Overview of SDP Solution for Battery Units

Version 2.0

Scheduling and Dispatch Programme

05/11/2025

Glossary

Table 1: Key Acronyms

APC	Active Power Control
ASU	Associated Supplier Unit
BCOP	Bidding Code of Practice
BMPCOP	Balancing Market Principles Code of Practice
BMPS	Balancing Market Principles Statement
COD	Commercial Offer Data
DASSA	Day Ahead System Services Auction
DESY	Dispatch Instruction to Desynchronise
DI	Dispatch Instruction
DMAT	De Minimis Acceptance Threshold
EDIL	Electronic Dispatch Instruction Logger
EMS	Energy Management System
FASS	Future Arrangements for System Services
FFR	Fast Frequency Response
LTS	Long Term Scheduling
MDMW	Maximum Generation Available MW
MNMW	Minimum Generation Available MW
MVAR	Mega Volt Amperes Reactive
MW	Mega Watt
MWOF	Dispatch instruction to adjust the Generator Unit Output to the specified Target Instruction Level
NIV	Net Imbalance Volume
Online / Offline Merit Orders	Online Merit Orders contain units that are already synchronised. These merit order lists are used during the balancing timeframe to increase or decrease energy output to balance demand on the system. Separate Offline Merit Orders contain units that are desynchronised and would need to be synchronised to provide additional generation.
PMEA	Price of the Marginal Energy Action
PMNMW	Name Plate Rated Minimum Output MW
PN	Physical Notification
POR	Primary Operating Reserve

RA	Regulatory Authority
RM1	Ramping Margin 1
RM3	Ramping Margin 3
RM8	Ramping Margin 8
RPT	Reserve Position Threshold MW
RTC	Real Time Commitment
RTD	Real Time Dispatch
SCADA	Supervisory Control and Data Acquisition
SDP	Scheduling and Dispatch Programme
SDP_02	SDP Initiative 2, Energy Storage Power Systems
SEM	Single Electricity Market
SEMO	Single Electricity Market Operator
SO	System Operator
SOC	State of Charge
SOR	Secondary Operating Reserve
SYNC	Dispatch Instruction to Synchronise
TEG	Temporary Emergency Generation
TOD	Technical Offer Data
TOR1	Tertiary Operating Reserve 1
TOR2	Tertiary Operating Reserve 2
Trading Day	Means the period commencing at 23:00 each day and ending at 23:00 the next day.
TSC	Trading and Settlement Code
TSO	Transmission System Operator

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 across the respective day. 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 and subsequently approved by SEM Committee in December 2024.

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. Following go-live of SDP_02 into production, any changes pertaining to battery units will be incorporated into the Balancing Market Principal Statement (BMPS).

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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. Following go-live of SDP_02 into production, any changes pertaining to battery units will be incorporated into the Balancing Market Principal Statement (BMPS).

1.2. What is the "problem" that 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 2 below:

Table 2: Elements of the "problem"

#	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 identified as necessary in SEM-21-017 (EirGrid and SONI Analysis of SEM Compliance with Commission Regulation (EU) 2017/2195 of 23

#	Summary	Description
		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 TSC 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 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.

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 Solution

2.1. Registration

The registration of battery units post SDP_02 will require a Generator Unit with fuel type = “BATTERY_STORAGE” to be set up on a Trading Site. The requirement to register as part of a Trading Site is to allow non-firm access quantities to be settled appropriately. Association of battery units with an Associated Supplier Unit (ASU) on a Trading Site is consistent with current registrations. As part of SDP_02 cutover i.e. moving from the test phase to live operations, there will be a process that will convert the Generator Unit from “MULTI_FUEL” to “BATTERY_STORAGE” ensuring the correct registration set up.

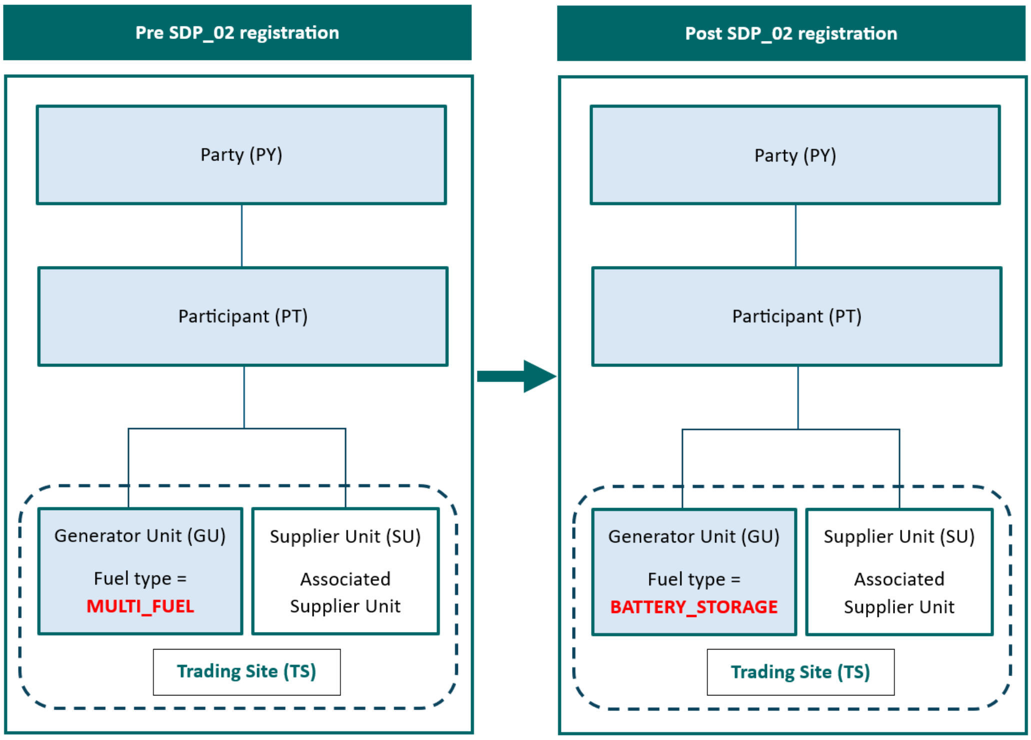

Figure 1: Pre and Post SDP_02 Registration Set Up for Battery Units

Registration data fields and requirements for Generator Units that have the fuel type “BATTERY_STORAGE” are as per other generator units, with certain additional fields. Similarly to pumped storage units, battery units will have a registered Minimum and Maximum Storage Quantity in MWh, as described in the TSC.

2.2. 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, the Physical Notification can no longer be redeclared and becomes the Final Physical Notification (FPN) and Service Providers must have submitted an FPN that is compatible with providing the DASSA Services corresponding to their DASSA Orders (or will otherwise be subject to DASSA Compensation Payments to be payable to the TSOs).
8. DASSA Orders will not affect scheduling, other than through the declared FPNs. Scheduling processes will continue to be based on FPNs, COD, TOD, etc. Scheduling processes 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[1]:
    a) Payments to DASSA Order holders, based primarily on DASSA Orders and DASSA Clearing Price (unless Availability Scalars or Performance Scalars apply).
    b) Compensation Payments to the TSOs in the event that FPNs are not 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.

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

2.3. Ex-ante Markets

SDP_02 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). However, SDP_02 changes may result in 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.

2.4. Balancing Market Bidding and Data Submission

2.4.1. Physical Notifications (PNs)

As part of the SDP_02 solution, battery unit participants will have the ability to submit PNs (A01[2] or A04[3], as applicable) covering their full output range including both charging and discharging. Like any other unit, PNs initially submitted should reflect the intended Ex-Ante traded position and updated as needed so that FPNs reflect the Ex-Ante traded position. Each PN submission must be physically feasible reflecting the unit's TOD and other technical characteristics[4]. 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 Control Centres will monitor the feasibility of PNs with respect to state of charge. For further detail on PN feasibility see Section 2.5.2.

2.4.2. Commercial Offer Data (COD)

As part of the SDP_02 solution, market participants operating battery units will be required to submit COD as per the TSC. This must include default Complex COD and may also include more frequently updated Complex COD and Simple COD. In addition to the requirements for all Generator Units, there will be some additional fields applicable to battery units as set out in Table 2.

Fixed Costs and Price Quantity Pairs

Table 3: COD element: Fixed Costs and Price Quantity Pairs

Data Element	Battery Unit submission requirements
Fixed Costs	• No Load Costs = 0 • Start Up Costs = 0
Price Quantity Pairs (PQ Pairs)	Price Quantity Pairs should be submitted to cover the full operating range of the battery unit i.e. charging (negative values) and discharging (positive values).

[2] A01 – Stepwise Linear Profile. Represents a series of discrete output levels over time, where change between levels is an immediate "step".
[3] A04 – Piecewise Linear Profile. Represents a profile where change in output between defined time points is assumed to be a continuous curve.
[4] TSC D.7.1.3, D.7.1.4, D.7.1.5

Forecast Profiles

The forecast profiles in Table 3 must be submitted for battery units and should represent the unit's expected availability to operate as described. If discharging or charging capacity is expected to be temporarily reduced or zero for any reason, this should be reflected in forecast profiles.

Table 4: COD element: Forecast Profiles

Data Element	Battery Unit submission requirements
Forecast Availability Profile	For battery units, will be >0 (representing discharging) when available and 0 when unavailable / on outage.
Forecast Minimum Output Profile	For battery units, will be <0 (representing charging) when available and 0 when unavailable / on outage.
Forecast Minimum Stable Generation Profile	For battery units, must always be equal to 0.

Operational Storage Quantities

Generator Units that have fuel type set to "BATTERY_STORAGE" will have two additional fields which define storage limits for battery units; these are in addition to the registration fields outlined in Section 2.1. The new COD fields (set out in Table 4) provide participants the opportunity to inform the Control Centres if the unit's storage capacity is reduced from the registered values for any reason on a given day. These fields can be updated daily and within day. These values will be used by the Control Centres to perform feasibility checks on PNs and will not be used for operational 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.

Table 5: COD element: Operational Storage Quantities

Data Element	Battery Unit submission requirements
Operational Minimum Storage Quantity	Battery units may choose to submit values for Operational Minimum Storage Quantity. If not submitted, it will default to registered Minimum Storage Quantity.
Operational Maximum Storage Quantity	Battery units may choose to submit values for Operational Maximum Storage Quantity. If not submitted, it will default to registered Maximum Storage Quantity.

2.4.3. 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.

2.4.4. Technical Offer Data (TOD)

Post Mod_02_24 approval and SDP_02 go-live, TOD for battery units will consist of the same fields as generator units, albeit some fields will be optional as they are not relevant to battery units. Additionally, battery unit must submit a Storage Cycle Efficiency field. Some TOD parameters as they relate to battery units are detailed below:

- **Storage Cycle Efficiency -** A percentage value calculated from the level of Generation provided by the discharge of a defined quantity of charge from the Battery Storage Unit divided by the level of Demand required to store the same defined quantity of charge.

  The efficiency is applied in the charging direction in the same manner as pumped storage. For example, if there is a PN to charge 10 MW for 1 hour and an efficiency of 90% - the storage level will increase by 9 MWh. It is assumed all energy in a PN to export will be seen at the connection point. For example, if there is a 20 MW export PN for 1 hour it is expected 20 MWh will be seen at the export point.
- **Ramp up / ramp down rates** should cover the battery unit’s full output range, charging and discharging. These should reflect the Active Power Control Set-Point Ramp Rate which has been tested and validated during Grid Code Compliance testing (i.e. Lower of 10 MW/min and Registered Capacity per minute)
- **Minimum Stable Generation** must be submitted as zero
- **Loading / de-loading characteristics** (which only apply between zero and Minimum Stable Generation and vice versa) will not apply.

2.5. Scheduling

The Operational Scheduling process includes LTS, RTC, and RTD sequences, each incorporating extensive system and unit data. Operational scheduling aims to minimise the cost of deviating from PNs while satisfying all system and unit constraints. The resulting schedules are indicative, and actual dispatch may differ (for many reasons, not least of which is that real-time system conditions rarely align fully with forecasts in operational scheduling).

Following SDP_02 go-live, it will be possible to include battery units more effectively in schedules by allowing scheduling to their submitted PN in both positive and negative MW ranges. For SDP_02, the scheduling optimisation will not optimise the output of batteries with respect to their energy limits but can (under normal conditions) be scheduled using the “follow PN” functionality i.e. the ability to schedule units to their submitted PN. Functionality allows that each battery unit can be designated as “follow PN” or not.

Key features of the SDP_02 solution with respect to scheduling include:

- Operational scheduling will now utilise both charging and discharging states. Previously in operational scheduling, charging could not be taken into account.
- Battery units can be considered “ON” at 0 MW output within the operational scheduling process.

- When “follow PN” is enabled, a battery’s schedule will follow its latest submitted PN. This is implemented as a soft constraint in the optimisation process, meaning it may be breached if essential to ensure a feasible operational scheduling solution.
- If “follow PN” is disabled, the battery unit is marked unavailable for that Operational Scheduling Run. This does not mean that the unit is also excluded from dispatch. The reasons for this are outlined in Appendix B.
- Scheduling optimisation will include the contribution to reserve needs from battery units. For further detail see section 2.5.3.

2.5.1. 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.

2.5.2. PN Feasibility Assessment

The effectiveness of the “follow PN” approach for battery units depends on participants submitting physically feasible PNs. Assessing the feasibility of PNs for battery units is more complex than for non energy limited plant. Hence, a new PN Feasibility Assessment Display will provide Control Centre Engineers with visibility of each battery unit’s projected state of charge (SoC), operating limits, remaining export energy (MWh), and remaining import energy (MWh) based on the submitted PN.

The PN Feasibility Assessment Display will enable Control Centre Engineers to assess whether a unit can follow its PN within operational constraints. If a PN appears infeasible, Control Centre Engineers may wait for updated submissions closer to gate closure or contact the participant to resolve the issue. If the PN remains infeasible, the unit may be removed from “follow PN” treatment and excluded from operational scheduling. This does not mean that the unit is also excluded from dispatch.

The TSOs have formulated the flow chart in Figure 2 to cover scheduling, dispatch, and declarations of battery units, based on the outcome of discussions with industry and RAs at the TSC modifications meetings. The TSOs will make all reasonable endeavours to follow the process set out in Figure 2.

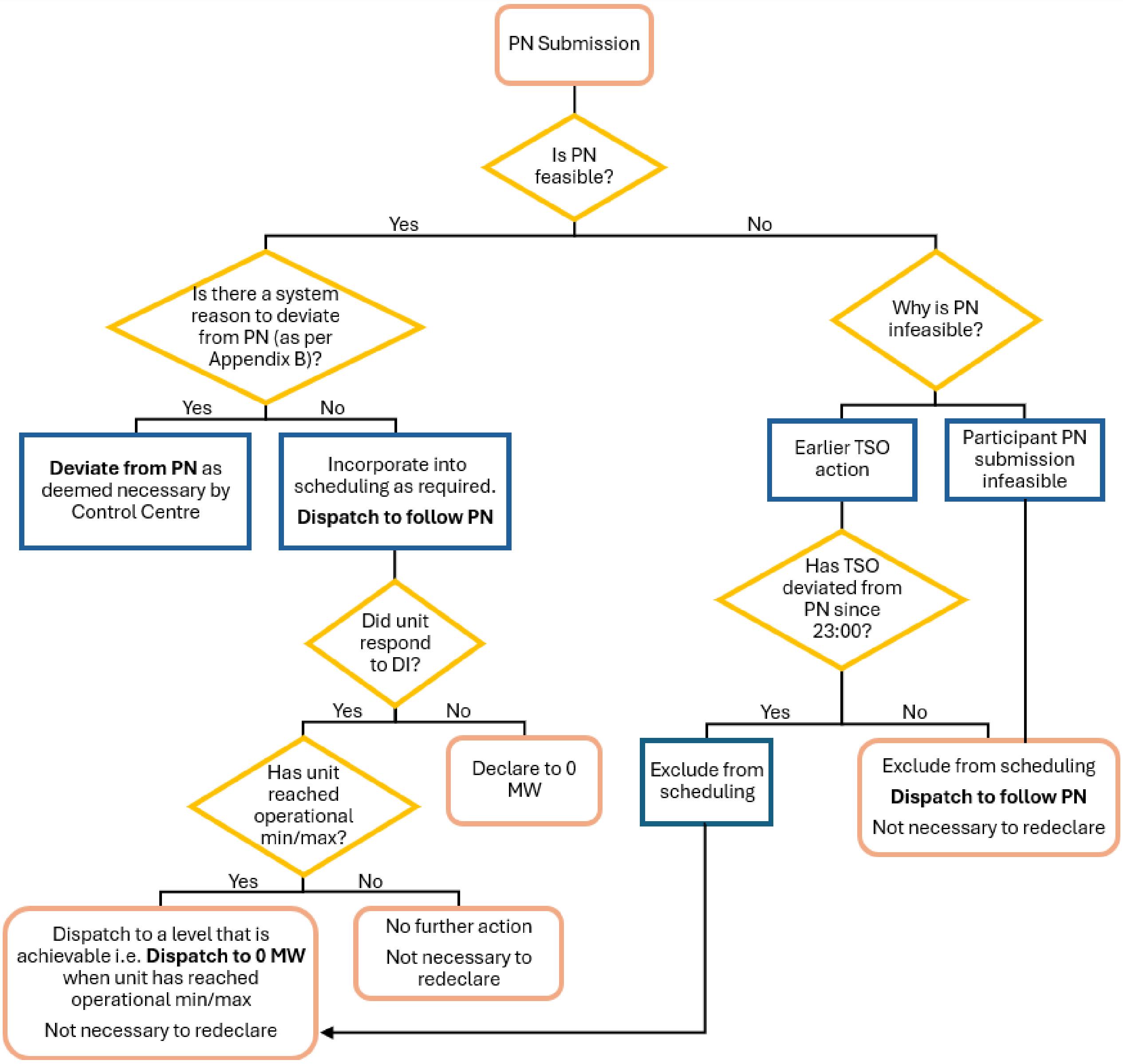

Figure 2: Illustrative Flow Chart for Scheduling, Dispatch and Declarations based on PN Feasibility.

Where PNs are assessed to be feasible:

- If PNs are feasible, and there is no system reason (outlined in Appendix B) to deviate from PNs, TSOs will dispatch to follow the submitted PNs
- If a battery unit does not respond to these dispatch instructions, it must declare unavailable via EDIL until it is capable of responding to instructions as issued by the TSOs (for further detail on Availability Declarations, see Section 2.6.2)
- TSOs will dispatch to 0 MW if the unit has reached its Operational Minimum/Maximum Storage Quantity and it is not necessary to redeclare in EDIL.

Where PNs are assessed to be infeasible:

- If PNs are infeasible, the resulting action depends on the reason for the infeasible PNs
  - If the PNs are infeasible due to a TSO action earlier in the Trading Day i.e. since 23:00, TSOs will dispatch to 0 MW once the unit has reached its Operational Minimum/Maximum Storage Quantity and it is not necessary to redeclare in EDIL.

This treatment is in line with the direction from the RAs following the TSC modifications process i.e. “if later PNs in the trading day are infeasible due to earlier TSO actions, the TSO will dispatch the unit away from those infeasible PNs”.

- If the PNs are infeasible due to A) a TSO action that happened prior to the beginning of the Trading Day or B) the PN submission was not feasible in its own right, then the TSOs will under normal circumstances (i.e. those not listed in Appendix B) dispatch to follow PN and it is not necessary to redeclare in EDIL. This is to ensure the TSOs do not incur imperfections costs due to the submission of infeasible PNs.

Note: Repeated submission of infeasible or inappropriate PNs will be formally escalated to the Market Monitoring Unit.

2.5.3. Reserve Contribution

The contribution from battery units to reserve will now be included within Indicative Operational Scheduling, with contributions determined by their reserve capability curves, state of charge (SoC), and real-time availability. These curves may include negative MW outputs and span continuously through 0 MW. Batteries can provide the following system services, in order of priority: FFR, POR, SOR, TOR1, TOR2 and negative reserve depending on operational policy. This means for SOR, TOR1, and TOR2 reserve contributions assume prior activation of all preceding reserve categories.

To accommodate the “follow PN” schedule, reserve contributions from batteries are pre-processed before scheduling optimisation. This pre-processing uses the submitted PN and forecast available energy for each interval to pre-determine how much reserve can be contributed for each battery unit. Reserve optimisation for other unit types remains unchanged as detailed in the BMPS.

2.6. Dispatch and Merit Order Lists

A battery unit must be capable of complying with any instruction within its operating range. A participant must respond to either:

- a dispatch instruction via EDIL, or
- a MW set point issued by the TSO via SCADA (if EDIL is unavailable).

Battery units are also expected to respond automatically during system frequency events, in line with the unit’s system services capabilities and frequency response mode.

Battery units will appear in the online merit orders based on submitted Simple COD, as is the case for other generator units. They will appear in the offline merit order only in cases where they are returning from outage (as they are otherwise assumed to be ON, including at zero MW).

Battery units will not be dispatched away from PNs based on the TSOs’ merit orders alone. As far as is possible, battery units will be dispatched by the TSOs to “follow PNs”.

When set to “follow PN”, dispatch instructions can be automatically generated by market systems to match PN values and will be reviewed and approved by the TSOs before being issued via EDIL. Control Centre Engineers may also manually create or amend dispatch instructions if needed. If one of the scenarios outlined in Appendix B occurs, the TSOs may dispatch a battery unit away from its PN, using the online merit order as decision support.

As agreed during the TSC modifications process, battery units will retain the ability to trickle charge up to 1 MW i.e. they will be permitted to charge at up to 1 MW without a dispatch instruction. For any greater charge quantity, a unit must first receive a dispatch instruction from the TSOs.

2.6.1. Energy Management System (EMS)

In exceptional circumstances, Control Centres may take direct control of a battery unit's output via the EMS. In such cases, the TSO may issue set points directly to the battery control system using functionality called Active Power Control (APC) in Ireland or Emergency Action in Northern Ireland. When either APC or Emergency Action is active, the corresponding set point overrides any instruction issued via EDIL.

Additionally, Frequency Response Mode can be configured, and reactive power (MVAR) or voltage (kV) set points issued to the battery control system via EMS. This is existing functionality, with no changes to participant control systems expected as a result of SDP_02.

Real time availability signals for active power (import/export) and reserve products will continue to be transmitted to the TSOs via SCADA, providing situational awareness to the control centres. These declarations dynamically reflect the remaining energy available throughout the day.

The real-time reserve contribution of battery units will be included in the total and jurisdictional reserve calculation within EMS. These real-time contributions are determined using real-time availability signals (mentioned above), EDIL declarations, state of charge, and reserve capability curves.

2.6.2. Electronic Dispatch Instruction Logger (EDIL)

Battery units must be capable of interacting with EDIL to declare availabilities and to acknowledge / respond to Dispatch Instructions. This functionality is essential for real-time communication with the Control Centres and general auditability.

Following the implementation of SDP_02, EDIL operations will support the full output range of batteries including both charging and discharging. Key dispatch instructions relevant to battery units include:

- SYNC = instruction to synchronise to the grid (for battery units will indicate return to service after outage).
- MWOF = instruction to go to a level of [x] MW and to stay there until a further instruction is issued. Battery units will be considered "ON" except when on outage, meaning that once synchronised, only MWOF instructions (including to 0 MW) will be issued until de-synchronised for an outage.
- DESY = instruction to disconnect from the system for an outage.

Battery units will also be able to submit negative declarations where relevant, particularly for the following field: Minimum Generation Available MW (MNMW).

The TSOs will submit data for the following fields, which will also accept negative declarations, on behalf of participants during registration: Reserve Provision Threshold MW (RPT) and Name Plate Rated Minimum Output MW (PMNMW).

Availability Declarations

Battery units declare availability through both EMS and EDIL, each serving distinct purposes. As set out during the TSC modifications process for the SDP_02 initiative, batteries should not have to redeclare availability in EDIL following a TSO deviation from PN.

To clarify how this will be enacted in operations, the following principles apply to availability declarations via EDIL:

1. Participants are not required to redeclare availability via EDIL when a unit has exhausted its stored energy.
2. Participants may choose to declare zero availability to import/export if their submitted PN is infeasible. This is not mandatory.
3. Participants must redeclare availability via EDIL if the unit's export or import capability is reduced e.g. a battery unit has lost some inverters and has partial loss in MW capability.
4. If a participant refuses to respond to a dispatch instruction within the required timeframe, they must declare unavailable via EDIL until they are capable of responding to instructions as expected.

When a battery unit is on outage, positive and negative energy and ancillary services availability must be declared as zero via EDIL. As the unit returns to service, each availability category should be updated to reflect non-zero values, in line with its operational capability.

Real time availability signals will continue to be transmitted to the TSOs via SCADA/EMS allowing the unit to meet its grid code obligation of availability reflecting a unit's actual ability to export or import power.

Availability declarations are essential for accurate pricing and settlement of both the balancing market and system services arrangements (currently DS3). Balancing market settlement and pricing rely exclusively on EDIL availability declarations. System services settlement, by contrast, considers both EMS and EDIL declarations to ensure payments are made only when sufficient energy was available to deliver the contracted service.

2.7. Imbalance Pricing

As battery units will as default be configured to "follow PN", there will generally be no balancing actions to consider. In situations where dispatch deviates from PNs, all actions included in pricing processes[5] will be SO flagged (as deviating from PNs will primarily be for non-energy reasons, including system security). In such circumstances where dispatch deviates from PNs, this means that (consistent with all other units):

- Actions included in the pricing process will initially be flagged out of pricing

[5] Bid Offer Acceptances less than the De Minimis Acceptance Threshold (DMAT) are excluded from the final price setting process as per TSC E.1.1.2.

- 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 or below DMAT).

2.7.1. Instruction Profiling

Instruction Profiling of dispatch instructions for battery units will be carried out similarly to other generators, covering their full range of operation including charging and discharging. SYNC instructions and MWOF instructions will be profiled in either the positive or negative output range. Battery units will be considered "ON" except when on outage, meaning that once a SYNC instruction is issued, only MWOF instructions (including to 0MW) will be issued until de-synchronised for an outage.

2.7.2. Flagging and Tagging

Following engagement with RAs and industry, it was decided that where dispatch deviates from PNs, these actions will be System Operator (SO) flagged. This is to reflect the fact that battery units will primarily be dispatched to follow PN, 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 in accordance with the merit order lists) for the reasons described in Appendix B.

This SO flagging will be implemented using an existing, manually maintained list of units 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, if they are included in pricing processes, 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.

2.7.3. Price Determination

As a result of the SO flagging described above, battery units 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 (currently set to 10MWh) of the highest (for a positive NIV) or lowest (for a negative NIV) priced energy actions following this process.

2.8. Settlement

2.8.1. Commercial Offer Data Selection (Settlement)

As explained earlier, “follow PN” would result in no balancing actions but the SDP solution allows for the TSOs to dispatch away from PNs when necessary, as outlined in Appendix B. To prevent participants from taking advantage of situations where they might anticipate future dispatches based on earlier TSO actions, Complex prices will primarily be used for settlement. Commercial Offer Data for settlement purposes is selected as per the process outlined in TSC F.3.3.2.

- All actions on battery units with a volume greater than DMAT will be SO flagged, and this will enable these actions to be settled on Complex COD.
- Actions on battery units with a volume less than DMAT will not be SO flagged[6] (as such volumes are excluded from the Imbalance Pricing process) and may therefore be settled on Simple COD depending on the outcome of the NIV tagging process.

2.8.2. Balancing Market Settlement

This section describes how balancing market settlement will be performed for battery units, as outlined in Mod_02_24 and post SDP_02 go-live. Settlement, including Instruction Profiling of dispatch instructions will cover the full range of operation, both charging and discharging. Imbalance Payment or Charge (CIMB)

CIMB will be applied as it is for all Generator Units; meaning that differences between metering and ex-ante quantities will be settled at the Imbalance Price. This will apply when charging and discharging. Prior to SDP_02, different treatment applied while battery units were charging.

CPREMIUM

CPREMIUM will be calculated as it is for all Generator Units and will apply across the full operating range of each battery unit. COD selection will be as outlined in section 2.8.1.

CDISCOUNT

CDISCOUNT will be calculated as it is for all Generator Units and will apply across the full operating range of each battery unit. COD selection will be as outlined in section 2.8.1.

- The outcome of the availability declaration arrangements agreed during the TSC modification process and as described in Section 2.6.2, means that if a battery unit does not declare unavailable in EDIL, then decremental actions from PNs that have become infeasible as a result of TSO actions will receive CDISCOUNT payments in addition to a CIMB charge. If the unit declares unavailable in these cases, no CDISCOUNT is paid and only the CIMB charge would apply.

[6] As per F.3.3.2 of the Trading and Settlement Code, in the absence of a value for the period resulting from the process outlined in Chapter E (Imbalance Pricing) a value of one shall be used.

- Firm access will be applied as it is for other units, in that no CDISCOUNT will be paid for non-firm volumes. Existing logic also ensures that quantities below zero will never be settled as non-firm.

Uninstructed Imbalance Charge (CUNIMB)

Uninstructed Imbalance charges are based on undelivered quantities and uninstructed imbalance tolerances. Following SDP_02 go-live, this will be applicable to battery units while charging and discharging. Prior to SDP_02, there was different treatment while battery units were charging.

Note: the tolerances within the Uninstructed Imbalance calculation (1 MW at present) may be used by battery units to trickle charge to avoid operating at a dangerously low level of charge as described in Section 2.6.

Fixed Cost Payment or Charge (CFC)

Battery units will be mandated to submit zero Start Up Costs and No-Load Costs. As a result, 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 (CTEST)

CTEST will be calculated for battery units in a manner that ensures it is always applied as a charge (meaning that all testing volumes will be subject to the Testing Tariff rate). When metering is positive it is multiplied by -1, when metering is negative it is used as-is in the calculation.

Other Charge Components

All other applicable charge components will be applied in the same way as conventional Generator Units in accordance with the TSC.

3. Day in the Life

As part of the industry engagement with respect to the Scheduling and Dispatch Programme, "Day in the Life" overviews have been a valued part of each initiative highlighting the key stages of the proposed approach. Figure 3 sets out the "Day in the Life" for battery units post approval of Mod_02_24 and SDP_02 go-live.

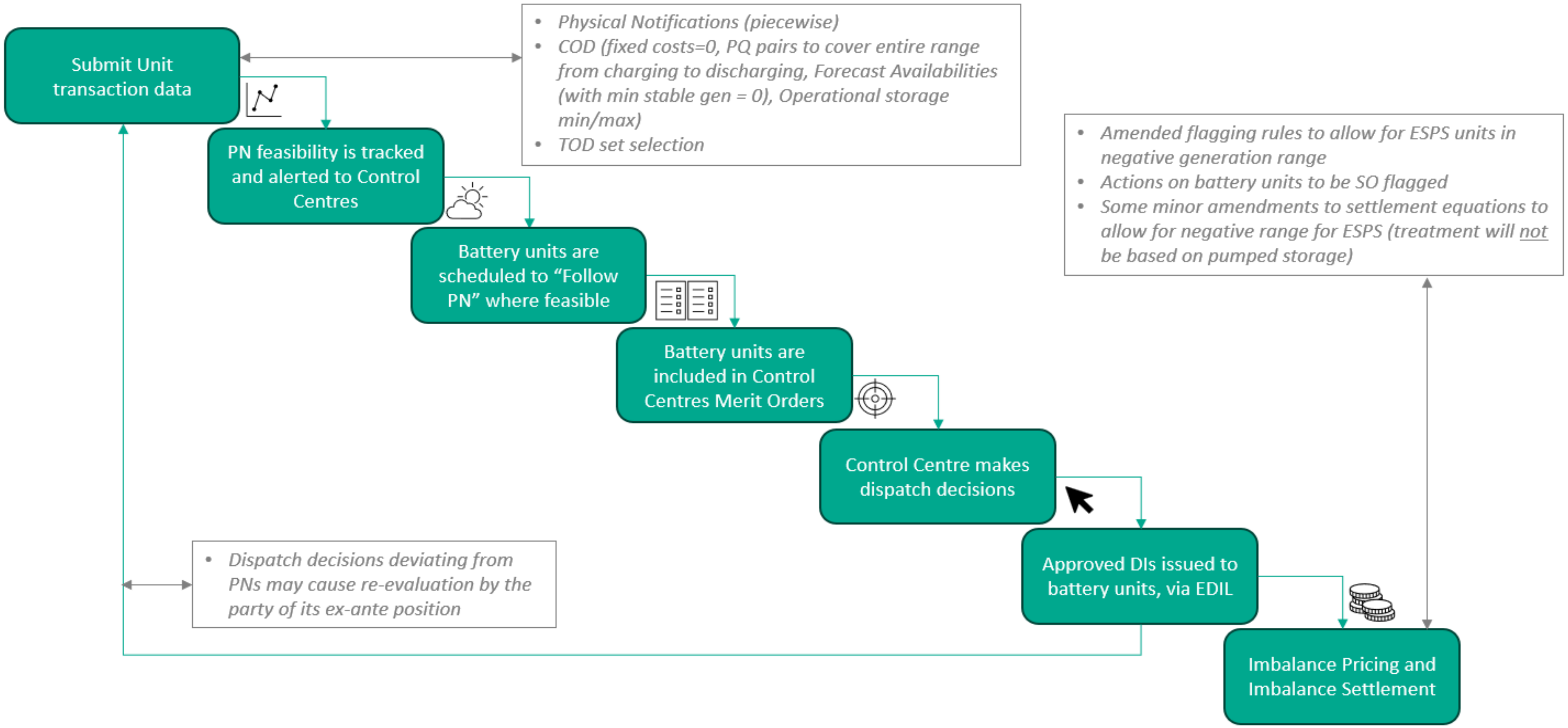

Figure 3: SDP_02 "Day in the Life"

Table provides further explanation of the key stages of the "Day in the Life" diagram, highlighting how battery units will be treated. The obligations described below are set out in the TSC and Grid Code.

Table 6 : Explanation of SDP_02 "Day in the Life"

"Day in the Life" stage	Explanation

Submit Unit transaction data	**Physical Notifications** should be submitted to cover the full operating range of the battery unit i.e. charging and discharging. PNs must be physically feasible with respect to the unit's projected state of charge.
	
	Commercial Offer Data:
	• Fixed Costs (Start Up Costs and No Load Costs) must be zero
	• Price Quantity Pairs should be submitted to cover the full operating range of the battery unit.
	• Forecast availability limits to be submitted as follows:
	  ○ Forecast Availability Profile will be > 0 (representing discharging) when available and 0 when unavailable / on outage.
	  ○ Forecast Minium Output Profile will be < 0 (representing charging) when available and 0 when unavailable / on outage.
	  ○ Forecast Minimum Stable Generation will be 0.
	• Battery units can optionally submit Operational Minimum and Maximum Storage Quantities; if not provided, the system will default to the registered Minimum and Maximum Storage Quantities.
	
	Technical Offer Data for battery units will consist of the same fields as generator units, albeit some will be optional as they are not relevant to battery units. Additionally, battery unit will submit a Storage Cycle Efficiency field.
	
	EDIL declarations to reflect MDMW ≥ 0 (upper availability limit) and MNMW ≤ 0 (lower availability limit)

PN feasibility is tracked and alerted to Control Centres	• As decision support, a PN Feasibility Assessment Display is being introduced, providing Control Centre Engineers with visibility of each battery unit's projected state of charge (SoC), operating limits, and remaining export energy (MWh), based on the submitted PN. This display will enable Control Room Engineers to assess whether a unit could reliably follow its PNs within operational constraints.

“Day in the Life” stage	Explanation
Battery units are scheduled to “Follow PN” where feasible	• Control Centre Engineers can designate each battery unit as “follow PN” or not based on feasibility of PN submission or other forecasted system conditions. • Battery units may be included in Indicative Operations Schedules by allowing scheduling to their submitted PN in both positive and negative MW ranges.
Battery units are included in Control Centre Merit Orders	• Battery units will appear in the online merit orders based on submitted Simple COD, as is the case for other generator units. They will appear in the offline merit order only in cases where they are returning from outage.
Control Centre makes dispatch decisions	• When set to “follow PN”, dispatch instructions can be automatically generated by market systems to match PN values and will be reviewed and approved by the TSOs before being issued via EDIL. Control Centre Engineers may also manually create or amend dispatch instructions if needed to meet system needs. • Control Centre Engineers may dispatch a battery unit away from its PN, using the online merit order as supporting information, for any of the reasons outlined in Appendix B. • Otherwise, battery units will be dispatched to “follow PN”
Approved DIs issued to battery units, via EDIL	• When set to “follow PN”, dispatch instructions can be automatically generated by market systems to match PN values and may be reviewed and approved by the TSOs before being issued via EDIL. Control Centre Engineers may also manually create or amend dispatch instructions if needed.
Imbalance Pricing and Imbalance Settlement	• Where dispatch deviates from PNs, all actions included in pricing processes (i.e. volumes greater than DMAT) will be SO flagged. • Instruction Profiling will be carried out similarly to other generators but covering the full range of operation, charging and discharging. • Minor amendments have been made to settlement equations to allow for balancing market settlement to be performed accurately across their full operating range.

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 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 reserves 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 now 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

The TSOs will need to deviate from PNs at times in order to maintain system security. The sections below list the most common scenarios where such deviations occur.

B.1. 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.

Table 7: Scenarios Where the TSO Will Deviate From PNs

Alert or Emergency State	If a battery unit's PNs would exacerbate a system alert situation or dispatching away from PN 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 (i.e. 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 Trading Day i.e. since 23:00, the TSOs will make reasonable endeavours to dispatch the unit away from PNs to an achievable level given its state of charge. This is described in further detail in Section 2.5.2 and

	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.

B.2. 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.

Table 8: Scenarios Where the TSO May Deviate from PNs.

High Frequency Response	Battery units have a capability to respond downwards (to charge) in response to high-frequency events which may occur on the power system. In order for the Control Centres to realise these benefits they may have to deviate from PN to ensure sufficient "foot room" is kept both from a MW and MWh perspective (e.g. Limiting state of charge below a certain level). This may be done to reduce dispatch down of priority dispatch units or in order to secure the system against other contingency conditions.
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.