Public

Guidance on Baseline and Meter Data Approaches for Dynamic Response

Battery and Site Load Co-Located Scenario

December 2025

NESO
National Energy System Operator

This guidance is designed to enable battery and site-load co-located assets to participate effectively in Dynamic Response (Dx) markets. NESO invites industry participants and stakeholders to review this guidance and submit any comments, concerns, or feedback. The consultation period will remain open for one month, **until 31 January 2026**.

All feedback on this guidance should be sent to Box.futureofbalancingservices@neso.energy.

Following the review and consideration of all feedback received within the consultation period, a final version of this guidance will be published.

Contents

1. Introduction

This paper sets out approved configuration arrangements that enable eligible assets to participate in Dynamic Response (Dx) markets while maintaining the high standards of performance monitoring, situational awareness, and fairness required by NESO. Its primary purpose is to clearly articulate three permitted solutions for baseline and metering data submission, each of which has been assessed and approved for use in specific site configurations. These permitted solutions are presented and explained in detail in **Section 2 Permitted Solutions**, supported by illustrative diagrams that show the associated energy and information flows.

In addition to the three approved solutions, the paper also provides supplementary material to support transparency and stakeholder understanding. This includes background information on Dynamic Response services in the context of a lower-inertia system, the assessment criteria used to evaluate different approaches, and a detailed discussion of alternative options that were considered but not approved. These additional approaches, along with the rationale for their rejection, are documented in the Appendix.

When developing the solutions and assessment, the following assumptions are made:

Site Configuration

- Sites are assumed to comprise controllable assets (i.e., battery storage) co-located with variable loads, connected behind a single boundary meter.
- Each site is assumed to have a single point of connection to the distribution or transmission network.

Metering and Data

- Where DC meters are used, all DC-AC conversions are assumed to follow NESO agreed and validated loss-adjustment methodologies.
- Where derived data (e.g., loss-adjusted AC equivalent values) are used, these are assumed to be calculated from measured inputs by asset providers and sent to NESO after derivation.
- Operational metering data and performance monitoring active power are assumed to correspond to the same electrical point, i.e., the same grid connection point and the same side of a transformer or inverter.

Service Delivery and Monitoring

- The Dynamic Response services provided by co-located BESS are assumed to operate under current Service Terms, performance monitoring methodologies, and settlement processes.

Taken together, this guidance clarifies NESO's expectations, supports consistency across providers, and provides a clear reference for developers and operators when designing site configurations and metering arrangements for Dynamic Response participation.

2. Permitted Solutions

2.1 Current approach

The diagram below shows the assumed flow of information and energy from different elements of current battery-based units. Green lines represent measurable energy flow(s) and orange lines represent data connections through which signals are sent from controllers.

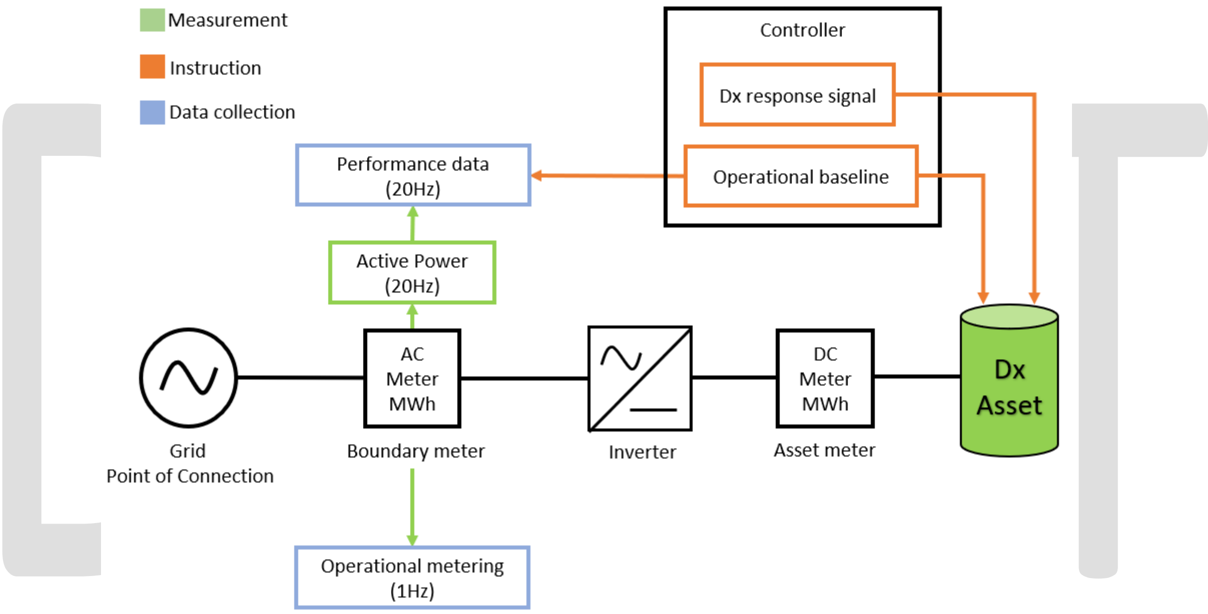

Figure 1: Diagram of information and energy flows on current sites.

This diagram is not exhaustive as it does not show the source of all performance monitoring variables such as the measured frequency, availability flag, armed flag. These variables, which are not relevant to the discussion, have been omitted for simplicity.

Performance monitoring data

In the performance data submitted by service providers there are two variables that are used to determine the response provided, i.e., **Active Power and Baseline**. The baseline value in performance monitoring data is the operational baseline as defined in the Service Terms.

- **Baseline**: operational baseline value reported in performance data is based on the signal sent to the unit prior to any adjustments for dynamic response. This includes any PN, BOA, and non-Dynamic Response Service obligations.
    - The Baseline is a controller **signal**

- **Active Power**: The power flow of the unit to/from the grid as measured at the grid connection point.
    - The Active Power is a **measurement**

When the unit is not providing dynamic response, then the baseline and active power values are expected to be equal.

Performance monitoring calculations

In performance monitoring, the dynamic response delivery is extracted from the submitted data and assessed against the performance bounds. This is achieved by using the baseline and active power values submitted in the performance data.

The formula

$$\textit{active power}_{mw} = \textit{baseline}_{mw} + \textit{response}_{mw}$$

is re-arranged to extract the response:

$$\textit{response}_{mw} = \textit{active power}_{mw} - \textit{baseline}_{mw}$$

The formula only includes one unknown variable, the DX delivery. It is derived using information on what the unit was doing in real time (active power) minus its expected baseline.

This means that any deviations from the baseline are counted as a part of the dynamic response. Therefore, any deviations from the expected baseline that are not response delivery are then translated into penalties in the performance monitoring methodology.

Gaming checks calculations

In order to further enhance confidence in service delivery, NESO has developed a suite of gaming checks. These checks can be used to assess confidence levels in alternative approaches to baseline submission such as varying baselines that may create an opportunity for units to game or manipulate their data. These gaming checks help verify the robustness of data through validation and identifying anomalous behaviours.

These checks can be divided into two categories. Basic checks and anomaly detection checks.

- Basic checks:
    - Correlation between baseline and ideal response.
    - PM vs Operational Metering (OM) active power outside threshold.
    - Reported active power vs ideal response outside performance bounds.
- Anomaly detection checks:
    - Reported vs expected baseline.
    - Reported active power vs ideal response + baseline.
    - Unavailability behaviour.

- Price incentives reactions.
- PM vs OM active power.

Many of these checks require that the data submitted by Operational Metering (OM) and the Active Power in the performance data correspond to the same reading. If these two values refer to differing power flow values, then the checks have limited usefulness or cannot be performed. The same applies to the baseline checks. If the expected baseline (PN) and the baseline reported in the performance data do not align, some of the checks are not possible.

2.2 Solution 1

Different from the current approach, this solution relies on an additional meter, connected with the ancillary load directly, to discern between battery and ancillary load behaviour through measured data. It allows for more confidence in delivery and a more equal treatment.

Further information on applicable site configurations is provided in the *NESO Positions* section of this document.

Diagram

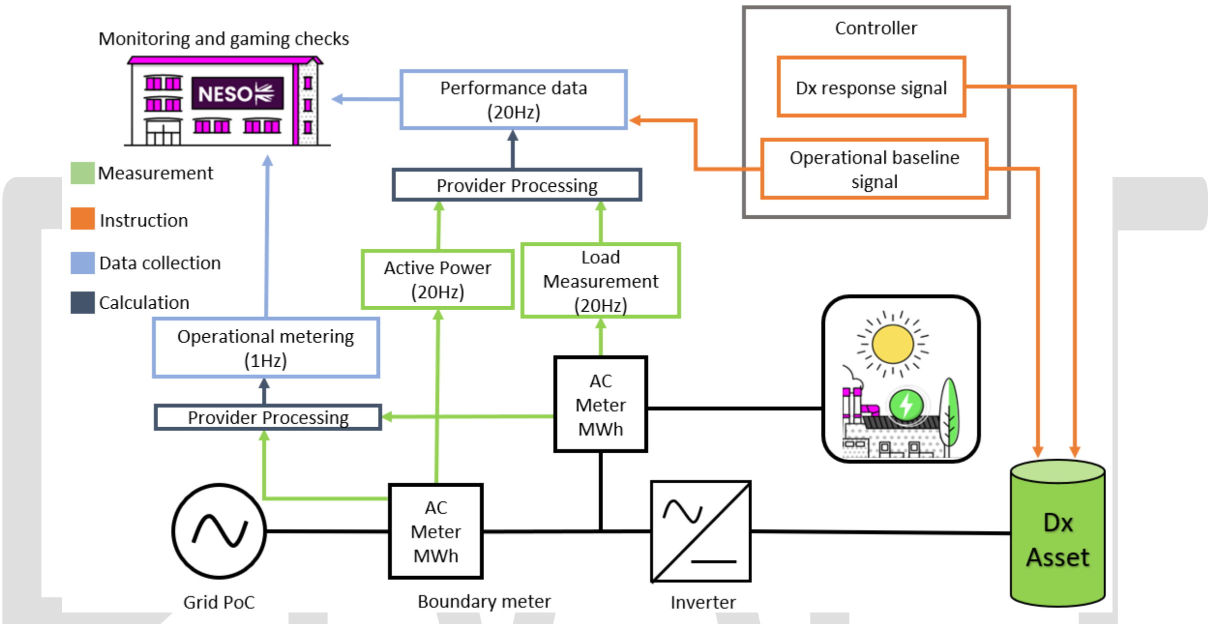

Figure 2: Diagram of information and energy flows for Solution 1 sites.

Description

In this solution, boundary meter is required to deliver 20Hz, but additionally there is a meter on the ancillary load. The complexity and cost of the solution is highly dependent on whether the ancillary load is coming from a single source or whether it is distributed, and the difficulty to install such a meter or meters.

The performance monitoring data submitted in this solution is derived from the signals sent to the battery and one derived value submitted to NESO.

- Battery Baseline is a **signal**
- Battery Active Power can be derived from **measurements**
  - Battery Active Power is the difference between Site Active Power (a **measurement**) and Ancillary Load (a **measurement**).

Performance monitoring data include 20 Hz measured active power for the purpose of assessing site behaviour during system events. NESO requires that submitted performance monitoring data clearly distinguishes the battery baseline from any co-located ancillary load. A single, combined site baseline must not be used to allow for good situational awareness for post event investigations. Therefore, the battery baseline needs to be reported as a separate variable to enable accurate assessment of dynamic response performance.

The performance data submitted by the unit includes both Battery baseline and the active power. This means that the performance data and operational metering data should align, as OM data needs to be equivalent to the active power submitted for performance monitoring. The gaming checks that rely on comparing live operational data to post-delivery metering data could therefore be used to detect gaming and anomalous behaviours.

Therefore, NESO requires that operational metering data submitted for DX operational awareness provides battery-specific visibility. Operational metering data representing whole-site active power, including co-located load, should not be used as the operational signal for the dynamic response asset.

2.3 Solution 2

Like Solution 1, this solution relies on an additional DC or AC meter installed on the BESS to distinguish battery behaviour from ancillary load behaviour through measured data. This enables greater confidence in delivery and ensures equal treatment across participants.

Where an AC-side meter is used, the performance monitoring process aligns with the current approach. Accordingly, the remainder of this section focuses on the metering requirements for a DC-connected BESS. Further information to make this route available are covered in next steps in this document.

Diagram

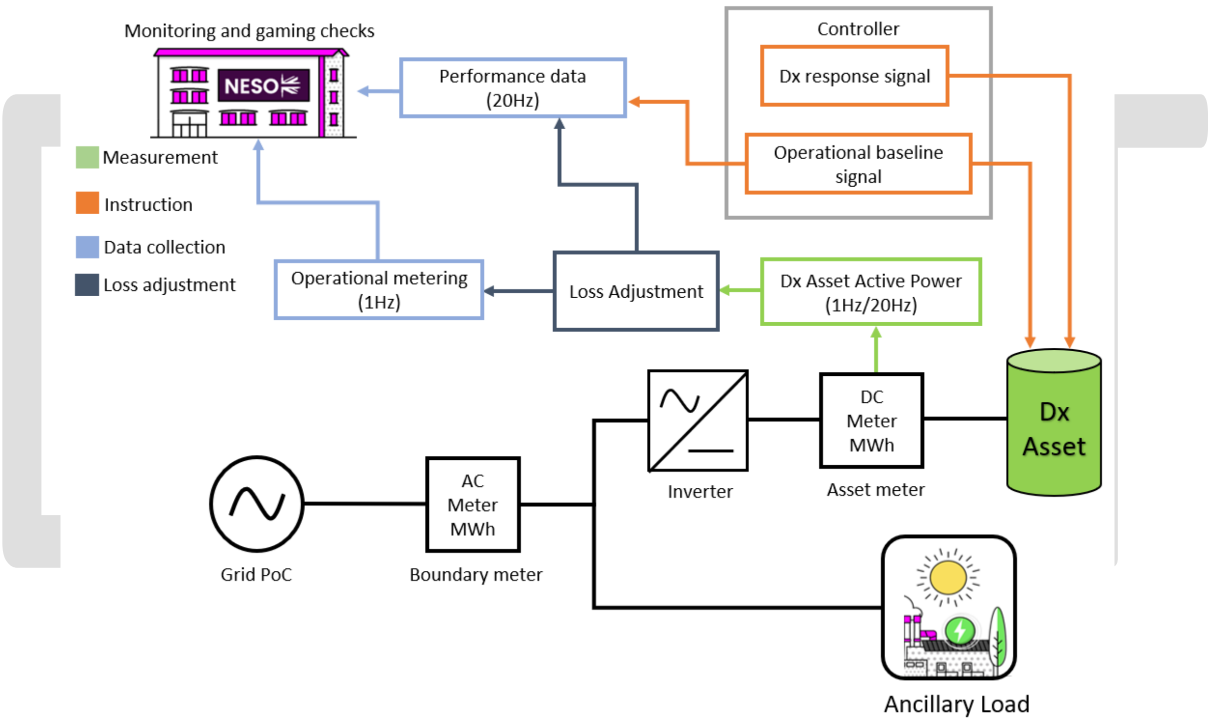

Figure 3: Diagram of information and energy flows for Solution 2 sites.

Description

Points to note:

- The Dx asset needs to adjust its output while considering the change in DC to AC conversion losses.
- The methodology according to which the loss adjusted values, from DC to AC equivalent, are calculated will need to be approved by NESO.

This solution has similar hardware requirements to Solution 1. The additional meter sits on the battery, which could be either an AC or DC meter, depending on what is most suitable for the site. If the meter is a DC meter, a loss adjustment methodology will have to be provided and agreed with NESO to obtain a loss adjusted AC equivalent measurement. The loss adjusted AC equivalent measurement will then be used in the performance monitoring calculations. The complexity and cost of the solution is highly dependent on whether the battery units are grouped together or whether they are distributed, and the difficulty to install such a meter or meters.

The performance monitoring data submitted in this solution is derived from the instructions sent to the battery and one measured value send to NESO.

- Battery Baseline is a controller **signal**
- Battery Active Power is a **measurement** or **loss adjusted measurement**

Performance monitoring data includes 20 Hz measured active power for the purpose of assessing site behaviour during system events. NESO requires that submitted performance monitoring data clearly distinguishes the battery baseline from any co-located ancillary load. A single, combined site baseline must not be used to allow for good situational awareness for post event investigations. Therefore, the battery baseline needs to be reported as a separate variable to enable accurate assessment of dynamic response performance.

The performance data submitted by the unit includes both Battery baseline, Battery and Site active power. This means that the performance data and operational metering data should align, as OM data would be equivalent to the active power from performance monitoring. The gaming checks that rely on comparing live operational data to post-delivery metering data could therefore be used to detect gaming and anomalous behaviours.

NESO requires that operational metering data submitted for DX operational awareness provides battery-specific visibility. Operational metering data representing whole-site active power, including co-located load, should not be used as the operational signal for the dynamic response asset. Given that DC meters connect with the battery, NESO requires providers to submit loss-adjusted operational metering data that represents the output/input of BESS at the boundary point, derived from DC metering. This operational metering data shall exclude site load and must be suitable for real-time assessment of whether the BESS is delivering dynamic response in accordance with service requirements. In the testing and pre-qualification process, an AC boundary meter capable of 20Hz data is necessary to demonstrate the accuracy of the DC loss adjustment methodology proposed by the provider.

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2.4 Solution 3

Solution 3 covers a unique scenario, different from Solutions 1 and 2, where the Dx asset and the auxiliary load share a single inverter and thus are DC coupled.

We believe this solution can meet the requirements of the service against all the assessed criteria. However, we also believe that an acceptable implementation of this solution could require a high level of planning and effort due to the interconnectivity required between the various systems, and the complexity of the calculations that derive the loss adjusted AC equivalent metering from the controller signals and DC meter values.

Diagram

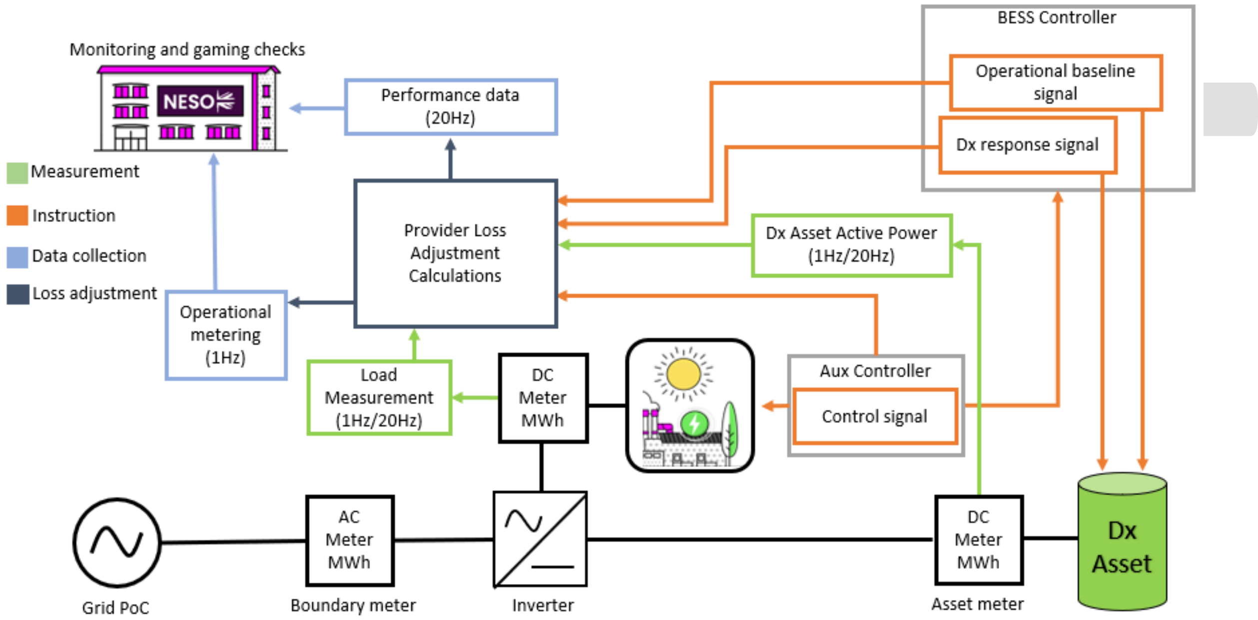

Figure 6: Diagram of information and energy flows for Solution 3 sites.

Description

The solution has more complex requirements than Solutions 1 and 2, especially when it comes to the data processing required The Dx asset and ancillary load both are coupled to a single DC to AC inverter, and each has their own DC metering measuring their flow.

The complexity and cost of the solution is highly dependent on whether the battery units and ancillary load are grouped together or whether they are distributed, and the difficulty to install such a meter or meters.

The performance monitoring data submitted in this solution is derived from the signals sent to the battery, the auxiliary load (if it is controllable), and two measured values. These data are processed via loss adjustment calculations by service providers before they send Battery Active Power and Battery Active Power to NESO.

- Battery Baseline is a controller **signal**
- Battery Active Power is a **loss adjusted measurement**
- Ancillary Load operating level is a controller **signal** (if the ancillary load is controllable)
- Ancillary Load is a **loss adjusted measurement**

The performance monitoring in this scenario is highly complex as the ancillary load and Dx asset are DC coupled to a single inverter with individual DC meters each. To correctly assess asset performance, we require a loss adjustment process to be applied by providers to the 20Hz DC meter readings from both Dx asset and ancillary load. The loss adjustment methodology needs to be agreed with NESO prior to participating in Dynamic Response services. In the testing and pre-qualification process, an AC boundary meter capable of 20Hz data is necessary to demonstrate the accuracy of the DC loss adjustment methodology proposed by the provider.

3. Applicability of Solutions Across Asset Registration Combinations

NESO recognises that the applicability of the proposed metering data submission approach of co-located assets depends on two key factors:

- The market registration status of the Dynamic Response asset (Balancing Mechanism Unit – BMU, or Non-Balancing Mechanism Unit – NBMU), which determines the level of visibility required by the Electricity National Control Centre (ENCC).
- The configuration and coupling type of the site (AC-coupled or DC-coupled).

These two dimensions together determine both the technical feasibility of each solution and the level of situational awareness required by ENCC.

Coupling Type – Technical Suitability

• **AC-coupled sites:**

For sites where either the Dx asset or any co-located load or generation is connected on the AC side, Solutions 1 and 2 provide technically suitable arrangements. These solutions use additional metering (either on the ancillary load or the battery asset) to derive measured active power and verify performance.

• **DC-coupled sites:**

For sites where the Dx asset and ancillary load share a single inverter and are coupled on the DC side, Solution 3 is the only technically feasible configuration. In these cases, performance monitoring requires DC metering and a validated loss-adjustment methodology to produce AC-equivalent measurements.

Registration Type – ENCC Situational Awareness

NESO's operational metering requirements differ depending on whether the asset is registered as a BMU or a NBMU, reflecting the level of situational awareness required by the ENCC.

Solutions 1, 2, and 3can, in principle, be applied to sites containing BMUs, and NBMUs. However, the site's coupling type (AC-coupled or DC-coupled) determines which solution is technically feasible and therefore acceptable.

For AC-coupled configurations, where the DX asset and any co-located load/generation are electrically separated on the AC side, Solutions 1 and 2 are the applicable arrangements to: BMU /BMU, NBMU/BMU, NBMU/NBMU sites.

For DC-coupled configurations, where both the Dx asset and the ancillary load share a single inverter, only Solution 3 provides the necessary capability and therefore applicable to: BMU/BMU, NBMU/NBMU sites. Mixed NBMU / BMU configurations are not compatible with Solution 3 due to its inability to maintain consistent metering granularity and visibility for the BMU component.

In conclusion, the final selection of the applicable solution is driven primarily by technical coupling type and site configuration, while BMU/NBMU registration status determines the level of situational awareness ENCC requires. This ensures fairness, transparency, and operational confidence across the Dynamic Response services

4. Next Steps for Participation

NESO encourages all potential service providers to engage early to confirm the suitability of their metering arrangements and site configuration for participation in Dynamic Response services.

• **For providers intending to adopt Solutions 1 or 2:** Providers wishing to pursue these configurations should contact the Balancing Services team to discuss onboarding, qualification testing, and data validation requirements. Further details will be provided in the published *Dynamic Response Testing Guidance*.

• **For providers interested in Solution 3:** Providers should first refer to the "Guidance on Enabling Asset Metering for Co-located Assets" (published on the NESO Market Roadmap webpage: Markets Roadmap | National Energy System Operator). If, after reviewing this guidance, providers require clarification or wish to confirm compliance of their proposed setup, they should reach out to the Balancing Services team for direct support.

Balancing Services can be contacted at commercial.operation@neso.energy.

5. APPENDIX

Background

Dynamic Frequency Response Services Dynamic containment (DC), Dynamic Moderation (DM) and Dynamic Regulation (DR) are essential services for the NESO to manage system frequency and operate a secure system. These services are procured through competitive day ahead auctions.

Mean average clearing prices for DC, DM, and DR for winter 2023/24 were 59%, 24%, and 65% lower than for winter 2022/23 respectively indicating good liquidity in dynamic response markets. Average clearing prices for Dynamic Services increased in winter 2024/25 compared to winter 2023/24. In order to continue to minimise costs to consumers, it is important that we make the markets accessible to the widest range of service providers as possible in order to facilitate competition. Where there are controllable assets that can technically deliver the service, we will explore changes we can make to enable wider participation whilst continuing to meet the core requirements of the service.

The criticality of these services drives the need for robust performance monitoring and situation awareness requirements. Such requirements are supported by baseline and metering data submission from service providers. Current baseline and metering data submission requirements in these markets have been identified as a barrier to entry for certain asset types and site configurations. In particular, controllable assets that can technically provide the service, but share a boundary meter with a variable load or generation, may not be able to provide the required metering or baseline data to support performance monitoring.

We have therefore conducted a thorough review of requirements in these areas. 5 different options for enabling participation of these types of sites have been assessed against standard criteria covering market access, confidence in delivery, situational awareness and level playing field.

The analysis and conclusions identify potential approaches to baselining and data submission that differ from current practices but highlight that the data provided through these approaches should be clearly derived from measured data. In effect, this means that where a controllable asset sits behind a boundary meter with a variable load or generation, measured data from one of these assets would need to be used as an input into the dynamic response performance monitoring data submission.

We would welcome any feedback on this report, particularly the assumptions regarding site set up and data flows in each scenario via commercial.operation@neso.energy..

NESO has proposed three feasible solutions in this guidance that support co-located sites with DC metering on the frequency response asset side, the load/generation side, or both. These solutions enable the accurate and fair participation of a Battery Energy Storage System (BESS) in dynamic response markets, which is co-located with load, subject to successful onboarding qualification and testing.

The Appendix also presents two additional options and their associated assessment processes; however, these options will not be accepted due to the difficulty of meeting performance monitoring requirements. Further details of the assessments are provided in the Appendix.

5.1 Dynamic Response Services in context

Changes in inertia

In the 2023 Frequency Risk and Control Report (FRCR) NESO proposed to reduce the minimum inertia requirement to 120 GVAs. The proposal was approved by Ofgem, and it was implemented in two phases in February 2024 (130GVAs) and June 2024 (120GVAs).

Lower inertia across the system results in a greater rate of change of frequency. To prevent the frequency from falling (or rising) too much too quickly, response needs to be delivered rapidly to restore the balance of power in time. The correct delivery of dynamic services, adhering to the maximum activation time and minimum ramp rate, is more important than under previous higher inertia conditions.

Another result of lower inertia is the greater fluctuation of frequency within operational limits. Dynamic Regulation and Dynamic Moderation are of greater importance for current system conditions compared to a higher inertia system.

Dynamic Response reforms must ensure that consumers are receiving value for the money spent on balancing services. This requires confidence in the data received that evidence service delivery. In addition, equal treatment and enforcement of rules and requirements are important to ensure a level playing field and a healthy competitive market.

NESO is implementing enhanced checks and monitoring to verify compliance of providers with the service terms.

5.2 Assessment criteria for examined solutions

For each of the examined data derived solutions we assessed the solution against four criteria.

Accessible markets

The solution should allow as wide a range of providers as possible into the dynamic response markets. It should be flexible to allow for a wide variety of site layouts and asset combinations. This should be achieved with the minimal amount of additional cost of necessary hardware and software implementation. Any additional requirement should be simple to fulfil. However, this is subject to a solution meeting three further criteria.

Confidence in delivery

It is important for NESO to be capable of verifying that contracted units performed according to the service requirement. This is achieved through performance monitoring. To ensure robust performance monitoring mechanisms, the data used to calculate the performance must be based on 'true' observed data. The solution should provide data that is measured so that the true delivery can be extracted, and it must be measured at a high enough resolution to identify any behaviours of interest.

Situational awareness

In real time operations, the ENCC requires good visibility of the availability and performance of contracted assets. This is particularly true for frequency response given the criticality of these services. In situations where assets are unavailable or are not delivering as expected, the ENCC needs to perform mitigating actions. If it is not possible to monitor the asset accurately, then the correct mitigating actions will not be taken. The solution should allow for live monitoring of the true behaviour of the unit.

When events occur on the network, NESO performs event investigations to determine the cause of the event and understand any effects it had on the system. This includes analysis of the dynamic response service delivery and behaviour. The high frequency of the performance data, and spread of units across the country, provide valuable benefit.

Level playing field for all providers

Any chosen solution should not allow for preferential treatment of any asset type. The solution must ensure that all the assets are held to the same standards and penalised in the same way for non-delivery or non-compliance with requirements.

5.3 All Examined Solutions and Assessments

Solution 1

Different from the current approach, this solution relies on an additional meter, connected with the ancillary load directly, to discern between battery and ancillary load behaviour through measured data. It allows for more confidence in delivery and a more equal treatment.

Further information on applicable site configurations is provided in the *NESO Positions* section of this document.

Diagram

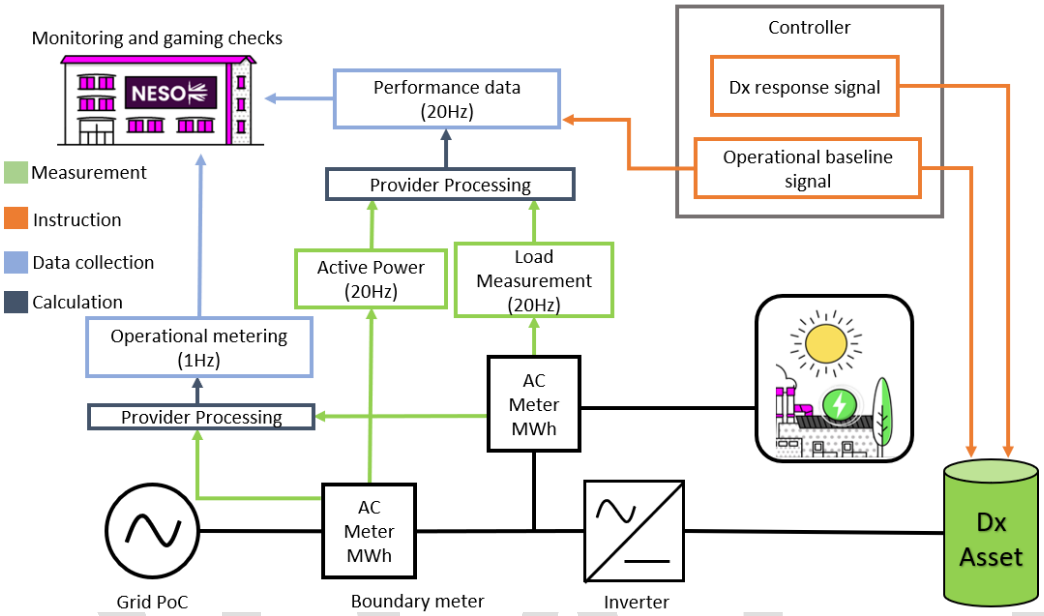

Figure 4: Diagram of information and energy flows for Solution 1 sites.

Description

In this solution, boundary meter is required to deliver 20Hz, but additionally there is a meter on the ancillary load. The complexity and cost of the solution is highly dependent on whether the ancillary load is coming from a single source or whether it is distributed, and the difficulty to install such a meter or meters.

The performance monitoring data submitted in this solution is derived from the signals sent to the battery and one derived value submitted to NESO.

- Battery Baseline is a **signal**
- Battery Active Power can be derived from **measurements**
  - Battery Active Power is the difference between Site Active Power (a **measurement**) and Ancillary Load (a **measurement**).

The performance monitoring data processing relies on measurements. As we can derive the dynamic response from measured data, instead of relying on signals. Using Site Active Power and Site Load we can extract the Dynamic Response:

$$\boldsymbol{response_{mw}} = \boldsymbol{site\ active\ power_{mw}} - \boldsymbol{site\ baseline_{mw}}$$

The site baseline includes the battery baseline and the ancillary load.

$$\boldsymbol{site\ baseline_{mw}} = \boldsymbol{ancillary\ load_{mw}} + \boldsymbol{battery\ baseline_{mw}}$$

Therefore, the response consists of two measurements and the battery baseline instruction.

$$\boldsymbol{response_{mw}} = \boldsymbol{site\ active\ power_{mw}} - (\boldsymbol{ancillary\ load_{mw}} + \boldsymbol{battery\ baseline_{mw}})$$

$$\boldsymbol{response_{mw}} = \boldsymbol{site\ active\ power_{mw}} - \boldsymbol{ancillary\ load_{mw}} - \boldsymbol{battery\ baseline_{mw}}$$

This is analogous to the current situation where response is derived using information on what the unit was doing in real time (active power) minus its controller signal baseline. Any deviations from the battery baseline are counted as a part of the dynamic response.

This makes performance monitoring effective. Any errors where the battery does not follow controller signals are translated into penalties in the performance monitoring methodology.

There is no preferential treatment compared to units following the current approach. We can identify non-compliant behaviour, and the unit will be penalised through lower k-factors and thus reduced payments.

Performance monitoring data include 20 Hz measured active power for the purpose of assessing site behaviour during system events. NESO requires that submitted performance monitoring data clearly distinguishes the battery baseline from any co-located ancillary load. A single, combined site baseline must not be used to allow for good situational awareness for post event investigations. Therefore, the battery baseline needs to be reported as a separate variable to enable accurate assessment of dynamic response performance.

The performance data submitted by the unit includes both Battery baseline and the active power. This means that the performance data and operational metering data should align, as OM data needs to be equivalent to the active power submitted for performance monitoring. The gaming checks that rely on comparing live operational data to post-delivery metering data could therefore be used to detect gaming and anomalous behaviours.

Therefore, NESO requires that operational metering data submitted for DX operational awareness provides battery-specific visibility. Operational metering data representing whole-site active power, including co-located load, should not be used as the operational signal for the dynamic response asset.

Summary

Criterion	Score	Explanation
Accessible Markets	Poor/Fair	It would provide market access to co-located sites with additional DC metering capabilities. Metering requirements mean distributed sites unlikely.
Situational awareness	Fair/Good	20Hz performance metering with separated battery measurement allows for detailed post event analysis. Separate OM for the battery only can ensure a good real time visibility of response service, while a combined OM with ancillary load provides limited visibility.
Confidence in delivery	Good	Observed battery delivery can be derived for analysis to ensure delivery meets expectations.
Level playing field for all providers	Good	Relies on observed data just like the current monitoring approach, same treatment as existing sites.

Solution 2

Like Solution 1, this solution relies on an additional DC or AC meter installed on the BESS to distinguish battery behaviour from ancillary load behaviour through measured data. This enables greater confidence in delivery and ensures equal treatment across participants.

Where an AC-side meter is used, the performance monitoring process aligns with the current approach. Accordingly, the remainder of this section focuses on the metering requirements for a DC-connected BESS. Further information to make this route available are covered in next steps in this document.

Diagram

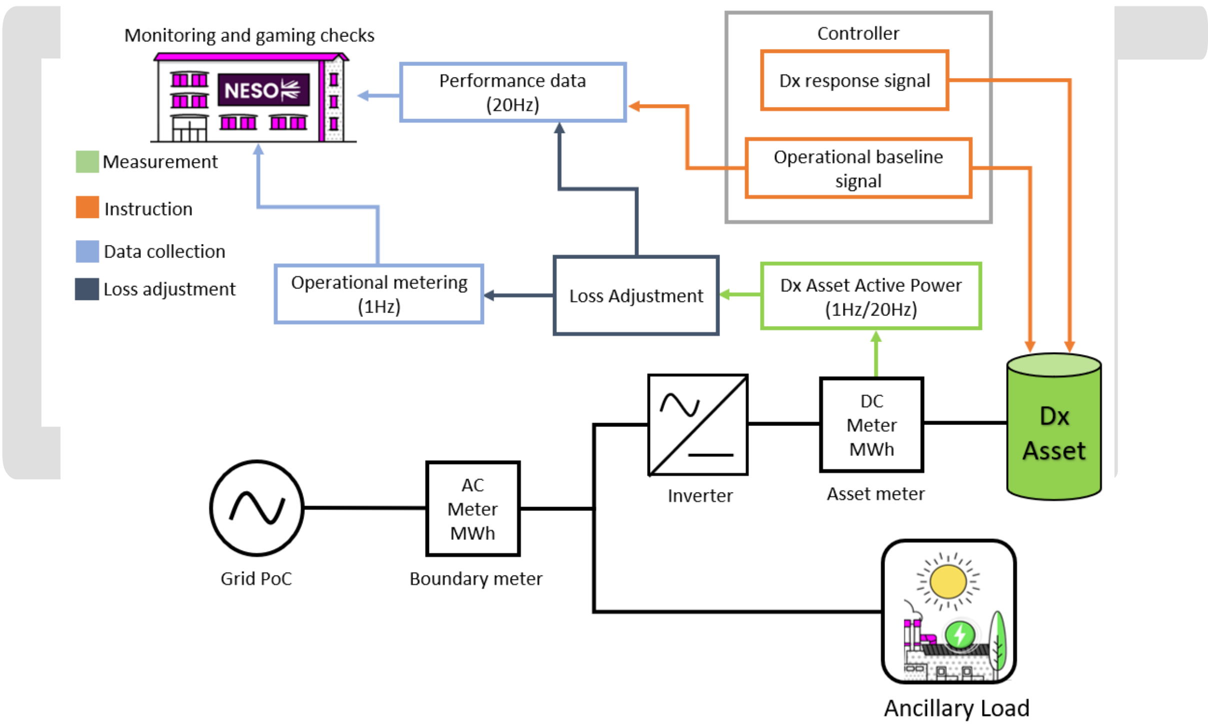

Figure 5: Diagram of information and energy flows for Solution 2 sites.

Assumptions and assessment

Points to note:

- The Dx asset needs to adjust its output while considering the change in DC to AC conversion losses.
- The methodology according to which the loss adjusted values, from DC to AC equivalent, are calculated will need to be approved by NESO.

This solution has similar hardware requirements to Solution 1. The additional meter sits on the battery. This meter could be either an AC or DC meter, depending on what is most suitable for the site. If the meter is a DC meter, a loss adjustment methodology will have to be provided and agreed with NESO to obtain a loss adjusted AC equivalent measurement. The loss adjusted AC equivalent measurement will then be used in the performance monitoring calculations. The complexity and cost of the solution is highly dependent on whether the battery units are grouped together or whether they are distributed, and the difficulty to install such a meter or meters.

The performance monitoring data submitted in this solution is derived from the instructions sent to the battery and one measured value send to NESO.

- Battery Baseline is a controller **signal**
- Battery Active Power is a **measurement** or **loss adjusted measurement**

The performance monitoring data processing would rely on measurements. As we can derive the dynamic response from measured data, instead of relying on signals. We can derive the response to the same form as in the current situation.

$$response_{mw} = site\ active\ power_{mw} - site\ baseline_{mw}$$

The site baseline includes the ancillary load and the battery baseline.

$$site\ baseline_{mw} = ancillary\ load_{mw} + battery\ baseline_{mw}$$

Ancillary load is not directly measured but we can derive it from available measurements.

$$ancillary\ load_{mw} = site\ active\ power_{mw} - battery\ active\ power_{mw}$$

We can use this derivation in the previous equation.

$$site\ baseline_{mw} = (site\ active\ power_{mw} - battery\ active\ power_{mw}) + battery\ baseline_{mw}$$

Substituting this site baseline derivation into the first equation we obtain the dynamic response.

$$response_{mw} = site\ active\ power_{mw} - ((site\ active\ power_{mw} - battery\ active\ power_{mw}) + battery\ baseline_{mw})$$

$$response_{mw} = site\ active\ power_{mw} - site\ active\ power_{mw} + battery\ active\ power_{mw} - battery\ baseline_{mw}$$

$$response_{mw} = battery\ active\ power_{mw} - battery\ baseline_{mw}$$

This is the same formula as in the current situation. The battery response comes from a measurement and the battery baseline signal.

This makes performance monitoring effective. Any errors where the battery does not follow instructions are translated into penalties in the performance monitoring methodology.

There is no preferential treatment compared to units following the current approach. NESO can identify non-compliant behaviour, and the unit will be penalised through lower k-factors and thus reduced payments.

Performance monitoring data includes 20 Hz measured active power for the purpose of assessing site behaviour during system events. NESO requires that submitted performance monitoring data clearly distinguishes the battery baseline from any co-located ancillary load. A single, combined site baseline must not be used to allow for good situational awareness for post event investigations. Therefore, the battery baseline needs to be reported as a separate variable to enable accurate assessment of dynamic response performance.

The performance data submitted by the unit includes both Battery baseline, Battery and Site active power. This means that the performance data and operational metering data should align, as OM data would be equivalent to the active power from performance monitoring. The gaming checks that rely on comparing live operational data to post-delivery metering data could therefore be used to detect gaming and anomalous behaviours.

NESO requires that operational metering data submitted for DX operational awareness provides battery-specific visibility. Operational metering data representing whole-site active power, including co-located load, should not be used as the operational signal for the dynamic response asset. Given that DC meters connect with the battery, NESO requires providers to submit loss-adjusted operational metering data that represents the output/input of BESS at the boundary point, derived from DC metering. This operational metering data shall exclude site load and must be suitable for real-time assessment of whether the BESS is delivering dynamic response in accordance with service requirements. In the testing and pre-qualification process, an AC boundary meter capable of 20Hz data is necessary to demonstrate the accuracy of the DC loss adjustment methodology proposed by the provider.

Summary

Criterion	Score	Explanation
Accessible Markets	Poor/Fair	It would provide market access to co-located sites with additional DC metering capabilities. Metering requirements mean distributed sites unlikely.
Situational awareness	Fair/Good	20Hz performance metering with separated battery measurement allows for detailed post event analysis. Separate OM for the battery only can ensure a good real time visibility of response services, while a combined OM with ancillary load provides limited visibility.
Confidence in delivery	Good	Observed battery delivery can be derived for analysis to ensure delivery meets expectations.
Level playing field for all providers	Good	Relies on observed data just like the current monitoring approach, same treatment as existing sites.

Solution 3

Solution 3 covers a unique scenario, different from Solutions 1 and 2, where the Dx asset and the auxiliary load share a single inverter and thus are DC coupled.

We believe this solution can meet the requirements of the service against all the assessed criteria. However, we also believe that an acceptable implementation of this solution could require a high level of planning and effort due to the interconnectivity required between the various systems, and the complexity of the calculations that derive the loss adjusted AC equivalent metering from the controller signals and DC meter values.

Diagram

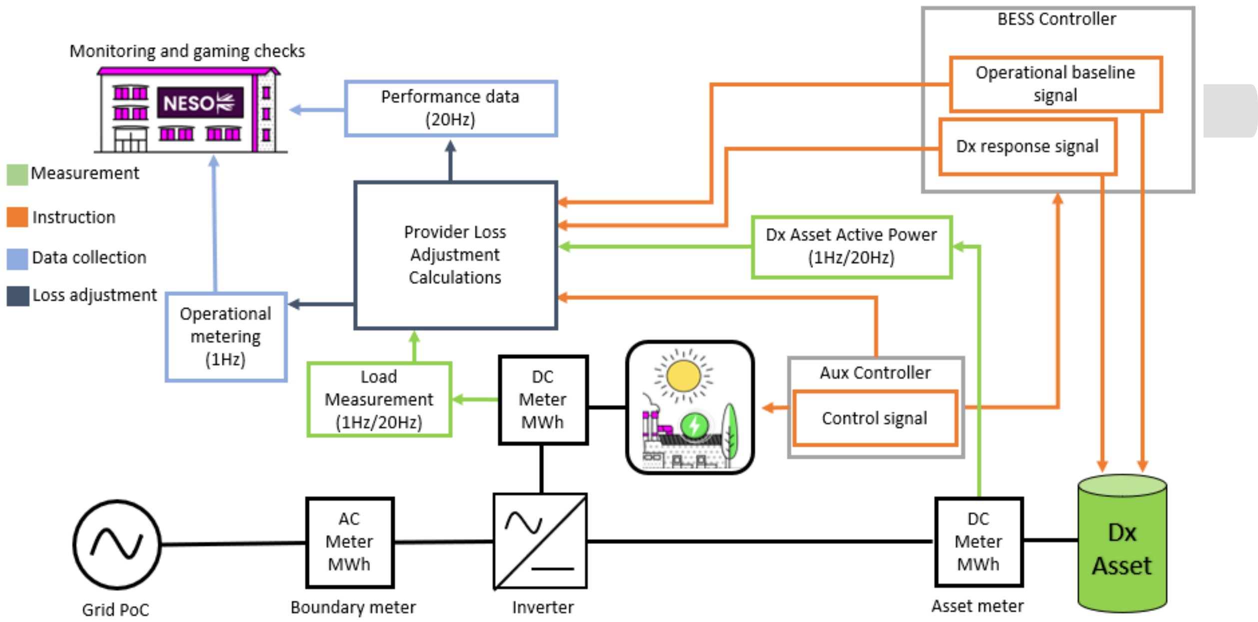

Figure 6: Diagram of information and energy flows for Solution 3 sites.

Assumptions and assessment

The solution has more complex requirements than Solutions 1 and 2, especially when it comes to the data processing required The Dx asset and ancillary load both are coupled to a single DC to AC inverter, and each has their own DC metering measuring their flow.

The complexity and cost of the solution is highly dependent on whether the battery units and ancillary load are grouped together or whether they are distributed, and the difficulty to install such a meter or meters.

The performance monitoring data submitted in this solution is derived from the signals sent to the battery, the auxiliary load (if it is controllable), and two loss-adjusted measured values. These data are processed via loss adjustment calculations by service providers before sending to NESO.

- Battery Baseline is a controller **signal**

- Battery Active Power is a **loss adjusted measurement**
- Ancillary Load operating level is a controller **signal** (if the ancillary load is controllable)
- Ancillary Load is a **loss adjusted measurement**

The performance monitoring in this scenario is highly complex as the ancillary load and Dx asset are DC coupled to a single inverter with individual DC meters each. To correctly assess asset performance, we require a loss adjustment process to be applied by providers to the 20Hz DC meter readings from both Dx asset and ancillary load. The loss adjustment methodology needs to be agreed with NESO prior to participating in Dynamic Response services. In the testing and pre-qualification process, an AC boundary meter capable of 20Hz data is necessary to demonstrate the accuracy of the DC loss adjustment methodology proposed by the provider.

Criterion	Score	Explanation
Accessible Markets	Poor/Fair	It would provide market access to DC coupled co-located sites with additional DC metering capabilities.
Situational awareness	Good	It's required in this scenario that two assets to be registered as both BMUs or NBMUs, and therefore, the real time visibility is good.
Confidence in delivery	Good	Observed Dx asset delivery can be derived with loss adjustment for analysis to ensure delivery meets expectations.
Level playing field for all providers	Good/Fair	Relies on observed data just like the current monitoring approach, same treatment as existing sites. Although require DC to AC loss adjustment

Solution 4

This option relies on using the signals sent to the battery as a basis for performance monitoring data. It assumes that the boundary meter operates at 1Hz and its data is only used for operational metering and gaming checks. The following figure shows the site diagram for option 1. We can see that only signal data flows into the performance data. This is unlike the current situation, as shown in Figure 1, where both signal and measurement data flow into the performance data.

This solution is not permitted as Performance monitoring cannot verify unit responded correctly which fundamentally undermines confidence in delivery and a level playing.

Diagram

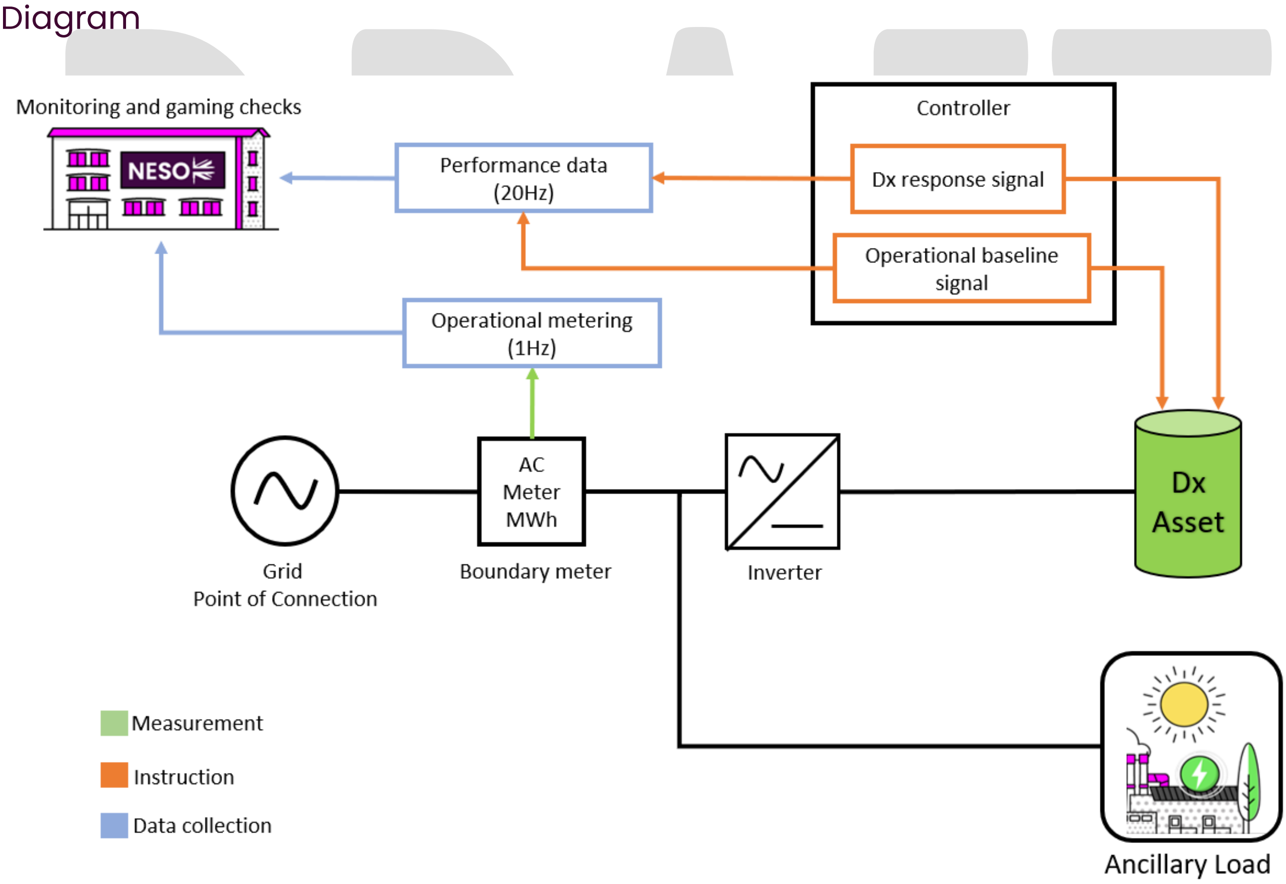

Figure 6: Diagram of information and energy flows for Solution 4 sites.

Assessment

This option has very limited hardware requirements. There is only one meter, the boundary meter, all other information can be taken from the unit's control systems. This makes the option very accessible as it does not require any additional meters or complex data processing.

The performance monitoring data submitted in this option includes the signals sent to the battery and does not include any measured values.

- Battery Baseline is a controller **signal**
- Battery Active Power is a controller **signal**
    - Active Power is the sum of the Baseline and Response instructions.

This means that, if the controllers are set up correctly, the performance monitoring Dx delivery will correspond to the ideal Dx delivery.

Since in performance monitoring:

$$\boldsymbol{response_{mw}} = \boldsymbol{active\ power_{mw}} - \boldsymbol{baseline_{mw}}$$

This makes performance monitoring redundant. If the dynamic response derived from performance monitoring is equal to the ideal response, then the performance of the unit will correspond to the ideal response.

The constant ideal performance resulting from signal-based data, results in preferential treatment compared to units that submit measured active power data. Since the unit will always achieve a k-factor of 1 and therefore receive full payment (assuming availability).

Without a measured active power value, assessing the behaviour of the unit at a high (20Hz) resolution during frequency events and other system events such as sub synchronous oscillations will not be possible. This limits the situational awareness for post event investigations.

The operational metering data is the only source of measured data, it includes both the site load and dynamic response. Even if the site load were to be zero, the 1Hz resolution is not granular enough to assess/verify the performance of the unit. It is also not granular enough to perform high resolution post event analyses.

The operational metering submitted to the ENCC would include both the dynamic response and the site load. Depending on variation in the site load, identifying whether the unit is providing dynamic response as expected could be challenging. Therefore, the real time visibility of the asset's dynamic response to the ENCC could be very low.

The performance data submitted by the unit would only include controller signals and not include any information about the site load. This means that the performance data and operational metering data would not align, as Operational Metering data would include site load. Some of the gaming checks rely on comparing live operational metering data to post-delivery performance data. These checks could not be used as the two sources would have data that covers different loads.

Not having all gaming checks present would be unfair when compared to existing sites which will undergo all gaming checks.

Summary

Table 1: Assessment summary for Solution 1

Criterion	Score	Explanation
Accessible Markets	Good	It would provide market access to co-located and distributed sites with limited metering capabilities.
Situational awareness	Poor	Live ENCC awareness and Situational awareness for post event analysis would be limited because NESO doesn't have sufficiently granular data on the BESS and load outputs.
Confidence in delivery	Poor	Performance monitoring cannot verify unit responded correctly. The 1Hz boundary meter is not granular enough to check delivery speed.
Level playing field for all providers	Poor	Other providers are assessed on measured power and not controller signal power. Assessment on instructions could provide an unfair advantage through k-factors of 1 and limited gaming checks.

Solution 5

Similar to Solution 4, this option also relies on using the signals sent to the battery, but it additionally includes an upgraded 20Hz boundary meter. Information from the 20Hz boundary meter is included in the performance monitoring data. This increases confidence in delivery compared to Solution 1, through post event analysis and gaming checks.

In **Error! Reference source not found.** we can see that the boundary meter has two measurement dataflows. One is the 1Hz Operational Metering flow which then goes to the gaming checks, and the other is the 20Hz measurement which flows to the performance data

Solution 5 is not permitted as Performance Monitoring cannot verify unit responded correctly which fundamentally undermines confidence in delivery and a level playing.

Diagram

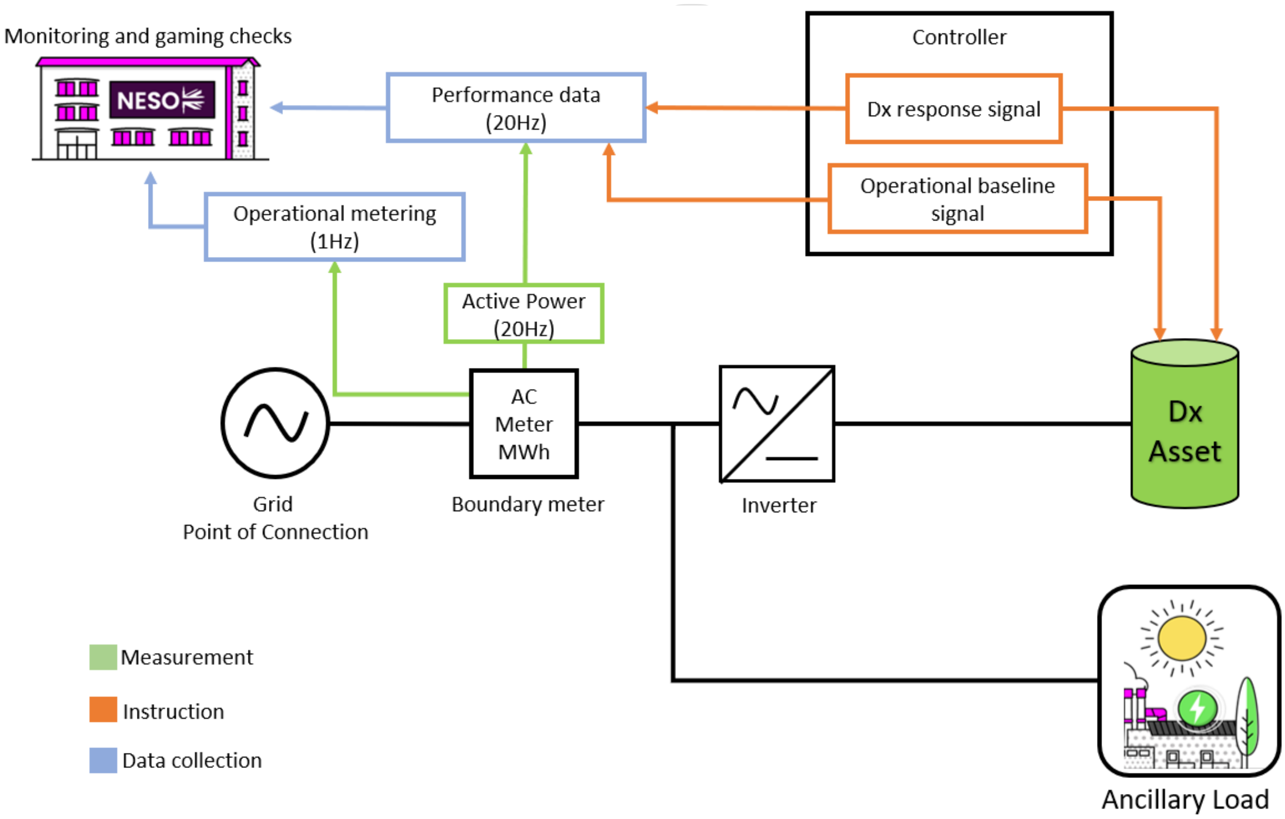

Figure 7: Diagram of information and energy flows for Solution 5 sites.

Assessment

This option has greater hardware requirements than option 1. There is still only one meter, the boundary meter, all other information is taken from the unit's control systems. The boundary meter is 20Hz rather than 1Hz. This makes the option accessible as it does not require multiple meters, only an upgraded boundary meter.

The performance monitoring data submitted in this option includes the signals sent to the battery and one measured value.

- Battery Baseline is a controller **signal**
- Battery Active Power is a controller **signal**
    - Battery Active Power is the sum of the Baseline and Response instructions.
- Site Active Power is a **measurement**

The performance monitoring data processing would still rely on response signals to assess the performance of the unit as there is no way to derive the response from the single measurement. This is because, to extract the response from the site active power, we require the site baseline.

$$response_{mw} = site\ active\ power_{mw} - site\ baseline_{mw}$$

Site baseline is the sum of the site ancillary load and the battery baseline. The only way to derive the site baseline is to work backwards from the site active power, as there are no other measurements or signals that include the site ancillary load.

$$site\ baseline_{mw} = site\ active\ power_{mw} - response_{mw}$$

This derivation results in the performance monitoring response being equal to the response signal sent to the battery.

$$response_{mw} = site\ active\ power_{mw} - (site\ active\ power_{mw} - response_{mw}) = response_{mw}$$

This means that, if the controllers are set up correctly, the performance monitoring Dx delivery will correspond to the ideal Dx delivery.

This makes performance monitoring redundant. If the dynamic response derived from performance monitoring is equal to the ideal response, then the performance of the unit will correspond to the ideal response.

The constant ideal performance from controller signal data results in preferential treatment compared to units following the current approach. Since the unit will always achieve a k-factor of 1 and therefore receive full payment (assuming availability).

The 20Hz measured site active power value would be useful for assessing the behaviour of the site at a high (20Hz) resolution during system events. However, not being able to discern between the ancillary load and battery behaviour effects means that the results of analyses would be less useful than those of sites with the current approach. This reduces the situational awareness for post event investigations.

The operational metering submitted to the ENCC would include both the dynamic response and the site load. Depending on variation in the site load, identifying in real time whether the unit is providing dynamic response as expected would be challenging. Therefore, the real time visibility of the asset's dynamic response to the ENCC could be low.

The performance data submitted by the unit would include controller signals and the site active power. This means that the performance data and operational metering data should align, as OM data would be equivalent to the site active power from performance monitoring. The gaming checks that rely on comparing live operational data to post-delivery metering data could therefore be used to detect gaming and anomalous behaviours.

Summary

Criterion	Score	Explanation
Accessible Markets	Fair	It would provide market access to co-located and distributed sites with 20Hz boundary metering capabilities.
Situational awareness	Fair	20Hz operational metering would allow for some post event analyses. The operational metering from site load and dynamic response being combined would limit real time visibility of response service performance.
Confidence in delivery	Poor/Fair	Performance monitoring cannot verify unit responded correctly as it is controller signal based. Gaming checks could be performed to identify gaming behaviours.
Level playing field for all providers	Poor	Other providers are assessed on measured power and not instructed power. Assessment on instructions could provide an unfair advantage.