to those Physical Notifications.
4	Batteries should not be treated like Pumped Storage Units (TSC)	At present in the TSC (not utilised), the treatment of Battery Storage Units while charging is the same as the treatment of Pumped Storage Units while pumping. Battery units, while charging, are subject to a different form of the Imbalance Charge to other generator units, contrary to EU regulatory requirements for Balance Responsible Parties. A change to the application of the Imbalance Charge was

#	Summary	Description
		identified as necessary in SEM-21-017 (EirGrid and SONI Analysis of SEM Compliance with Commission Regulation (EU) 2017/2195 of 23 November 2017 Establishing a Guideline on Electricity Balancing) in order to comply with the EU's Clean Energy Package (CEP), Energy Balancing Guidelines (EBGL), and Imbalance Settlement Harmonisation Proposal methodology (ISHP). Battery units are also exempt from Uninstructed Imbalance charge while charging. This treatment was put in place in settlement because Pumped Storage Units cannot control the level to which they consume power when dispatched to pump. This is not a feature of Battery Storage Units and so once market systems have the capability to issue negative Dispatch Instructions, this treatment will no longer be appropriate for Battery Storage Units.
5	TSC logic for Instruction Profiling is incomplete (if treated as Pumped Storage Units)	If battery units were treated as Pumped Storage Units, then Appendix O would not describe the desired Dispatch Instruction and Instruction Profiling logic which would allow battery units to be dispatched to specific MW levels in their charging range and priced and settled accordingly. The existing logic does not allow for ramp rates to be applied below zero as these units would be subject to GOOP instructions which involve ramping instantaneously to the unit's full storage capacity when instructed to pump. If battery units were treated as Pumped Storage Units, instruction profiling would inappropriately result in instantaneous ramping below zero, to a fixed pumping load rather than to the target charging instruction level.
6	Various other aspects of current settlement treatment for batteries is not appropriate	Non-firm volumes: Pumped Storage Units not being allowed to register under a Trading Site is a legacy SEM rule which was not changed with the transition to ISEM. The intention of Pumped Storage Units (and Battery Storage Units) was to settle the units metering on the generator and not a supplier. Consequently, Pumped Storage Units were restricted from registering under a Trading Site to ensure the metering was recorded on the generator. As battery units have a possibility of having non-firm volumes, they are required to be assigned to a Trading Site to enable for these volumes to be calculated as the volumes are calculated at a Trading Site level. Therefore, battery units must be removed from the exception which applied to Pumped Storage Units regarding Trading Sites and are therefore required to register battery units to a Trading Site, as per other generators. Testing Charge: A change to the Testing Charge is required to handle negative meter quantities. Without this, the Testing

#	Summary	Description
		Charge would be a payment to participants when the battery unit is importing. The Testing Charge should always be applied as a charge rather than a payment to participants.

Table 1: Elements of the "problem"

SDP_02 is seeking to significantly mitigate the “problem” (via the solution set out in the Modification and the design discussed extensively with industry and RAs) and the TSOs are seeking to identify a longer term solution via the “enduring solution for ESPS” initiative under the Balancing Market Reform element of the TSOs’ Strategic Markets Programme.

1.3. What principles are relevant to a solution

The proposed Modification (and associated design) are based on the following key principles:

- **Battery Units will generally follow ex-ante price signals**
  - expectation that batteries will follow ex ante price signals and will trade to charge/discharge appropriately via the ex ante markets.
  - This will drive a more efficient outcome in the ex-ante markets
- **Instance of discharge PNs at times of high wind/solar will be rare**
  - Based on following ex-ante price signals, this is a realistic assumption.
  - “Follow PN” encourages units to pursue a profit making position in the ex-ante auctions and thus should drive efficient, and more intuitive, behaviour by participants
- **Imperfections charges will be reduced**
  - Battery units following ex-ante signal and entering intuitive PNs will reduce the need for the TSO to redispatch these units.
  - A selection bias will result where the battery will offer demand when demand is needed & supply when supply is short, thus reducing the need for the TSO to redispatch these units and thus should reduce imperfections charges
- **PNs must be feasible**
  - Per all other Generator Units, PNs for battery units must be feasible (which for Battery Units will include the effect of state of charge based on its dispatch instructions)
- **“Follow PN” in scheduling provides transparency**
  - Recognising the principle above with respect to ex-ante trading and the vendor’s system limitations regarding “optimisation” of battery units, Operational Scheduling Runs will (in general) assume “follow PN” for battery units while respecting system security. The Control Centre may dispatch away from PNs where necessary (e.g., frequency events, system alerts, infeasible PNs)
- **“Follow PN” is not absolute (TSOs continue to make all dispatch decisions)**

    - Battery units must continue to only change output on receipt of dispatch instructions from the control centre.
    - If a battery unit has non-zero PNs, the Control Centre Engineer will dispatch the unit to those PNs so far as is reasonably practicable while respecting system security.
    - On rare occasions, e.g. frequency events or system alerts the control centre may need to dispatch these units away from PNs.
    - Control Centres will not be forced to accept and dispatch to a set of PNs that is infeasible before any action by the TSO (e.g. if a battery unit declares a PN to discharge, without charging first).
- **TSOs will minimise deviation from ex-ante results (PNs)**
    - As per the Balancing Market Principles Statement, the scheduling process objective is to minimise the cost of diverging from Participants' Physical Notifications (PNs).
- **Maintains integrity of Operational Scheduling timings**
    - Any changes to the scheduling optimisations can have serious implications for the time to produce Operational Scheduling solutions. In this context, any solution must be able to produce solutions at times that are consistent with the process timings for RTD, RTC and LTS Operational Scheduling Runs.

2. SDP Approach

2.1. History of Industry Engagement

The first industry workshop for the Scheduling and Dispatch Programme was held on 16th November 2022. During this workshop, the TSOs and SEMO introduced the programme to market participants and covered the high-level scope of the initiatives under the SDP, including initiative 2. Several bilateral engagements took place in advance of these monthly workshops to help inform the scope of Initiative 2.

The Scheduling and Dispatch Programme then progressed into the detailed design phase, and beginning in September 2023 monthly workshops were held to provide updates on design and delivery, and answer queries from participants.

Based on an initial proposed market design, the first battery TSC modification proposal was presented to the modifications committee on the 19th October 2023. At this meeting participants requested more time to consider the proposal, and as a result the modification was presented for discussion only. Two additional workshops to discuss the proposed modification were held by the TSOs on the 8th November 2023 and the 15th November 2023.

Based on feedback received in these sessions, the original modification proposal was reviewed, and an updated proposal was drafted. The amended modification proposal was brought back to the

modifications committee for a vote on the 5th December 2023, where it was voted to be recommended for approval.

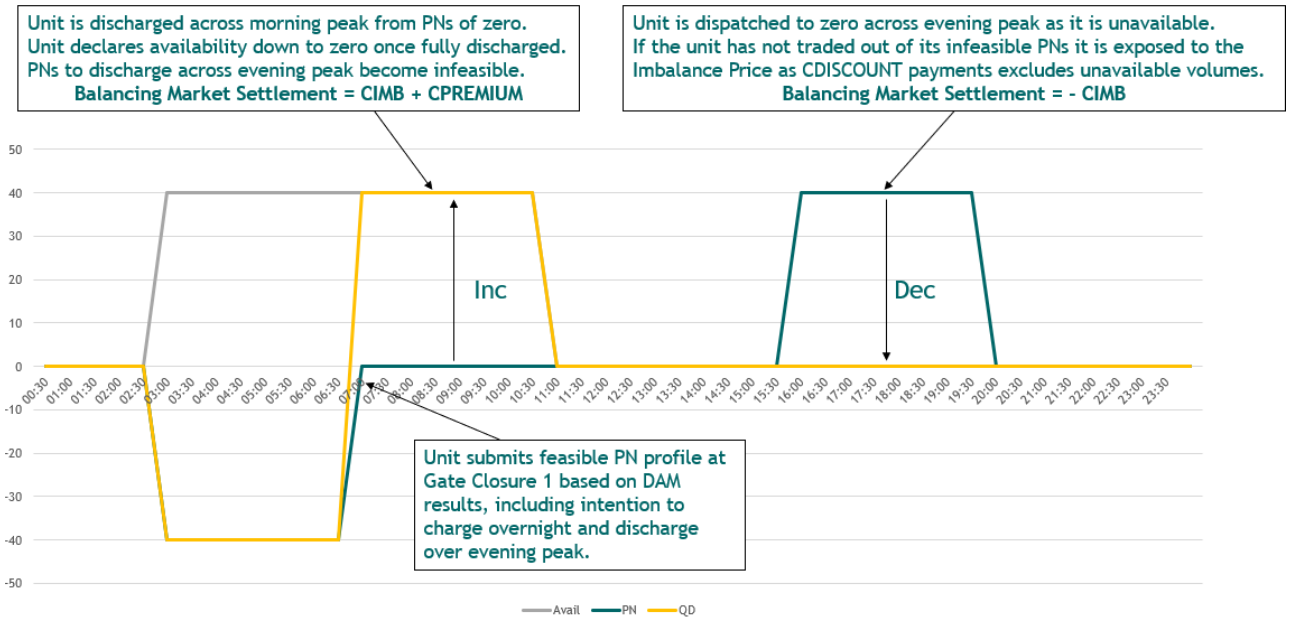
Following the December modifications committee meeting, the Regulatory Authorities (RAs) received a Final Recommendation Report in support of the modification. The RAs expressed concerns to the TSOs on the content of the proposed modification and requested that changes be made. On 5th April 2024, an additional session was held with industry stakeholders and RAs to discuss the RAs' suggestions. An updated proposal was resubmitted to the modifications committee for consideration at the April 23rd meeting where it was voted to be recommended for approval.

2.1.1. Initial Proposal (October 2023)

As mentioned above, system limitations do not allow for the optimisation of battery units in the scheduling processes, meaning that the operational scheduling processes cannot determine the optimal time to charge and discharge the units across a time period based on commercial data, technical data and system needs. For this reason, it was proposed early in the Scheduling and Dispatch Programme that battery units would be scheduled to "follow PN", i.e. scheduled to a fixed profile based on their submitted PNs.

Under the initial proposal for the operation of battery units to be implemented under the Scheduling and Dispatch Programme, battery units would have the option to participate in ex-ante markets similarly to other units and would be required to submit Physical Notifications that are reflective of that ex-ante position and are technically feasible. The TSOs would schedule the unit to follow those PNs and would economically dispatch battery units away from their PN based on their position in merit order lists (based on Simple COD) independent of future PN profile and associated state of charge. Any dispatch away from PNs could make PNs already submitted for later in the day infeasible due to the unit's state of charge being changed by dispatch decisions. Participants would be expected to trade out of any market position which has become infeasible in ex-ante markets and submit updated PNs to reflect their new, feasible market position and may need to declare unavailable if fully discharged. If a battery unit fails to trade out of their infeasible position, they are at risk of an imbalance which would be settled at the Imbalance Price.

This initial proposal would allow for full, price-based balancing market participation of batteries. An example of this proposal is given in the diagram below:



1

Market participants expressed a number of concerns with this proposal and advised that they could not support it at the TSC modifications committee. These concerns included the lack of liquidity in intra-day markets limiting their ability to update their market position, inability to trade out of a position in a trading period for which gate closure 2 has passed, exposure to risk that they cannot control (risk of imbalance due to TSO actions), and the highly manual trading process that would be required. Participants also highlighted the principle outlined in the TSC that "Physical Notification Data shall be equal to the Output intended by the Participant for each of its Generator Units, excluding Accepted Offers and Accepted Bids during each Imbalance Settlement Period, γ." This was interpreted to mean that PNs submitted by participants should not be required to account for actions already taken by the TSOs.

In addition, the Regulatory Authorities (RAs) raised concerns (as referenced in Appendix A) that Participants might price these risks into their Simple bids, potentially leading to higher market payments, which could increase overall market costs.

2.1.2. Updated Proposal (December 2023)

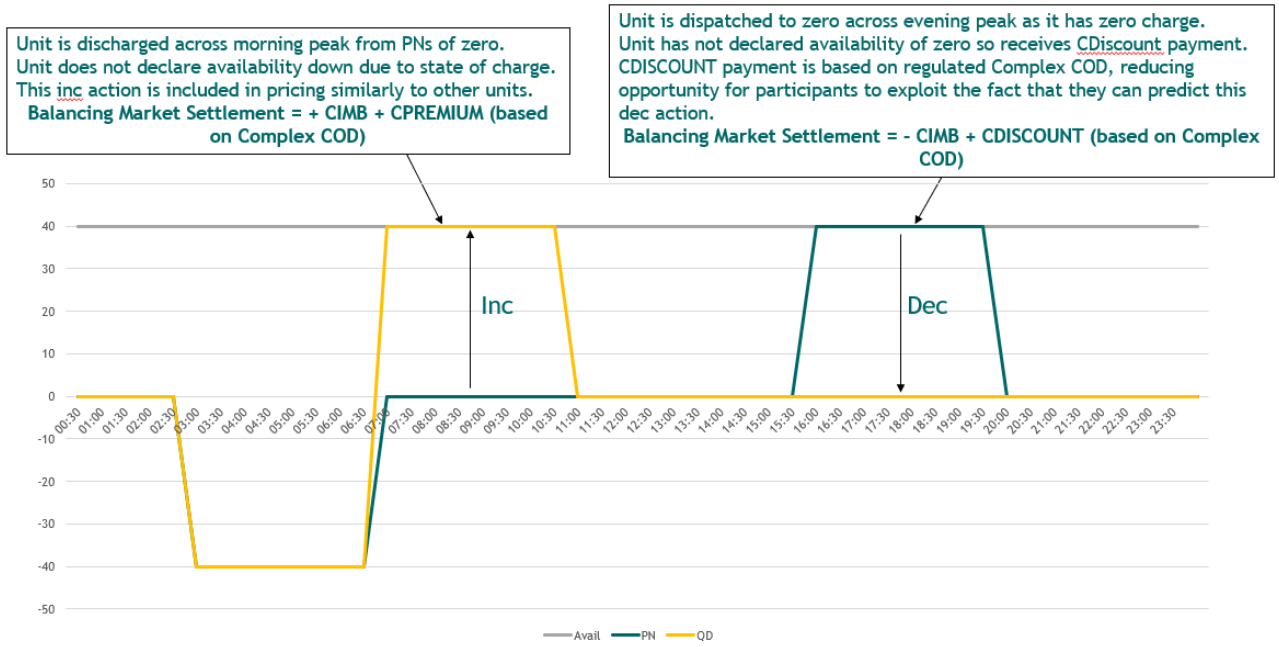
Following discussions with market participants, an updated proposal was developed. Under this updated proposal the TSOs would dispatch battery units to follow PNs as far as is reasonably possible. Units may be moved away from PNs in certain cases, e.g. during system alerts or to maximise priority dispatch generation, but would not be dispatched away from PNs based on merit order alone.

[1] Avail = Availability
QD = Dispatch Quantity
PN = Physical Notification

Participants would not be expected to trade out of PN positions which have become infeasible due to earlier TSO actions, and would not be required to declare down their MW availability in EDIL in those cases. TSOs would still dispatch these units to an output level that they can achieve based on their state of charge, i.e. won't dispatch to PNs which have become infeasible, but dispatch away from those infeasible PNs would be settled as if fully available, i.e. at the better of the Imbalance Price and COD price.

Furthermore, in this proposal, Simple prices could be submitted and contribute to the formation of the Imbalance Price (as per other units), so that if an action taken to move a battery away from PNs is the marginal energy action the Imbalance Price will accurately reflect that. Settlement would use Complex prices only for all actions on these units. This is to reflect the fact that actions taken on these units would likely be for non-energy reasons under this proposal and would not be market-based. It would serve to protect the market from large CDISCOUNT or CPREMIUM payments based on unregulated Simple prices where the TSO has no choice but to take the action to dispatch away from infeasible PNs.

The amended approach would remove the risk to participants of imbalances caused by TSO actions, participants will be at least made whole in the balancing market[2]. The cost to the market is minimised by limiting the occurrences of dispatch away from PNs, limiting payments to Complex prices, and removing the need for participants to price their risk into their bids and offers. An example of this proposal is given in the diagram below:



[2] Participants will receive corresponding incs & decs at, whichever is preferential, their complex price or the imbalance price. The assumption here is that complex incs & decs will, roughly, balance and thus participants will be made whole to their ex-ante revenue.

The RAs raised concerns in relation to this proposal, suggesting that because these units would always be settled using Complex prices, it would not be appropriate for them to submit Simple prices, as this could distort Imbalance Price formation.

2.1.3. Final Proposal (April 2024)

In response to the updated proposal described above, the RAs proposed a change whereby battery participants would be prevented from submitting Simple COD. Following discussions with industry stakeholders, it was agreed that battery units would be permitted to submit both Simple and Complex COD, however all actions on these units would be System Operator (SO) flagged. This would mean that these actions would initially be flagged out of pricing (although could be Net Imbalance Volume (NIV) tagged back in if the volume is required to make up the NIV) as per the existing process, and would always be settled using Complex COD. This would allow batteries to participate in Imbalance Price formation in an appropriate manner while minimising risk to the market.

This approach associated with the TSC modification was voted to be recommended for approval at the modifications committee on the 5th April 2024.

2.2. Registration

Unlike under the current arrangements where battery units are registered as multi-fuel generators, under the SDP solution battery units will be registered as generator units with 'Battery Storage' as a fuel type. This will allow TSO systems to model battery units more accurately.

Registration data fields and requirements are as per generator units, with certain additional fields specific to battery units. Similarly to pumped storage units, battery units will have a registered minimum and maximum storage quantity in MWh[3], as described currently in the TSC.

Furthermore, battery units will be required to register as part of a trading site like other generator units. Currently under the TSC battery units are prohibited from registering as part of a trading site. This restriction was included to mirror the treatment of pumped storage units. However, because battery units are currently registered as multi-fuel generator units they are registered as part of a trading site. Under the proposed TSC modification Mod_02_24, the exception for battery units would be removed, meaning that these units would be required to register as part of a trading site with a Trading Site Supplier Unit (TSSU) or Associated Supplier Unit (ASU). This proposed change is to allow non-firm values to be settled appropriately for these units[4].

[3] Maximum Storage Quantity (MWh) is a registration TOD field representing "the maximum quantity of Generation that can be produced by the Battery Storage Unit", or the installed storage capacity of the unit.

[4] Non-firm quantities are calculated dynamically on a trading site basis, and so if a unit is not registered as part of a trading site, no non-firm quantities will be calculated regardless of the firm access quantity assigned under a connection agreement

2.3. Balancing Capacity Procurement (DASSA)

One concern expressed by the RAs when reviewing the Mod_02_24 Final Recommendation Report was whether “follow PN” would mean that battery units would be “locked in” to their PNs in the balancing timeframe and would therefore not be providing reserve and not be getting paid system services revenues for reserves, ramping margin, etc.

The TSOs have clarified that this concern is unfounded and does not reflect the FASS / Mod_02_24 design. The justification is summarised as follows:

1. The future Day Ahead System Services Auction (DASSA) arrangements, scheduled to go live in December 2026, are concerned with the procurement of Balancing Capacity only, whereas Mod_02_24 relates to Balancing Energy. The TSOs’ Operational Scheduling processes are seeking to minimise the cost of Balancing Energy (deviation from PNs) subject to several constraints (including ensuring that reserve needs are met but not including any results from DASSA or Balancing Capacity procurement costs).
2. The DASSA will run at the day-ahead stage (at 15:30), after the first LTS Operational Scheduling Run for the target Trading Day, but before the LTS results are published.
3. The DASSA will award DASSA Orders to Services Providers for each System Service and Trading Period in the target Trading Day.
4. A DASSA Order holder will have a commitment obligation to be available to provide the System Service for the applicable Trading Period.
5. A DASSA Order’s commitment obligation is tied to a Service Provider’s submitted FPN.
6. Secondary trading, including the facilitation of bilateral trading, of DASSA Orders will commence once the DASSA results are published and will end at Gate Closure 2 for the respective Trading Period.
7. At Gate Closure 2, Physical Notifications are “locked in” and Service Providers must have submitted compatible FPNs corresponding to their DASSA Orders (or will otherwise be subject to DASSA Compensation Payments to be payable to the TSOs).
8. Scheduling processes will not utilise DASSA results; they will continue to be based on FPNs, COD, TOD, etc. Scheduling process optimise energy costs (based on submitted COD) subject to all constraints, of which calculated reserve requirements are part.
9. TSO dispatch will not utilise DASSA results; reserve needs will be met via TSO issuing dispatch instructions (utilising indicative operational schedules) as decision support.
10. Units providing Balancing Capacity in real-time may not correspond with those with DASSA Orders resulting from the DASSA.
11. DASSA settlement will calculate payments[5]:

[5] Discussion regarding the FAM or an alternative ex-post top-up mechanism is ongoing.

a. Payments to DASSA Order holders, based primarily on DASSA Orders and DASSA Clearing Price (unless Availablity Scalars or Performance Scalars apply).
b. Compensation Payments to the TSOs (reflecting if FPNs are compatible with DASSA Orders).

The majority of the DASSA arrangements will treat battery units in the same manner as all other units. However, the expectation of "follow PN" may mean that battery units may enter the DASSA and secondary/bilateral trading with some confidence in its FPN and can bid for DASSA volume (for a reserve service for now) that is compatible with the unit's feasible FPN. It is worth noting that DASSA arrangements described in this section are not finalised and elements of the design are subject to change.

2.4. Ex-ante Markets

The proposed SDP approach has no impact on the technical ability of battery units to participate in the ex-ante markets (the day-ahead and intraday markets operated by SEMOpx), primarily as the ex-ante markets have few technology specific requirements (including to account for ex-ante trading being permitted for participants with no assets). In general, any unit which is registered to trade in those markets can do so for sell trades (e.g. generating energy) or buy trades (e.g. charging energy), so long as they have the required commercial requirements in place (e.g. sufficient levels of credit etc.). Therefore, batteries can trade in the ex-ante markets today for both charging and discharging. However, the proposed SDP approach should encourage increased participation by battery units in the ex-ante markets, as it will allow them to represent both buy positions (charging) and sell positions (discharging) in their PNs.

Mod_02_24 has been designed based on the expectation that batteries will follow ex-ante price signals & thus it is expected that battery units will establish an ex-ante position to charge during times of surplus renewables, when likely prices will be low, and establish a position to discharge during times of low supply of renewables, thus selling when prices are high. This will have the dual benefits of reducing dispatch down during times of high wind and low demand & driving more efficient behaviour in the ex-ante markets. This more efficient, price signal following, behaviour is expected to provide the additional benefit of reducing imperfections charges as there will a natural (price driven) selection bias driving participants behaviour.

2.5. Balancing Market Bidding and Data Submission

2.5.1. Physical Notifications (PNs)

Battery unit participants will be able to submit positive and negative PNs as their intended output for each trading period.

In general, PN submissions should be considered like any other unit, as the FPNs should reflect the ex-ante traded position and must be physically feasible reflecting the unit's TOD and other technical characteristics. As part of this requirement, PNs should be feasible with respect to the unit's projected state of charge at the time of submission. The level to which submitted PNs reflect the physical position of each battery such as the state of charge will be monitored.

2.5.2. Commercial Offer Data (COD)

Market participants operating battery units will be required to submit COD as per the TSC. This must include at least default Complex COD and may also include more frequently updated Complex COD and Simple COD. In addition to the requirements for generators there will be some additional fields and requirements applicable to battery units only.

Price quantity pairs should be submitted to cover the full range of operation for these units, charging and discharging.

As set out in the TSC currently, start-up and no-load costs must be submitted as zero for battery units. This is to reflect the fact that these units will be always on except when on outage and can move between zero and non-zero output without the need to start up or shut down.

Forecast Availability and forecast Minimum Output profiles should represent the unit's expected availability to operate, i.e. should be submitted as non-zero values representing discharging and charging capacities respectively when the unit is not on outage. Availability should contain values greater than or equal to zero and Minimum Output should contain values less than or equal to zero. If discharging or charging capacity is expected to be temporarily reduced or zero for any reason this should be reflected in forecast profiles.

Forecast minimum stable generation profiles should be submitted as zero for all time periods. This reflects the fact that when a battery unit is synchronised it is instantly available to dispatch to charge or discharge, there is no minimum output level below which it cannot be dispatched.

Battery units may also choose to submit values for two new data elements as follows:

- Operational Minimum Storage Quantity (MWh)
- Operational Maximum Storage Quantity (MWh)

These two new fields are additional to the existing registration fields which define storage limits for battery units. The new fields will give participants the opportunity to let the control centre know if the unit's storage capacity is narrowed for any reason on a given day, and are only used by the control centres to perform feasibility checks on PNs (and are not used for scheduling, pricing or settlement processes). A warning message will be provided to the control centres if PNs submitted by a participant for a battery unit cause the unit's storage level to fall outside of these operational limits. These fields are included under COD rather than TOD so that they can be updated daily and within day. If not submitted, these fields will default to the registered minimum and maximum storage quantity values.

2.5.3. Bidding Code of Practice (BCOP)

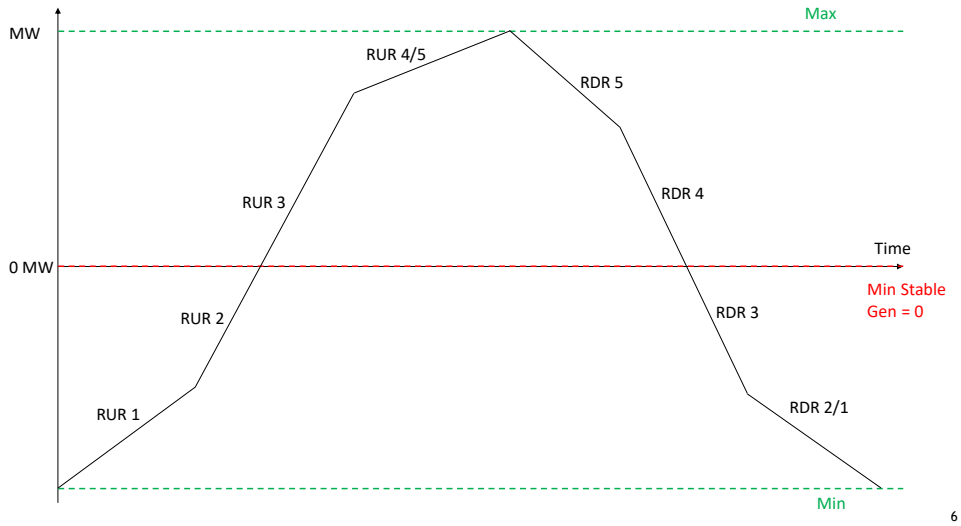
The Bidding Code of Practice (BCOP) (eventually to be replaced by the Balancing Market Principles Code of Practice (BMPCOP)), contains requirements around cost-based bidding principles. The BCOP applies to all generator units in the balancing market as a generator unit licence condition. All such units must submit Complex COD meeting these principles, including price quantity pairs, start-up costs and no-load costs. Ex-ante trades and Simple COD are not bound by BCOP/BMPCOP.

2.5.4. Technical Offer Data (TOD)

Market Participants operating battery units will have to submit at least one Technical Offer Data (TOD) set. TOD for battery units will consist of the same fields as generator units, with the addition of a Storage Cycle Efficiency field.

Ramp rates should cover the battery unit's full output range, charging and discharging. Minimum Stable Generation will be mandated to be submitted as zero, and as a result loading and de-loading characteristics (which only apply between zero and the Minimum Stable Generation value) will not apply.

A sample TOD profile for battery units is shown below:



[6]

The Battery Storage Capacity field has been proposed to be removed from the TSC as part of Mod_02_24 as it exists only to allow for instruction profiling of GOOP PUMP dispatch instructions (mirroring pumped storage units), which will not be used for battery units.

2.6. Scheduling

Over recent years, the dispatch of battery units has evolved as outlined in the Balancing Market Principles Statement to allow for dispatch to positive quantities for the reasons listed below:

- Per the System Alert Procedure
- To restore system frequency

[6] RUR = Ramp Up Rate
RDR = Ramp Down Rate

- To positive PNs where practically feasible
- When in merit and their energy is not required for a future time frames.
- To constrain the state of charge to within a tighter range in order to maintain the battery units' high and low frequency response

However, dispatch to negative quantities and scheduling of batteries has not been possible due to the system limitations. This current approach includes a pre-agreed charging arrangement, by which battery units can charge at up to a pre-defined charging rate without pre-approval from the TSO. The Scheduling & Dispatch Programme changes (SDP_02, to which Mod_02_24 relates) will enable batteries to be included in indicative operational schedules by scheduling to their PN and enhance the dispatch capability to allow for dispatch to positive and negative quantities. This ensures that battery units can be utilised more than can currently be the case, providing greater utility of these assets and to enhance overall grid flexibility. Modification Mod_02_24 already enables some greater utilisation of flexibility from battery units, as there are circumstances where the flexibility can be utilised in the form of dispatch in the negative range (e.g., for over-frequency situations). Operationally, the Control Centres will still have the capability to dispatch away from PN for all the reasons outlined below so flexibility will remain to call upon the batteries where required to secure the system or maximise priority dispatch.

"Follow PN" represents an improvement in the usage of battery units in the context of system limitations and the inclusion of an enduring solution within the scope of the Strategic Markets Programme. This improvement is realised in that TSOs will be able to include both charging and discharging in scheduling processes and will be able to dispatch in both positive and negative ranges.

- Battery units will be able to be considered ON at zero MW (which is not currently possible in the TSO Operational Scheduling tools)
- When "follow PN" mode is active, a battery unit's indicative operations schedule will adhere to its latest submitted Physical Notifications (PNs), provided the PN is feasible. The "follow PN" constraint is considered a soft constraint within the optimisation and will be breached if essential in order to allow the optimisation to find a solution. Deviations may occur for various reasons, as set out in Appendix B.
- In the event that "follow PN" is disabled by the TSOs for scheduling processes, battery units are set to unavailable for the affected Operational Scheduling Runs and are therefore excluded from the scheduling processes. This is appropriate to ensure a feasible/secure schedule and is preferable to a schedule that is based on PNs from battery units that are known to be infeasible. This does not mean that the units will be excluded from dispatch.

The Operational Scheduling process comprises LTS, RTC and RTD Operational Schedules, each of which contains a large volume of input data with regard to system needs/status and unit status.

Each Operational Scheduling Run is seeking to minimise the cost of deviating from PNs, however Operational Schedules (for all units) are indicative, meaning that they are decision support but that actual dispatch may differ (there a multitude of reasons for this, but of particular importance is the unavoidable lag in transferring real-time data and the fact that schedules always look ahead). For battery units, Control Centre Engineers will have the ability to designate each unit as "follow PN" or not (as described above). This is because of vendor's system limitations in optimising the use of batteries in schedules. Once set to "follow PN", a battery unit's profile will be fixed in the schedule to follow the latest submitted PNs for that unit if possible.

The "follow PN" constraint will be a soft constraint within the optimisation, meaning that it may be breached in order to allow the optimisation to find a solution. Reasons for this may include PNs breaching the unit's higher operating limit/lower operating limit, network constraints, islanding, or under-generation. In these cases, the indicative operations schedule for that unit may deviate from PNs. As is always the case for any dispatchable/controllable unit, schedules are indicative only and actual dispatch may vary.

The Scheduling and Dispatch Programme "follow PN" approach is highly dependent on market participants' submitting physically feasible PNs, as required under the SEM Committee decision SEM-15-065. A projection of each unit's PNs, state of charge and operating limits will be displayed to the Control Centre Engineers. If PNs submitted appear to be infeasible, the Control Centre Engineers may choose to wait to see if the participant updates PNs closer to the time for open trading periods or contact the participant to rectify the issue. If PNs remain infeasible, the Control Centre Engineers may choose to remove that unit from the "follow PN" treatment. In this case the unit will be excluded from operational scheduling processes. Including infeasible PNs in operational scheduling processes could have an impact on the indicative operations schedules produced. Submission of infeasible PNs or inappropriate PNs that do not support the "follow PN" compromise solution will be brought to the Market Monitor as a matter of high priority given the limitation of the "follow PN" approach and impact on the indicative operations schedules.

"Full optimisation" of battery units is not practicable, which is the case for several reasons:

- The SEM is based on an ex-post calculated price, meaning that "optimisation" in real-time (reflecting relative costs between charging and discharging Trading Periods) is not possible. The TSOs have adopted the principle of "more efficient utility" for the solution delivered as part of SDP_02 and "most efficient utility" for its considerations for an enduring solution as part of the Strategic Markets Programme.
- There is no proven operational solution for "optimisation" of large volumes of storage units.
- Operational Scheduling is inherently time-limited; experience from other TSOs working to include battery units (e.g. NY ISO) is that their inclusion at volume creates significant challenges in terms of solution times.

2.6.1. Returning to PN

With regard the agreement via industry/RA workshops that the TSOs would make reasonable efforts to restore batteries to their PN profiles within the Trading Day, the TSOs will be taking into account various considerations with regard to how & when to return to PNs.

2.6.2. PN feasibility

In order to utilise the proposed “follow PN” approach, Control Centre understanding of feasibility of PNs is critical. As a result, a new “PN Feasibility Display” will be available to Control Centre Engineers. The purpose of the proposed “PN Feasibility Display” is to allow Control Centre Engineers to be informed of and visualise the feasibility of PN profiles submitted by battery units according to the current remaining Export Energy [MWh] stored in the unit. The “PN Feasibility Display” will provide a projection of each unit's state of charge based on PNs, and operating limits. Where the Control Centres are satisfied that the PNs submitted are feasible, units may “follow PN” in scheduling.

2.6.3. Reserve Contribution

Scheduling applications will include battery units in reserve scheduling, allowing each battery unit to contribute to any reserve category based on the reserve capability curves data, state of charge and real time availability of the unit. Reserve capability curves for battery units can include negative MW outputs, and can be continuous through 0 MW output.

System services to be provided by battery units include (in order of priority) four types of operating reserve: primary (POR), secondary (SOR), tertiary 1 (TOR1) and tertiary 2 (TOR2), followed by replacement reserve (RR) and three types of ramping margins of 1 hour (RM1), of 3 hours (RM3) and of 8 hours (RM8). Negative ramping reserve (NEG) is included the negative direction and the fast frequency response (FFR) schedule for each battery unit is also calculated.

To accommodate the fixed ‘follow PN’ schedule of battery units, the contribution of reserves from battery units in schedules will be pre-processed before optimisation of energy and reserves from other resources.

During a pre-processing step of the scheduling applications, reserve contribution from any capable batteries will be calculated based on the submitted PN and forecasted energy remaining for each scheduling interval. For reserve categories SOR, TOR1 and TOR2 the reserve contribution will be based on the assumption that the unit had to provide energy in all applicable preceding reserve categories (For example, when calculating reserve contribution for towards TOR1 the energy delivered in POR & SOR will be taken away from the forecasted energy remaining for that scheduling interval.) Reserve will be optimised along for all other unit types as it is today.

2.7. Dispatch and Merit Order Lists

A battery unit must achieve any instructed MW set point within its operating range if it has sufficient energy or capacity to do so. A battery unit's control system must be capable of adjusting the MW output of the unit on receipt of an input, which may be either:

- an operator input, following receipt of a dispatch instruction via EDIL; or
- a MW set point issued by the TSO via SCADA (if communication via EDIL is ineffective).

Battery units are expected to respond automatically during system frequency events based on the unit's system services capabilities and frequency response mode.

Battery units will appear in the online merit orders based on submitted Simple COD similarly to other generators. Battery units will not appear on the offline merit orders as they will be considered always 'on' except when on outage.

Online merit order lists only give a point-in-time view (i.e. what is available now) and cannot account for the energy limited nature of battery units. An action taken by the TSOs based on the merit order at a point in time may limit its use and ability to meet PNs at a later stage due to its changed state of charge. This may force the TSOs to take a particular action away from PNs which have become infeasible at a later time, the cost of which is not included in the merit order list at the time of the initial action. As a result, when considered over a longer time period that action may not be the most economic.

In addition to this, once a battery unit is dispatched away from PNs it will be challenging to return the unit to the intended state of charge so that dispatch to the submitted PN profile across the remainder of the trading day can be resumed. It was not considered workable by market participants to obtain an updated, feasible market position and submit new PNs reflective of that position in these cases. As a compromise, it was agreed that the TSOs will use reasonable endeavours to return the batteries to their PN within the trading day.

For these reasons, battery units will not be dispatched away from PNs based on merit order alone. As far as is reasonably possible, battery units will be dispatched by the TSOs to "follow PNs".

If set to "follow PN", dispatch instructions will be automatically generated within market systems to match PN values and can be reviewed and approved by the TSOs before issuance via EDIL. If necessary, Control Centre Engineers may manually create or amend dispatch instructions before they are issued to the unit. If one of the scenarios outlined in Appendix B occurs the TSOs may dispatch a battery unit away from its PN based on that condition and information in the online merit order.

2.7.1. Energy Management System (EMS)

The control centres may take direct control of a battery unit's output via EMS during emergencies. The TSO may use SCADA (Active Power Control (APC)) in Ireland or Emergency Action in Northern Ireland) to issue instructions directly to the battery control system. If APC or Emergency Action is

turned on, the set point issued via that control scheme takes precedent over an instruction issued via EDIL.

Additionally, Frequency Response Mode is configured and reactive power setpoints (MVAR+/MVAR-) are issued to the battery control system through SCADA (via EMS).

The real-time reserve contribution (positive and negative) of battery units will be included in the total and jurisdictional real time reserves within EMS. This will be calculated based on real time availability signals, EDIL declarations, state of charge and reserve capability curves.

2.7.2. Electronic Dispatch Instruction Logger (EDIL)

EDIL is a two-way messaging and logging system which connects the Control Centre Engineers with unit operators and shift managers so that they can communicate dispatch instructions, availability and ancillary services declarations relating to centrally dispatched generating units.

There is a need for battery units to interact with EDIL, having the ability to declare availabilities and accept/acknowledge instructions via EDIL, in particular so that this data is available for real-time monitoring in the control centres, for audit purposes, and for pricing and settlement of the balancing market and for system services.

Following delivery of initiative 2 of the SDP, EDIL operations will cover the full output range of batteries, i.e. charging and discharging. Dispatch of battery units will be possible in the positive and negative ranges, including synchronisation (SYNC) instructions to record when the battery reconnects and returns to service and instructions to a specific positive MW output level (MWOF). Battery units will be enabled to submit negative declarations where relevant, in particular the Minimum Generation Available MW (MNMW), Reserve Provision Threshold MW (RPT) and Name Plate Rated Minimum Output MW (PMNMW) fields.

Availability Declarations

When a battery unit is on outage, positive and negative energy and ancillary services availability should be declared as zero via EDIL. When that unit is about to come back online, each availability category should be declared as a non-zero value. Detailed requirements on how participants should make declarations under particular circumstances will be clarified in an operational document published before go-live of the tranche 1 initiatives.

Real time availability signals will continue to be transmitted to the TSOs via EMS, providing situational awareness to the control centre and allowing the unit to meet its grid code obligations for availability to reflect a unit's actual ability to export.

2.8. Pricing

Regarding flagging and tagging as a post-process to Real-Time Dispatch (RTD) Operational Scheduling Runs, as battery units will as default be "follow PN", there will generally be no balancing actions to consider. Where dispatch deviates from PNs, all actions will be SO flagged (as the primary

reasons for deviating will for non-energy reasons, including system security). In such circumstances where dispatch deviates from PNs, this means that (consistent with all other Units):

- Actions will initially be flagged out of pricing
- Where Simple prices have been submitted, they will be considered in Imbalance Pricing (unless the action is pre Gate Closure 2, meaning that Complex prices would be used as for all other units)
- Actions may be tagged back into pricing through NIV tagging, but the price used will always be capped by the Price of the Marginal Energy Action (PMEA). Battery units will not be able to set PMEA (as they are SO flagged).

Battery units will always be settled using Complex COD.

2.8.1. Instruction Profiling and Bid Offer Acceptance Quantity Calculations

Instruction profiling of dispatch instructions for battery units will be carried out similarly to other generators but covering their full range of operation, charging and discharging. SYNCs and MWOFs will be profiled in either the positive or negative output range. The mandated Minimum Stable Generation value of zero will allow for this, as a non-zero Minimum Stable Generation could result in the unit being profiled to a positive Minimum Stable Generation before a negative SYNC target or vice versa. Battery units will be considered on except when on outage, meaning that once synchronised, all dispatch instructions will be MWOFs (including to 0MW) until de-synchronised for an outage.

Instruction profiling of dispatch instructions for battery units will be carried out similarly to other generators but covering their full range of operation, charging and discharging. SYNCs and MWOFs will be profiled in either the positive or negative output range. The mandated Minimum Stable Generation value of zero will allow for this, as a non-zero Minimum Stable Generation could result in the unit being profiled to a positive Minimum Stable Generation before a negative SYNC target or vice versa. As mentioned above, battery units will be considered on except when on outage, meaning that once synchronised, all dispatch instructions will be MWOFs (including to 0MW) until desynchronised for an outage.

2.8.2. Flagging and Tagging

For the purposes of the Scheduling and Dispatch Programme solution, all actions on battery units will be System Operator (SO) flagged. This is to reflect the fact that these units will primarily be dispatched to follow PNs, and any actions away from PNs are likely to be non-energy actions, and will be taken on a non-market basis (i.e. not as per the merit order lists) for the reasons described in Appendix B.

This SO flagging will be implemented using an existing, manually maintained list which implements the same functionality for the recently introduced Temporary Emergency Generation (TEG) units.

Under the SDP_02 solution, all battery units will be added to this list and as a result all actions will be SO flagged.

Although all actions on these units will be SO flagged under the SDP solution, for completeness and future-proofing, system operator flagging (non-energy) and non-marginal flagging rules have been updated to accommodate battery units. This ensures that the charging and discharging range can be assessed appropriately and these units are not precluded from being flagged while charging.

This is relevant for an enduring solution which is within the scope of the Strategic Markets Programme. These updates ensure that charging and discharging can be assessed appropriately.

2.8.3. Price determination

As a result of the SO flagging of all battery unit actions, they will not be eligible to be considered the marginal energy action, and if the COD price (either Simple if the action is after Gate Closure 2 or Complex COD if before) associated with these actions is higher than the price of the Marginal Energy Action (PMEA) for a positive Net Imbalance Volume (NIV), or lower than the PMEA for a negative NIV, that price will be replaced with the PMEA within the pricing process.

Within the NIV tagging process, the SO flag will mean that these actions are initially not considered energy actions and therefore cannot set the price. If the volume of remaining energy actions does not add up to the NIV, the SO flagged actions may be NIV tagged back in as energy actions (on a least cost basis).

The Imbalance Price is then calculated as a weighted average (10MWh) of the highest (for a positive NIV) or lowest (for a negative NIV) priced energy actions following this process.

2.9. Settlement

This section describes how settlement will be performed for Battery Storage Units, as proposed in Mod_02_24 as aligned with the SDP_02 Scheduling and Dispatch Programme design.

As explained earlier, “follow PN” would result in no balancing actions but the proposal allows for the TSO to dispatch away from PNs when necessary. To prevent participants from taking advantage of situations where they might anticipate future dispatches based on earlier TSO actions, Complex prices will be used for settlement. However, Simple prices can still be submitted by Participants which are used as decision support in the TSO Merit Orders and can influence the setting of the imbalance price. Simple prices also serve as a market signal, included in price formation when they are tagged back into imbalance pricing via NIV-tagging.

Settlement will be based on EDIL availability, meaning that dispatch to zero from PNs that have become infeasible due to previous TSO actions will be settled at better of COD price and the imbalance price. When the TSO dispatches a battery unit to charge or discharge away from its

submitted PN, the availability status in EDIL will not be affected by the state of charge. This means the unit does not need to be declared unavailable in EDIL, which means that Participants operating battery units will not 'suffer loss of revenue' as a result of TSO action.

In summary, Mod_02_24 proposes that settlement for battery units will be as set out below:

- CIMB (Imbalance Component) – as for conventional Generator Units; differences between metering and ex-ante quantities are settled at the Imbalance Price (change to existing TSC to separate Battery Storage Units from Pumped Storage Unit treatment when charging)
- CUNIMB (Uninstructed Imbalances) – as for conventional Generator Units; charge is based on undelivered quantities and uninstructed imbalance tolerances
- CTEST (Testing Charges) – charges for Battery Storage Units will be correctly assigned based on whether the unit is charging (metering<0) or discharging (metering>0)
- CFC (Fixed Costs) - Battery Storage Units will be mandated to submit zero Start Up and No-Load costs and therefore CFC will generally be zero. However, there may be some circumstances where CFC will be non-zero due to the algebra in the CFC equations.

Firm access would be applied same as to other units, in that no CDISCOUNT (Discount Component Payment) will be paid for non-firm volumes. The proposal within the modification, which requires Battery Storage Units to be registered as part of a Trading Site, ensures that non-firm quantities can be applied to these units for settlement purposes. This prevents them from being automatically settled as fully firm, as would be the case under the existing arrangement.

In summary:

- For decrement (decs) actions, the lower of the Complex Offer Data (COD) price or the imbalance price will be used.
- For increment (incs) actions, the higher of the COD price or imbalance price will apply.

Applying these principles ensures consistency across the treatment of technologies with regard to settlement.

The proposed changes will not lead to an increase in imperfection costs; rather, they hold the potential to minimise redispatch (as "follow PN" is the default) and subsequently reduce these costs.

Imbalance Charges

In a change from the current text of the TSC, the Imbalance charge will be applied to battery units as it is for other generator units while charging and discharging, i.e. the volume difference between loss adjusted metering and ex-ante position, paid or charged at the Imbalance Price. At present the TSC includes an adapted Imbalance charge calculation for battery units while charging to match the treatment of pumped storage units.

The proposed change reflects the fact that, unlike pumped storage units, battery storage units can control the level to which they consume power when dispatched to charge. The change also complies with regulatory requirements for Balance Responsible Parties (under the EU's Clean Energy Package (CEP), Energy Balancing Guidelines (EBGL), and Imbalance Settlement Harmonisation Proposal methodology (ISHP)). The change to the application of the Imbalance Charge was identified by the TSOs as being necessary in SEM-21-017 (EirGrid and SONI Analysis of SEM Compliance with Commission Regulation (EU) 2017/2195 of 23 November 2017 Establishing a Guideline on Electricity Balancing).

Discount and Premium Charges

The Discount and Premium charges will be calculated for these units as they are for other generators. They will apply across the full operating range of battery units.

Because of the availability declaration arrangements described in this section, dispatch down from PNs that have become infeasible due to TSO actions will receive Discount payments in addition to the Imbalance charge. If the unit was required to declare unavailable in these cases only the Imbalance charge would be applicable and the participant would be exposed to an imbalance.

Offer Price Only Accepted Offer and Bid Price Only Accepted Bid Charges

The Offer Price Only Accepted Offer and Bid Price Only Accepted Bid charges will be calculated for these units as they are for other generators. They will apply across the full operating range of battery units.

Uninstructed Imbalance Charge

At present under the TSC, the Uninstructed Imbalance charge does not apply to batteries while charging, similar to pumped storage units while pumping. This is changed and the Uninstructed Imbalance charge is applicable to battery units while charging and discharging. Unlike pumped storage units, battery units can control the level to which they consume power when dispatched to charge, and so do not need different treatment while charging.

The existing tolerances within the Uninstructed Imbalance calculation (minimum of 1MW at present) may be used by battery units to trickle charge to avoid operating at a dangerously low level of charge.

Fixed Cost Charge

Battery Storage Units will be mandated to submit zero Start Up and No-Load costs. This is to reflect the fact that these units will be always on except when on outage, and can move between zero and non-zero output without the need to start up or shut down. Therefore, CFC will generally be zero, however, there may be scenarios where CFC is non-zero due to the calculation of Make-Whole Payment Operating Cost (COCMWP) and Make-Whole Payment Revenue (CREVMWP) within the CFC algebra.

Testing Charge

The Testing charge will be calculated for battery units in a similar manner as it is for interconnector units, i.e. when metering is positive it is multiplied by -1, when metering is negative it is used as-is in

the calculation. The Testing Tariff Price should always be applied as a charge rather than a payment to participants. Without this change the Testing charge would be a payment to participants when the battery unit is charging.

Appendix A: Current Arrangements and Limitations

The current arrangements for batteries were put in place in order to address the growing number of battery units that have been connecting to the power system. This current solution was created as a means of enabling battery units to connect prior to system upgrades which have long lead times. Battery units are not represented in every way intended, and as such the intention was that a subsequent solution would replace the current one. The current solution will be replaced by the proposed solution proposed under Scheduling and Dispatch Programme initiative 2, detailed in section 2 of this document.

At the highest level, the current solution is to register and operate battery units as a 'Multi-Fuel' generator type in market systems, with some refinements and specific approaches in certain areas, like charging and settlement.

A.1. Registration

In the current market system, it is not possible to register batteries as 'Battery Storage Units' as envisioned under the Trading and Settlement Code (TSC). Firstly, the TSOs have learned that several elements of the pumped storage model have been hard-coded for ease and to minimise system performance impacts. Secondly, Pumped Storage is a different technology to batteries. The proposed solution will allow the treatment of battery units to be decoupled from the treatment of Pumped Storage Units to better reflect their technical characteristics and allow them to participate in a competitive and non-discriminatory way. At present in the TSC (not utilised), the treatment of Battery Storage Units while charging is the same as the treatment of Pumped Storage Units while pumping. Particular treatment was put in place in settlement because Pumped Storage Units cannot control the level to which they consume power when dispatched to pump. This is not a feature of Battery Storage Units and so once market systems have the capability to receive Physical Notifications and Dispatch these units in their charging range this treatment will no longer be appropriate for Battery Storage Units. As a result, battery units are currently registered as 'Multi-Fuel Generator Units'.

As a result of this, registration data fields and requirements are as per generator units, and do not accurately reflect the characteristics of a battery unit. Negative registered minimum output and storage capacity cannot be entered for these units.

Additionally, the TSC currently mandates that battery units and pumped storage units must not be registered as part of a trading site, which is a legacy SEM rule reflecting the intention to settle the units metering on the generator and not a supplier. Consequently, pumped storage units were restricted from registering under a trading site to ensure the metering was recorded on the generator. As battery units have a possibility of having non-firm volumes, they are required to be assigned to a Trading Site to enable for these volumes to be calculated as the volumes are calculated at a Trading Site level. Therefore, the proposed solution means that battery units must be removed from the exception which applied to Pumped Storage Units regarding Trading Sites and are therefore required to register battery units to a Trading Site, as per other generators.

A.2. Balancing Market and Data Submission

A.2.1. Physical Notifications (PNs)

Battery participants who achieve an ex-ante position to export can reflect their generation quantities in a manner similar to other generator units. If they have traded ex-ante with the intention of charging, they cannot currently represent this with a negative PN. Instead, they must submit a value of zero for those periods.

In general, the submission of positive PNs is treated in the same way as any other unit, where the FPN should reflect the ex-ante traded position and must be physically feasible, aligning with the unit's Technical Offer Data (TOD) and other technical characteristics.

A.2.2. Commercial Offer Data (COD)

Under the current arrangements, the format of Commercial Offer Data (COD) for battery units reflects that of a multi-fuel generator unit. As per the TSC, battery participants must input zero values for start-up and no-load cost components in their Complex COD. Participants may submit price-quantity pairs with positive and negative quantities. However, as the TSOs cannot schedule the unit in its negative output range, issue dispatch instructions into this range or calculate balancing market volumes within this range, price-quantity pairs with negative quantities do not currently have any practical effect.

As a multi-fuel generator (the current approach), it is not possible to submit a negative forecast minimum output profile. This must be submitted with a value of zero rather than reflecting the charging capability of the unit, as is intended for battery units.

A.2.3. Technical Offer Data (TOD)

As a multi-fuel generator unit, battery units are constrained by the available parameters, which do not accurately represent the capabilities of their battery unit. Operating characteristics in the charging range cannot be submitted. Battery storage efficiency cannot be submitted as part of TOD for multi-fuel generator units, as envisioned under the TSC for battery units.

A.3. Scheduling

The Balancing Market systems (which encompass the components used to support operational scheduling) currently lack a suitable battery unit type capable of modelling the discharging and charging functionalities or energy limits of battery units. Therefore, as explained in section A.1, batteries must currently be registered as multi-fuel generator units, restricting the TSOs' ability to maximise battery unit usage. There are four key issues relating to battery units that prevent the TSOs from maximising the use of these units:

1. Negative PN submission: The system currently prevents these units from submitting negative PNs. Operational scheduling processes are unable to maximise battery and generator output due to the absence of charge quantities.
2. Charge Capability: The EDIL dispatch system cannot accept negative minimum output declarations, preventing operational scheduling processes from modelling battery unit charge capabilities effectively.
3. Energy Limit: The absence of real-time energy limits for multi-fuel units restricts operational scheduling processes from accurately optimising these units, potentially leading to exceeding energy limits.
4. Modelling of Reserve: Provision of reserve from typical conventional units is calculated based on the units' reserve capability curves (covering positive output range only), scheduled quantity and commitment status (which may only currently be ON when non-zero). Because of the energy limited nature of battery units and their ability to provide reserves at or below a 0MW output position, this approach is not possible for battery units.

Due to these limitations, it was determined that optimisation of energy is not possible within operational scheduling processes.

A.3.1. Reserve Contribution

One of the biggest benefits of battery units is their ability to deliver system services. This reduces the need for the TSOs to carry reserve on other generator units.

Because battery units' reserve contribution cannot be modelled similarly to conventional units as described above, reserve contributions from battery units are added to the interruptible load figure in scheduling systems. Interruptible load is a modelled load in the TSOs' system that would be 'interrupted' or 'removed' from the power system to restore system frequency in an event where demand exceeds supply leading to a low frequency event. Because battery units' reserve contribution cannot be modelled similarly to conventional units as described above, reserve contributions from battery units are added to the interruptible load figure in scheduling systems. Interruptible load is a modelled load in the TSOs' system that would be 'interrupted' or 'removed' from the power system to restore system frequency in an event where demand exceeds supply

leading to a low frequency event. A 50% de-rated figure for each battery unit is manually added to the jurisdictional interruptible load figures, to reflect the limitation explained above.

A.4. Dispatch and Merit Order Lists

Battery units offer a crucial source of fast-acting reserve, yet due to current system limitations their modelling within market systems is inaccurate. Because these units are modelled as multi-fuel generators, the TSOs are unable to determine their state of charge. If dispatched, the TSOs will no longer be able to accurately reflect the available reserve a unit is providing to the interruptible load figure.

Because of this limitation, the initial working policy was to keep battery units at 0MW generation output, to provide reserve unless it was necessary to dispatch them to maintain system security. However, this working policy has been evolving which has resulted in an increase in dispatch of battery units. In part, the reason for increasing the level of dispatch has been that, in practice, there is an excess of reserves from all sources available. Therefore, dispatching batteries for energy has become more feasible.

Each battery unit must be capable of achieving any instructed MW set point within its operating limits, provided it has enough energy or capacity. Its control system should adjust the unit's MW output based on either an operator input following a dispatch instruction via EDIL or a MW set point issued by the TSO via the EMS. During system frequency events, battery units are expected to respond automatically in line with their system services capabilities and frequency response mode.

Control Centres utilise a series of Merit Orders (derived from RTD Operational Schedule outputs/utilising Simple COD and real-time status data from the EMS) as decision support to dispatch decisions (for all dispatchable units):

- Online Merit Order – Incremental (cheapest Inc action for units ON first)
- Online Merit Order – Decremental (cheapest Dec action for units ON first)
    - *Online Merit Orders only represent available resources/bids <u>now</u> and do not account for the energy-limited nature of battery units.*
- Offline Merit Order (Fast/Slow start) – not relevant for battery units as they are considered always 'on' except during outages.

Actions taken by the TSOs at a specific moment based on the Online Merit Orders may reduce the battery's state of charge, potentially limiting its ability to meet PNs later on. This may force the TSOs to deviate from PNs that become infeasible, which could incur costs not captured in the original merit order. Therefore, actions based on Merit Orders may not always be the most economic actions in the long run. Moreover, if a battery unit is dispatched away from its PNs, it can be challenging to return it to the required state of charge to resume following the PN profile for the rest of the Trading Day. Participants have deemed it unworkable to consistently update PNs with new, feasible positions in such scenarios.

A.4.1. Energy Management System (EMS)

The control centres may take direct control of a battery unit's output via EMS during emergencies. The TSO may use SCADA (Active Power Control (APC)) in Ireland or Emergency Action in Northern Ireland) to issue instructions directly to the battery control system. If APC or Emergency Action is turned on, the set point issued via that control scheme takes precedent over an instruction issued via EDIL.

Additionally, Frequency Response Mode is configured and reactive power setpoints (MVAR+/MVAR-) are issued to the battery control system through SCADA (via EMS).

A.4.2. Electronic Dispatch Instruction Logger (EDIL)

Due to limitations across the systems, it is currently not possible to issue a negative dispatch instruction to battery units to indicate an intended charge quantity; instead, a pre-agreed charging approach is utilized (described below). It is also not possible to reflect a unit's charge capability through a negative minimum output declaration.

Battery unit operators may expect to receive positive synchronisation (SYNC) instructions, instructions to a specific positive MW output level (MWOF), desynchronisation (DESY) instructions, and messages from the control centre. Battery units are considered always 'on' and so will only receive a SYNC instruction when being initialised or returning from outage.

Battery units must continuously manage their ancillary services and availability via EDIL. However, EDIL does not allow for battery units to account for their negative output (charging) range in their declarations.

A.4.3. Pre-Agreed Charging

Due to EDIL's inability to process or send negative dispatch instructions, Control Centre Engineers cannot currently initiate the charging of battery units. To address this, TSOs have agreed on a 'Pre-Agreed Charging' approach, allowing battery operators to charge autonomously without TSO dispatch instructions.

Under this approach, battery units may autonomously charge up to the minimum of 5MW, or 20% of Maximum Export Capacity (MEC), or Minimum Import Capacity (MIC), with some units having specific requirements, such as a waiting period after a frequency event before charging. Control Centre Engineers retain full control over when battery units can autonomously charge, with charging permitted unless instructed otherwise for system security reasons.

Any MW instruction from control centres (via EDIL) should override the pre-agreed charging. Pre-agreed charging should also be overwritten by APC or an Emergency Action as applicable.

A.5. Pricing

A.5.1. Instruction Profiling and Bid Offer Acceptance Quantity Calculations

Under the current arrangements, entering negative PNs or issuing negative dispatch instructions is not possible for battery units, as explained earlier. As a result, when these units are charging, dispatch and PN levels should both be 0MW. Consequently, Bid Offer Acceptance Quantities (QBOAs), which represent the difference between dispatch and PNs, and Bid Offer Acceptance Prices (PBOAs) for TSO actions are only calculated within the positive output range, and therefore only positive QBOAs are included in Imbalance Pricing.

A.5.2. Flagging and Tagging

The current battery solution affects System Operator (SO) flagging, directly impacting Imbalance Pricing and indirectly influencing settlement.

The TSOs can add battery units to any operational constraints that are appropriate for the unit based on its capabilities, locations, etc., and it will be SO flagged based on the rules for that constraint. Battery units do not have a set of reserve curves and are not considered "committed on" in scheduling systems. Constraints only flag units as contributing to the binding constraint when the unit is seen as “committed on”, or at certain output levels (e.g. maximum generation, minimum stable generation, operating on reserve curves). Therefore, depending on the circumstances of the exact constraints each battery unit is associated with, the unit may or may not be SO flagged for that constraint. Batteries, in general, have a smaller likelihood of being SO flagged for a constraint than other generator units.

This limitation has an impact on setting the Marginal Energy Action Price (PMEA). The NIV tagging process will still apply to battery units as normal considering the PMEA as its starting point through the normal Imbalance Pricing calculations process, which in turn affects the ability for units to be included in setting the final Imbalance Settlement Price.

A.6. Settlement

Battery units can be settled correctly as per the TSC in the positive output range. All relevant charge components can be calculated and applied as written for batteries while exporting, i.e. similarly to generator units. This includes the Imbalance Charge, Premium Payment, Discount Payment, Uninstructed Imbalance Charge, Offer Price Only Accepted Offer Charge, Bid Price Only Accepted Bid Charge, and Testing Charge.

Fixed Cost Charges are not applicable to batteries as start-up and no-load costs are required to be submitted as zero under the TSC.

Since balancing market volumes cannot be determined in the negative output range, settlement below zero is only possible through the Imbalance Charge, which settles metered vs. traded quantities at the Imbalance Price. However, the Imbalance Charge cannot be applied per the current

TSC rules for batteries in charging mode, which mirror the treatment of pumped storage units in pump mode, and instead is applied as it is for generators in all cases (charging and discharging).

Under the TSC, batteries are exempt from Uninstructed Imbalance charges when they are in charging mode. However, under the current arrangement, this exemption requires a manual workaround, as the settlement system does not recognise batteries in charging mode.

Appendix B: Reasons for deviating from PNs for Battery Units

Scenarios where the TSO will deviate from PNs

To maintain system security, maximise priority dispatch generation, and minimise non-market based redispatch of renewables, batteries will be dispatched away from PNs in the following situations.

Alert or Emergency State	If a battery unit's PNs would exacerbate a system alert situation or could mitigate a system alert situation during a system warning based on TSO's latest forecasts, the TSOs will dispatch away from PNs to minimise the impact of the period of capacity shortage. For example, a battery may not be discharged at a particular time so it can be discharged during peak time to avoid an alert state.
Local Transmission Constraint	If transmission network limits would be breached by dispatching a battery unit to its PNs, the TSOs will dispatch away from those PNs. For example, battery units will be dispatched down ahead of dispatching down wind and solar units for a local constraint.
As Directed by DSOs	Under future DSO-TSO operating models, there may be a need for DSOs to direct the TSOs to dispatch DSO-connected battery units away from PNs in certain cases. These cases would be agreed between the DSOs and TSOs under the existing governance structures.
Curtailment	Battery units will be dispatched down to 0 MW from a discharging PN in advance of curtailing wind and solar units. Based on ex-ante price signals, it is expected that the incidence of batteries having discharging PNs in high wind situations would be minimised by price signals in ex-ante markets.
Priority Dispatch	Any batteries which have a PN greater than or equal to 0 will be dispatched to 0 MW and not into their charging range to accommodate more priority dispatch generation. However, batteries which have charging PNs (ie. PN <0) will be dispatched to PN as normal. A review of the priority dispatch hierarchy is currently being undertaken by the TSOs and RAs.
Infeasible PNs	When a battery unit's PNs have become infeasible due to actions taken by the TSOs earlier in the day, the TSOs will make reasonable endeavours to dispatch the unit away from PNs to an achievable level given its state of charge. This mirrors the treatment of conventional units whereby if they have reduced availability they are dispatched to an achievable level.
During a Frequency Event	When there is a frequency event, battery units will automatically respond to provide operating reserve. If PNs are not suitable to continue this support, for example as additional generation is being committed, battery units will be dispatched away from PNs.

Scenarios where the TSO may deviate from PNs

The TSOs will retain the option to dispatch away from PNs in certain situations for practical reasons, described below. The TSOs will try to minimise the instances of dispatch away from PNs in these cases.

High Frequency Response	In high wind conditions, ex-ante price signals may mean that battery units obtain a position (and therefore PNs) to fully charge overnight. For example, if there are high north to south flows from Northern Ireland to Ireland, battery units will then not be in a position to provide any high frequency response for the System Separation contingency due to the lack of 'foot room'. Therefore, to secure each jurisdiction independently, north to south flows may have to be reduced by constraining wind and solar. To avoid this, Control Centre Engineers may choose to dispatch battery units above their PNs so that they have 'foot room' available to reduce output for high frequency response. Deviating from PN to retain high frequency response (keeping SOC <90%) would reduce dispatch down of priority dispatch units.
Meeting Positive Reserve needs	In a scenario where all battery units have PNs reflecting discharging at the same time (e.g. winter evening peak) they will have no headroom available to provide low frequency response. Reserve would be sourced from conventional units which may be inefficient. Control Centre Engineers may choose to dispatch battery units below their PNs so that they have headroom available to increase output for low frequency response.
Interconnector Ramping Management	EirGrid and SONI's Operational Policy Roadmap 2023-2030 sets out the intention to increase the combined interconnector ramping rates on the island from 10 MW/min to 40 MW/min by 2030. The fast change of active power output across the interconnectors imposes system operation difficulties, if not enough fast acting plant is available to support these exchanges of power with neighbouring systems. Battery units can provide fast ramping to enable high interconnector ramp rates, and in some cases Control Centre Engineers may have few or no alternatives to dispatching these units away from PNs for this purpose. The operational readiness of the Celtic Interconnector could increase the occurrence of this scenario, however this has been communicated transparently to the industry and such actions will continue to be made on a cost basis based on the TSOs' Merit Orders.
Frequency Regulation	Frequency regulation is becoming increasingly challenging with increased penetration of wind and now also solar. Battery technology allows batteries to be configured to provide frequency regulation (i.e. frequency dead band of ± 15 mHz). However, this would alter battery units' state of charge and may inadvertently make their PNs infeasible. The current proposal is to keep batteries configured to provide a relatively static frequency response (circa ±100mHz) to support the frequency containment process. This proposal will be reviewed as necessary by the TSOs.

Efficient Management of Summer Load Shape	The expected behaviour of battery units based on price signals from the ex-ante markets is that they would charge overnight and discharge during the day. During the summer, it may be more efficient to also have a charge and discharge cycle during the day, e.g. charge overnight, discharge for morning load rise, charge in the afternoon and discharge again over the evening peak. Initially following delivery of initiative 2 of the SDP these actions to dispatch battery units away from PNs to create an additional charge and discharge cycle during the day will not be taken, but this may be reviewed in the future.
Dispatch to PN Becoming Impractical	Given that dispatch to PN will be overseen by the Control Centre Engineer, where multiple batteries are submitting PNs with multiple change points and small MW deltas, it may become impractical to dispatch exactly to PNs. In this case the Control Centre Engineer may choose to deviate from PNs for ease of operation.