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Assessment of baseline and meter data approaches for Dynamic Response

NESO
National Energy System Operator

Contents

Executive Summary

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 2023/4 were 59%, 24%, and 65% lower than for winter 2022/23 respectively indicating good liquidity in dynamic response markets.

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. 4 different options for enabling participation of these types of site 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 box.fututreofbalancingservices@nationalgrideso.com .

NESO is progressing further work on solutions that would enable participation by this kind of co-located site with DC metering either on the asset or the load/generation. We expect behind the meter assets that are able to provide the appropriate data as outlined in solutions 3 and 4 will be able to participate in dynamic response markets in 2025.

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 Service reform NESO must ensure that consumers are receiving value for the money spent on balancing services. This requires confidence in the data received that evidences 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.

2. Current approach

Before we present and discuss potential solutions for data derived baselines, we will present the methodology on how the current approach functions. We welcome any remarks, suggestions, or feedback if any of the presented assumptions are inaccurate. The diagram 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 instructions are sent from controllers.

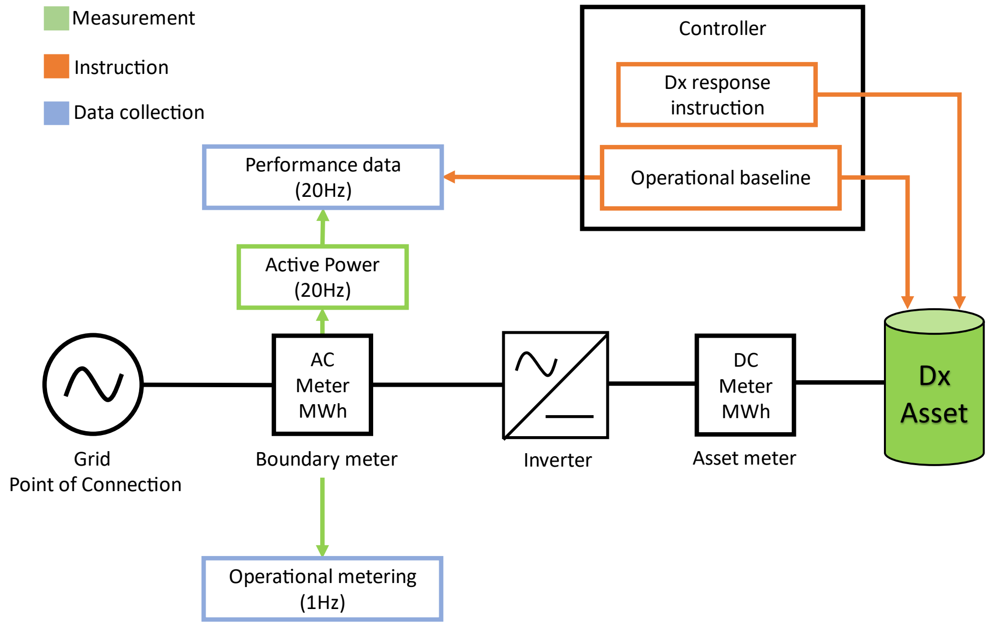

Figure 1: Diagram of information and energy flows on current sites.

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. 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 instruction sent to the unit prior to any adjustments for dynamic response.
  - The Baseline is an **instruction.**
- **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

$$active\ power_{mw} = baseline_{mw} + response_{mw}$$

is re-arranged to extract the response:

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

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 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 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.

3. 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.

4. Examined solutions.

Solution 1

This solution relies on using the instructions 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.

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

Diagram

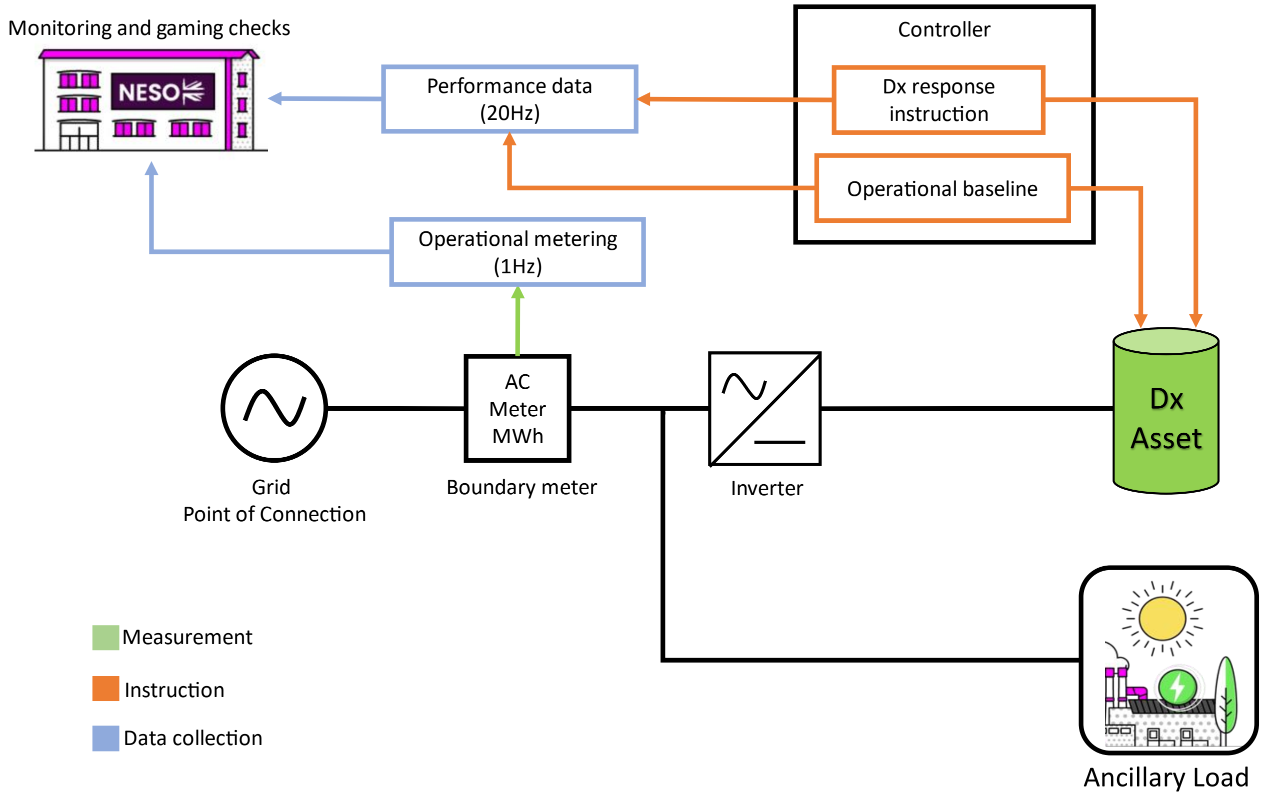

Figure 2: Diagram of information and energy flows for Solution 1 sites.

Figure 2 shows the site diagram for Solution 1. We can see that only instruction data flows into the performance data. This is unlike the current situation, as shown in Figure 1, where both instruction and measurement data flow into the performance data.

Assessment

This solution 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 solution very accessible as it does not require any additional meters or complex data processing.

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

- Battery Baseline is an **instruction**
- Battery Active Power is an **instruction**
    - 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:

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

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 instruction-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 instructions and not include any information about the site load. This means that the performance data and operational metering data would not align, as OM 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 would be limited. Situational awareness for post event analysis would be limited.
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 instructed power. Assessment on instructions could provide an unfair advantage through k-factors of 1 and limited gaming checks.

Solution 2

This solution is similar to Solution 1, it also relies on using the instructions 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.

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

Diagram

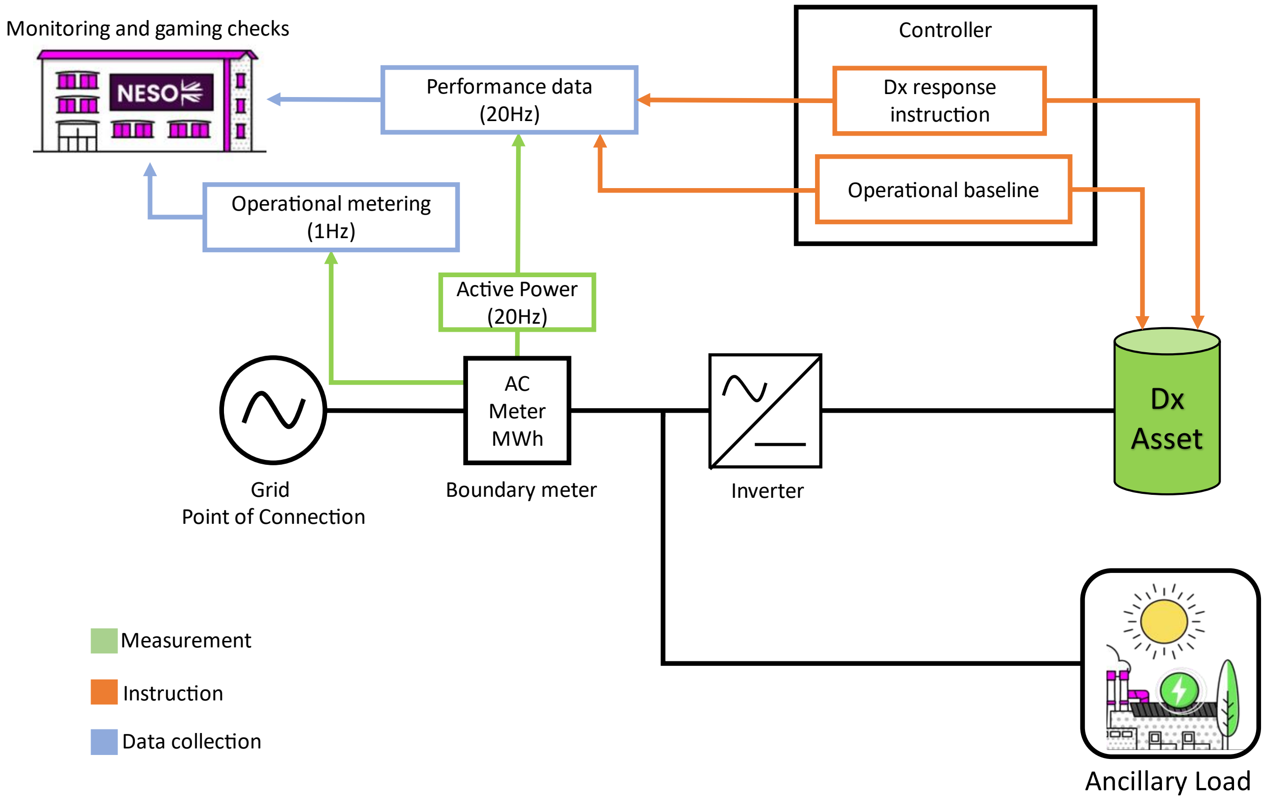

Figure 3: Diagram of information and energy flows for Solution 2 sites.

In Figure 3 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.

Assessment

This solution has greater hardware requirements than Solution 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 solution accessible as it does not require multiple meters, only an upgraded boundary meter.

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

- Battery Baseline is an **instruction**
- Battery Active Power is an **instruction**
  - 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 instructions 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.

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

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 instructions that include the site ancillary load.

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

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

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

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 instruction 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 instructions 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. Site load and 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 instruction 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.

Public

Solution 3

This solution relies on an additional meter, the ancillary load meter, to discern between battery and ancillary load behaviour through measured data. It is more complex than Solutions 1 and 2 but allows for more confidence in delivery and a more equal treatment.

We believe this solution can meet the requirements of the service against all of the assessed criteria. Further information on next steps to make this route available are covered in next steps in this document.

Diagram

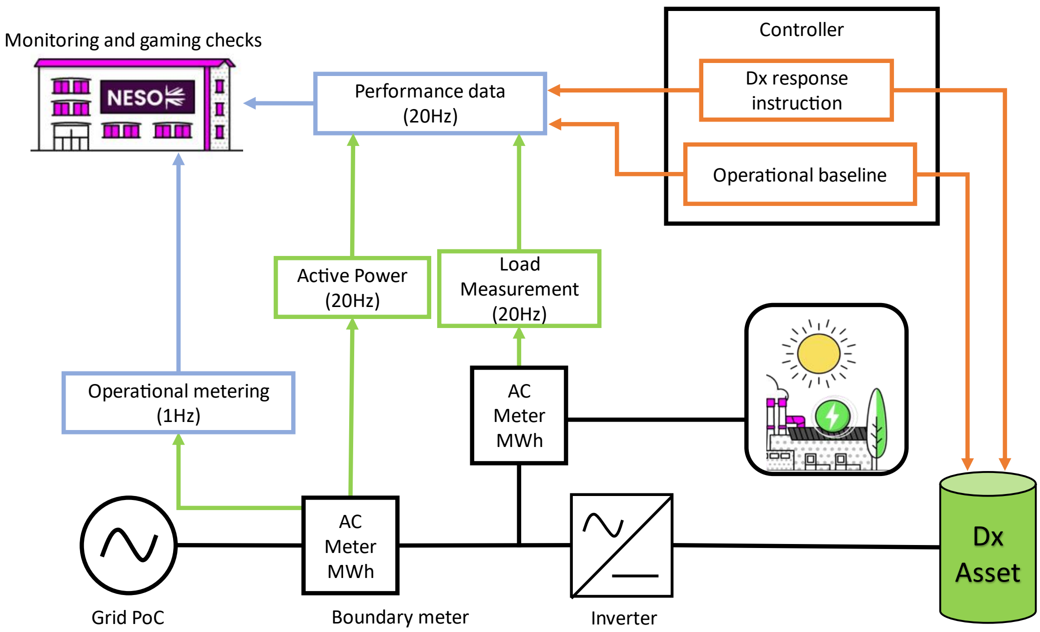

Figure 4: Diagram of information and energy flows for Solution 3 sites.

Assessment

As with Solution 2, the 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 includes the instructions sent to the battery and one measured value.

- Battery Baseline is an **instruction**
- Battery Active Power can be derived from **measurements**
    - Battery Active Power is difference between Site Active Power and Ancillary Load.
- Ancillary Load is a **measurement**

- Site Active Power is a **measurement**

The performance monitoring data processing would rely on measurements. As we can derive the dynamic response from measured data, instead of relying on instruction like in Solutions 1 and 2. Using Site Active Power and Site Load we can extract the Dynamic Response:

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

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

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

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

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

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

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 instructed 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 instructions 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.

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. Being able to discern between the baseline and response behaviour effects means that the results of analyses would be more useful than those of Solution 1 or Solution 2. This is particularly true if the submitted performance monitoring data includes ancillary load and battery baseline separately rather than combined into a single site baseline variable. This allows for good 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 could 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 site baseline 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	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. If OM metering for the battery BMU only is submitted then real time visibility is good, if combined with ancillary load then limited.
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.

Public

Solution 4

Like Solution 3 this solution relies on an additional battery meter, to discern between battery and ancillary load behaviour through measured data. It is more complex than Solutions 1 and 2 but allows for more confidence in delivery and equal treatment.

We believe this solution can meet the requirements of the service against all of the assessed criteria. Further information on next steps to make this route available are covered in next steps in this document.

Diagram

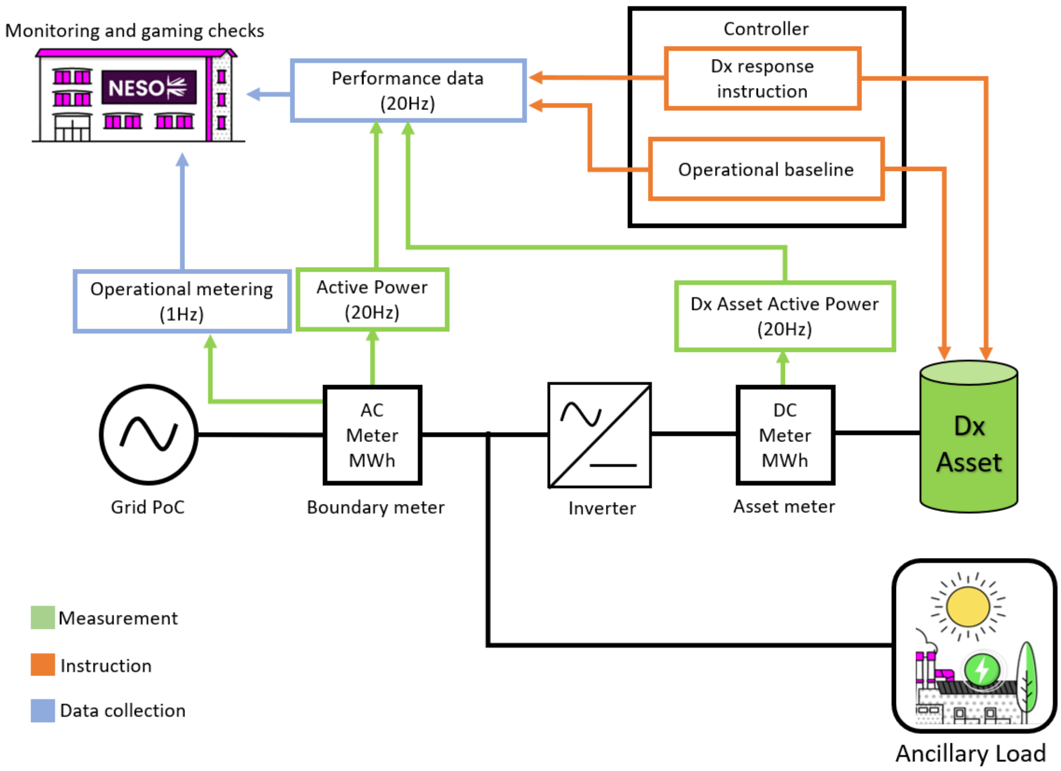

Figure 5: Diagram of information and energy flows for Solution 4 sites.

Assumptions and assessment

This solution has similar hardware requirements to Solution 3. Just as Solution 3, the boundary meter is required to deliver 20Hz. The additional meter sits between the battery and the ancillary load. 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 includes the instructions sent to the battery and one measured value.

- Battery Baseline is an **instruction**

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

The performance monitoring data processing would rely on measurements. As we can derive the dynamic response from measured data, instead of relying on instruction like in Solutions 1 and 2. We can derive the response to the same form as in the current situation.

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

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

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

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

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

We can use this derivation in the previous equation.

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

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

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

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

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

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

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.

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. Being able discern between the baseline and response behaviour effects means that the results of analyses would be more useful than those of Solution 1 or Solution 2 sites. This is particularly true if the submitted performance monitoring data includes ancillary load and battery baseline separately rather than combined into a single site baseline variable. This allows for good 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 could 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 site baseline 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	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. If OM metering for the battery BMU only is submitted then real time visibility is good, if combined with ancillary load then limited.
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.

5. Conclusions and next steps

Conclusions

Given the increasing criticality of Frequency Response services in a lower inertia electricity system it is imperative that assets have appropriate capability to not only deliver the services but also demonstrate service delivery through submission of data that provides NESO confidence in delivery.

This report assesses potential approaches to baselining and data submission that differ from current practices and highlights that the data provided through these approaches should be clearly derived from measured data.

Solutions 1 and 2, as outlined above, do not meet our requirements according to the criteria applied.

Solutions 3 and 4 have potential to meet our requirements subject to further requirements on onboarding process and a solution for DC metering arrangements. NESO are currently working with provider(s) on developing a DC metering solution for co-located sites with a single grid point connection. This approach is a hybrid of Solutions 3 and 4. For these co-located sites, the site load and battery each have an individual DC meter and are treated as separate BMUs.

The solution that enables this kind of asset to participate in dynamic response would also unlock participation for the site configuration identified in options 3 and 4.

Next steps

- Refinement of examined solutions based on feedback and further input.
- NESO to publish guidance on permitted alternative approaches to baselines and metering.