Public

Guidance on Enabling Asset Metering for Co-located Assets

Solar and Battery Co-located Scenario

October 2025

NESO
National Energy System Operator

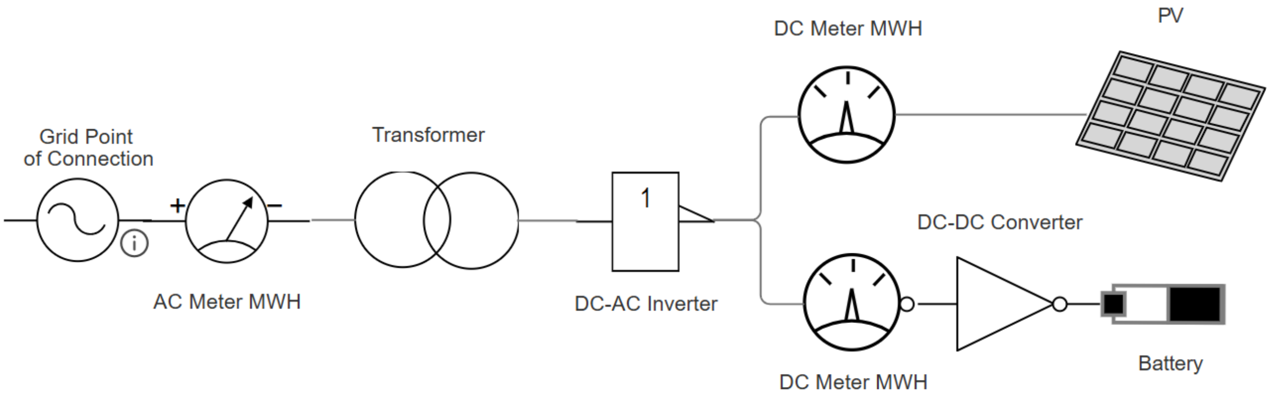
Contents

Summary

There is an increasing number of applications for the DC (Direct Current)-coupled co-located sites, which are power generating modules comprising units of different generating technologies or fuel types. This document provides guidance on enabling DC-coupled co-located Photovoltaic (PV) and Battery Energy Storage System (BESS) BMUs to participate in the Balancing Mechanism and Dynamic Response Markets, by addressing issues on Submission of PNs (Physical Notifications) & BOAs (Bid-Offer Acceptances), Operational Metering, Settlements, Performance Monitoring for Dynamic Response, and Alignment with Codes.

Given the increasing adoption of this type of connection, NESO will apply a consistent approach to all future similar configurations. Formal guidance and industry engagement on other co-location arrangements and appropriate DC metering solutions will be issued to ensure transparency, consistency, and fairness for all stakeholders.

In the new setup, as illustrated in the figure below, the PV and BESS are co-located behind a single Grid Entry Point via a DC-AC inverter and required to be registered as separate secondary BMUs (i.e., one BMU per technology).



This setup presents several challenges for ENCC situational awareness, operational metering, and Dynamic Response Performance Monitoring. This guidance provides solutions to resolve those challenges in accordance with the following principles:

- Accessible markets
- Confidence in delivery, including accurate metering
- Situational awareness and control to support system security
- Creating a level playing field for all providers including alignment with Codes and Compliance.

There will be a range of other site configurations that may wish to participate in the BM and balancing service markets. NESO will establish high-level minimum requirements to ensure flexibility for various sites while adhering to the aforementioned principles.

NESO is progressing further work on solutions that would enable participation by all other expected co-located configurations. We expect a more comprehensive solution for more scenarios to be shared.

We would welcome any feedback on this guidance, particularly the site set-up assumptions and data flows within scope via commercial.operation@neso.energy .

PNs and BOAs Procedures

NESO requires co-located asset providers in the aforementioned scenario to register each technology as individual BMU and submit their PN values as asset meters equivalent to the import/export MW levels at the AC boundary meter (i.e., Grid Supply Point). Similarly, if NESO issues BOAs to the co-located assets, loss compensation must be applied to reflect the desired changes at the AC boundary meter. For reference, all BOAs are issued relative to PN and result in a profile called CCL (Capped Committed Level). CCL is defined as PN adjusted by BOA, capped by MEL/MIL. Therefore, PN/CCL should account for losses between the DC meter, through the inverter, and reflect what is actually delivered at the AC boundary meter.

The requirement is established according to the following considerations. With regards to the Grid Code under Appendix 1 BC1.A.1.1, “the Physical Notification is a series of MW figures and associated times, making up a profile of intended input or output of Active Power at **the Grid Entry Point** or **Grid Supply Point**, as appropriate, except where a BM Unit is affected by a Stage 2 or higher Network Gas Supply Emergency load shedding event. For each Settlement Period, the first “from time” should be at the start of the Settlement Period and the last “to time” should be at the end of the Settlement Period.” To align with the Grid Code, both submitted PN values and instructed BOA values relating to each BMU should accurately reflect values at the grid point of connection (i.e., the AC side). Therefore, the PN/BOAs will need to account for inverter losses, as shown in Table 1 and Figure 1.

Operational Metering

The proposed PN/BOA solution requires PNs and BOAs to incorporate losses and accurately reflect delivery values at the AC point of connection. Meanwhile, the DC-metered readings from the PV and BESS BMUs will be provided to the ENCC systems as operational metering signals, which NESO operators rely on for issuing BOAs and monitoring unit output. This loss-adjustment PN/BOA methodology and metering approaches may result in discrepancies between operational metering and PNs. Such discrepancies could reduce ENCC’s situational awareness, leading to inefficient dispatch decisions and potentially increasing operational costs or creating system security risks.

To avoid potential discrepancy issues, NESO requires all BMU operational metering values/signals from the DC metered assets to reflect the delivery values at the Grid Entry Point (i.e., Point of Connection), after accounting for losses, as described above for PNs/BOAs. Therefore, co-located asset providers need to adjust the DC operational metering to account for losses before submitting the data to ENCC.

This requirement applies whether the site is a single directly connected AC set-up or a co-located DC set-up that has BMU(s) involved. Failure to comply with this requirement would impair situational awareness and result in rejection from BM participation and the provision of Balancing Services. This requirement allows NESO to instruct the individual BMUs knowing what the actual delivery/output will be at the Point of Connection. It is also consistent with the current approach for less complex / ‘traditional’ connections as well as Grid Code guidance on PN submissions.

Therefore, to address NESO control room’s need for visibility of delivery volumes for each BMU, the following approach is acceptable:

1. Separate operational metering (DC metering) for the PV and Battery BMUs is required to capture accurate MW and asset-specific parameters.

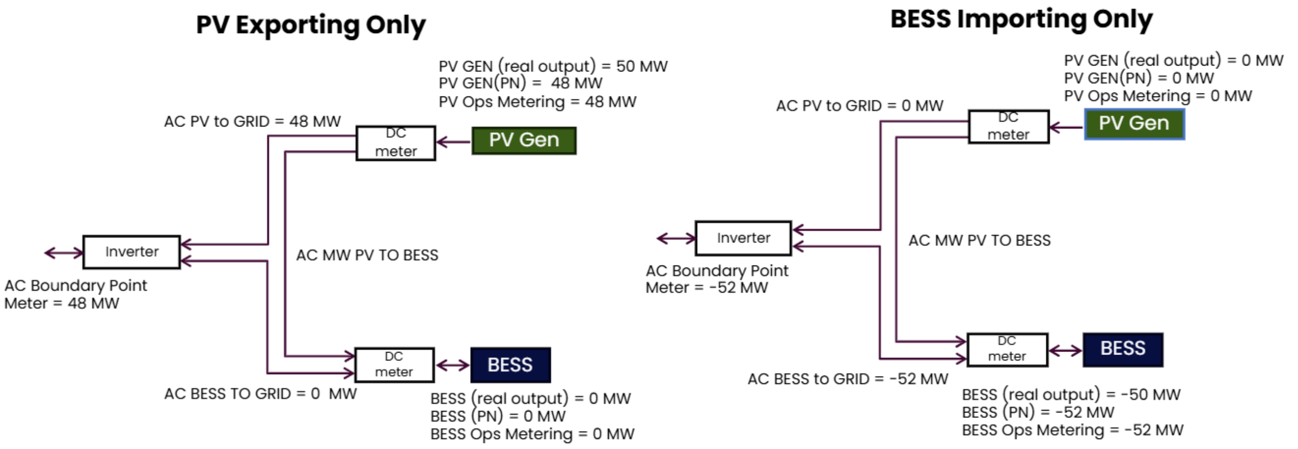
2. These DC metered active power must be adjusted by co-located providers to reflect inverter losses so that NESO sees delivery volumes that reconcile with the grid entry point metering.

To better demonstrate the PN/BOA and operational metering solutions, Table 1 shows detailed examples of PNs and DC metering signals under different scenarios. An average loss factor of 4% of the DC-AC inverter is used in all examples. It is notable that there are no losses observed between BESS and PV in the scenario where the PV is exporting and charging the BESS.

Table 1 Examples on PN/BOAs and DC metering signals under different scenarios

Scenario	**PV BMU output (MW)**	**BESS BMU output (MW)**	**AC boundary meter (MW)**	**PN for PV (MW)**	**PN for BESS (MW)**	**DC Metering Signals for PV (MW)**	**DC Metering Signals for BESS (MW)**
PV only	50	0	48	48	0	48	0
BESS importing only	0	-50	-52	0	-52	0	-52
BESS exporting only	0	50	48	0	48	0	48
Both exporting	50	25	72	48	24	48	24
PV exporting and charging BESS	50	-25	24	49	-25	49	-25
PV and Grid charging BESS	25	-50	-26	25	-51	25	-51

Figure 1 shows diagrams illustrating loss-adjusted PN/BOA submission guidelines in six scenarios with different PV/BESS exporting and importing status. See the appendix for flow diagrams of all scenarios. Please refer to the appendix to explore the flow diagrams for all scenarios and requirements.



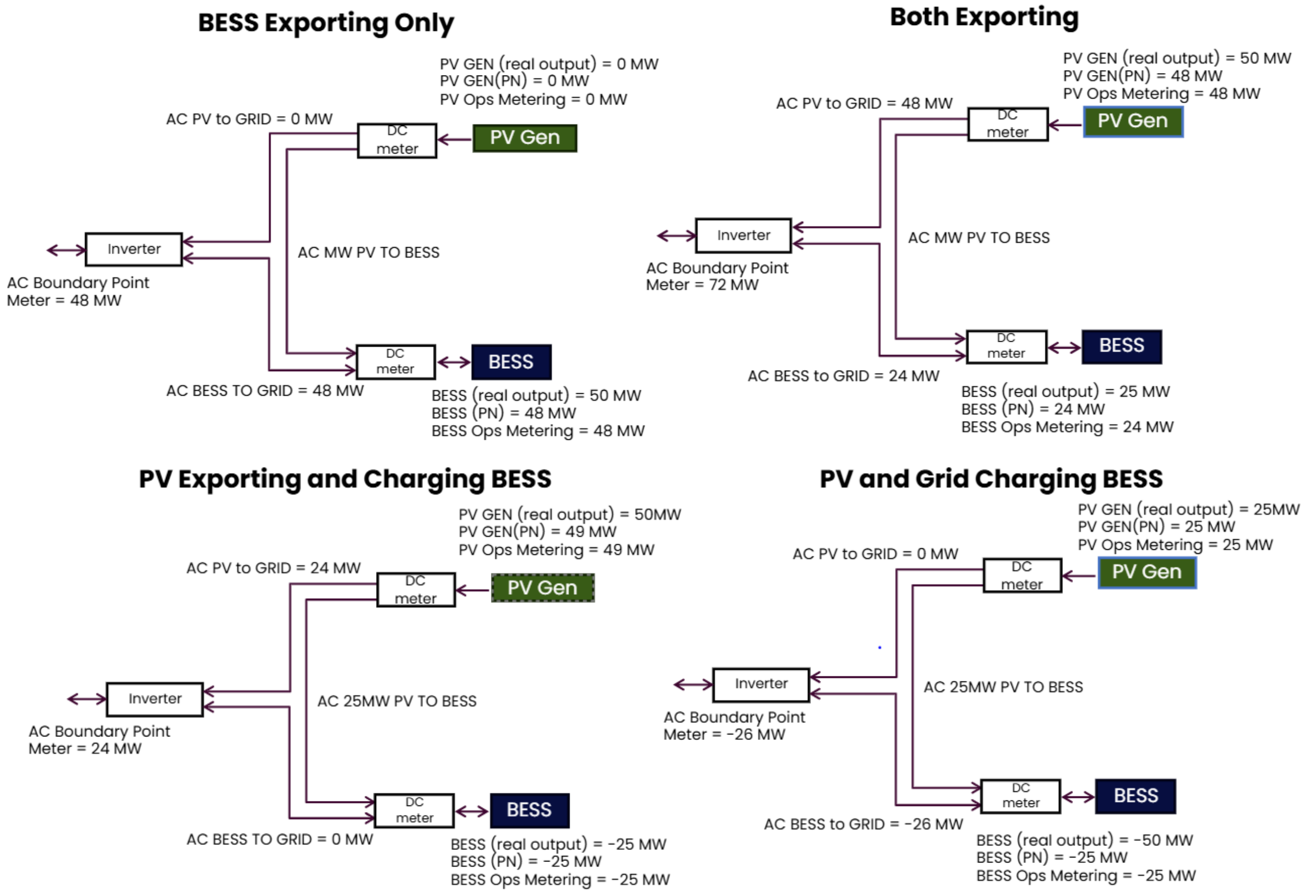


Figure 1. Demonstration of flow details of power and losses in six scenarios

Alignment with Grid Code and Bilateral Agreements

NESO recognises it essential to keep alignment of the proposed PN/BOAs methodology with Grid Code requirements on operational metering. NESO confirms that no Grid Code modifications are required to support the proposed metering arrangement for co-located PV and BESS assets operating as 2 separate BMUs.

Under the Grid Code, the requirements for operational metering are defined at a high level and rely on specific obligations detailed in the CUSC Contract (including *Bilateral Connection Agreement* (BCA), *Bilateral Embedded Generation Agreements (BEGAs), Bilateral Embedded Licence exemptable Large power station Agreement (BELLA), and Virtual Lead Party Agreement (VLPA)*) with each User. Specifically, operational metering obligations are met through the provision of real-time signals (e.g., MW, voltage, breaker status) from each Generating Unit, Power Generating Module or Electricity Storage Module to NESO via the marshalling cubicle at the nearest substation as specified in Grid Code CC/ECC.6.5.6.

Where relevant, additional technical requirements may apply under the CUSC for certain plant types. Specifically:

• Plants not bound by the CUSC are generally not subject to Grid Code obligations, so the monitoring requirements below would not apply.

• CUSC signatories operating Type C or D Power Generating Modules (over 10 MW) must comply with both Frequency Response Monitoring (TS.3.24.95), which samples at 1 Hz using high-accuracy meters, and Dynamic System Monitoring (TS.3.24.70), which samples at 12.8 kHz but does not rely on settlement-grade meters.

• Virtual Lead Parties (VLPs) are captured under the CUSC but have only limited Grid Code obligations, mainly covering telephony, operational metering, and data communication facilities set out in Appendix F of their Bilateral Agreements. They are not required to implement Frequency Response Monitoring or Dynamic System Monitoring.

• Suppliers, while also covered by the CUSC, have even fewer Grid Code obligations and similarly do not need to meet the above monitoring requirements.

NESO will define these operational metering requirements in the Bilateral Agreement's Appendix F5, with examples shown in Page 47-50 of https://www.neso.energy/document/33976/download. For the co-located PV and BESS configuration, NESO requires two BMUs' DC metering tables and one AC boundary metering table:

- A dedicated table for the PV BMU, capturing MW, ambient temperature, and global radiation, etc.
- A dedicated table for the Battery BMU, capturing MW, available energy, state of charge, etc.
- A combined table for the total site output at the AC grid connection point, capturing MW, voltage, breaker status, transformer tap position, etc.

Each table specifies the necessary data points (e.g., active power, voltage, state of charge for BESS, solar irradiance for PV, breaker status, etc.) based on asset types. The examples below (from Appendix F5 of Bilateral Agreements) illustrate how these updated operational metering requirements are structured.

Table 2 Examples on Updated Operational Metering Requirements based on Site Specific Technical Conditions

AC Boundary Metering Signals (Generators ≥ 1MW)	**Range**	**Scale (Unit)**	**Accuracy**	**Resolution**	**Refresh Rate**
Active Power	-100 MW to +100MW	MW	1% of meter reading	1kW	1 per second
Reactive Power	-100 MVAr to +100MVAr	MVAr	1% of meter reading	1MVAr	1 per second
EU Code User System Entry Point Voltage	0 – 100%	kV	1% of meter reading	1kV	1 per second
Controlling Breaker	Open/Closed	0/1	Not applicable.	Not applicable.	On Change.
Tap Position	1 – 64	Value	Not applicable.	Not applicable.	On Change.
Co-located BESS DC Metering Signals					
Loss Adjusted Active Power	-100 MW to +100MW	MW	1% of meter reading	1kW	1 per second
State of Charge (Energy) (Export)	0 – 100%	%	1% of meter reading	1%	1 per second
State of Charge (Energy) (Import)	0 – 100%	%	1% of meter reading	1%	1 per second

Energy Available (Import)	0 – 1000MWh	MWh	1% of meter reading	1MWh	1 per second
Energy Available (Export)	0 – 1000MWh	MWh	1% of meter reading	1MWh	1 per second
Co-located Solar PV DC Metering Signals					
Loss Adjusted Active Power	0 to +100MW	MW	1% of meter reading	1kW	1 per second
Global Radiation	0 – 2000W/M^2	W/m^2	1% of meter reading	1W/m^2	1 per minute
Ambient Temperature	-100 – +100°C	°C	1% of meter reading	1°C	1 per minute

This solution ensures full transparency for NESO while maintaining alignment with existing Grid Code provisions. It avoids the need for code change and instead leverages customisation of bilateral agreements, which is standard practice for unique configurations such as this.

Settlement metering must continue to align with the Balancing and Settlement Code (BSC) requirements. According to Elexon's guidance on asset metering, metering behind the site Boundary Point, referred to as Asset Metering, is compliant with Section L of BSC and Code of Practice (CoP) 11. This setup allows for the Settlement of Secondary BM Units (BMUs) using metering behind the site Boundary Point. Therefore, when properly registered and compliant with the relevant Codes of Practice, asset meters can be used for settlement and payment purposes. Additionally, the guidance on metering dispensations and co-located generation highlights that if, for practical and/or financial reasons, any metering equipment does not meet the requirements set out in the relevant CoP, a metering dispensation may be applied for. This process ensures that the metering setup remains compliant with settlement requirements even when standard configurations are not feasible. It is the responsibility of the market participant to ensure that settlement metering arrangements and associated dispensations are agreed with Elexon.

We have determined that there is no impact to the Settlements team within NESO. In order for there to be no impact to Settlements, the following must be true:

(1) Each "asset" must be registered as an individual BM unit, and supply all BM data including, FPN, MEL, MIL, NTO, NTB, NDZ, SEL, SIL, MNZT, MZT, RURE, RDRE, RURI, RDRI, etc.

(2) The meter data formats/ data provision must not be different from other BM units.

(3) The data provided will be adjusted as per any specification before the data reaches Settlements.

Dynamic Response Services

When participating in dynamic response services, providers are required to submit performance monitoring data to NESO. This performance monitoring data is used to assess the behaviour and delivery of the unit. The outcome of the assessment is reflected in the K-factor which affect the payments made to the provider.

Currently all assets use AC meters at the boundary point to collect the data needed for performance monitoring. This is not possible with this site as multiple BMUs contribute to the AC boundary meters; therefore, a new DC metering derived methodology has to be developed.

Operating scenarios

The methodology must be capable of handling various scenarios of how the site could be operating.

- **Scenario 1**: Overnight BESS exporting
    - LF and HF response contract possible
- **Scenario 2**: Daytime peak solar with PV to BESS
    - Only HF contracts possible
- **Scenario 3**: Overnight BESS importing
    - LF and HF contracts possible
- **Scenario 4**: Solar below export limit with PV and BESS exporting
    - LF and HF contracts possible
- **Scenario 5**: BESS charging from PV and Grid.
    - LF and HF contracts possible

Under certain circumstances, in Scenario 2 the PV could be switched off and the BESS would import from the grid meaning it could provide LF and HF response. In such a situation, Scenario 2 transforms into Scenario 3. Therefore, no extra Scenario is needed to account for that possibility.

Controller assumptions and information availability

In the examples provided, we use an inverter efficiency value of 96%. This value does not have to be fixed over time. For each calculation instance at a given time t, the most accurate efficiency value can/should be used to determine the instructions sent by the controller and re-used to obtain the loss adjusted AC meter values from the DC meter readings.

Ahead of time (before gate closure)

At gate closure, 1 hour before delivery, the Physical Notifications for the BMUs will be finalised. It will not be possible to change these values within gate.

These values will be referred to as:

- *pln_PV_AC_pn*: the final PN for the PV asset.
- *pln_BESS_AC_pn*: the final PN for the BESS asset.
- *pln_SITE_ac_pn*: the flow across the site boundary considering the final PNs for PV and BESS.

The values are in AC terms - as measured at the boundary point.

Ahead of time (within gate)

Within gate the ENCC can send BOA instructions to BMUs to increase or decrease their output to help balance the system.

These values will be referred to as:

- *pln_PV_AC_ccl*: PV Capped Committed Level, i.e. final PN modified with any BOA instructions for PV asset.
- *pln_BESS_AC_ccl*: BESS Capped Committed Level, i.e.final PN modified with any BOA instructions for BESS asset
- *pln_SITE_AC_ccl*: SITE Capped Commited Level, i.e. the flow across the site boundary considering the active PNs and BOAs for both PV and BESS.

The values are in AC terms - as measured at the boundary point.

In real time under baseline conditions (no active dynamic response)

In real time the controller must ensure that the plans set out ahead of time are feasible. This means that the internal flows in the site must be arranged so that the net flow at the boundary matches the expectations.

Figure 2 shows how the flows of an infeasible scenario are re-arranged to obtain a feasible scenario.

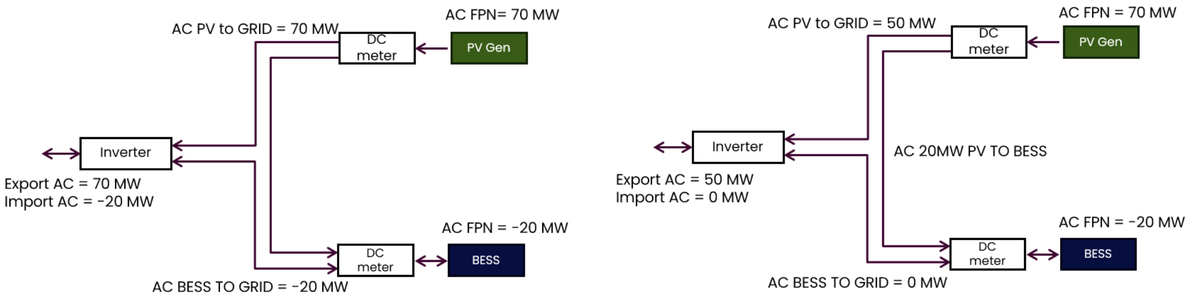


Figure 2: Creating a feasible flow solution

With the flow being feasible the correct losses can be calculated and therefore the frequency response instructions sent to the individual PV and BESS controllers can be determined. For the example in *Figure* 2, export losses need to be accounted for 50MW of PV generation, and no losses need to be accounted for in the PV to BESS flow.

Figure 3 shows how the losses, assuming an inverter efficiency of 96%, affect the flows within site and the meter readings.

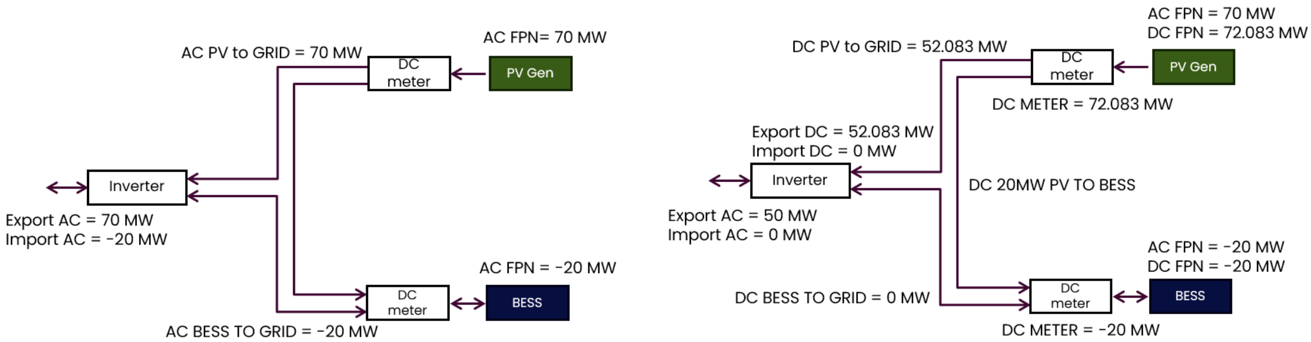


Figure 3: Converting AC flows to DC instructions

These instructions sent to the PV and BESS controllers are referred to as:

- *ins_PV_DC_ccl*: PV generation instruction that ensures the PV Capped Commitel Level obligations are satisfied (in DC terms).
- *ins_BESS_DC_ccl*: BESS instruction that ensures that the BESS Capped Committed Level obligations are satisfied (in DC terms).

Under perfect conditions, the PV DC Meter reading should directly correspond to the *ins_PV_DC_pnsboas* instruction value.

A note on excess PV generation and PV generation shortfall

Due to the ENCC situational awareness requirements, it is not possible to use the BESS to manage excess PV generation or a shortfall in PV generation.

Suppose the PV FPN is equal to 70MW and the battery FPN is equal to -20MW (taking the excess PV generation). These FPN values must be finalised at gate closure, the PV generation will therefore be an estimate which could be inaccurate. If in real time the maximum potential PV generation is equal to 75MW, then the site is required to stick to the FPNs provided. It is not possible to increase the generation to 75MW and the change the BESS baseline to -25MW. Additionally, the FPN values are not allowed to exceed more than their TEC (Transmission Entry Capacity).

Because of this, the PV DC meter reading and the PV DC instruction values should be equal to each other. If the PV generation is not able to meet the PV FPN, then the instruction and meter reading will both be below the FPN requirements.

In real time with dynamic response

When the BESS is active in dynamic response, depending on the frequency measured, then its active power must be adjusted correspondingly.

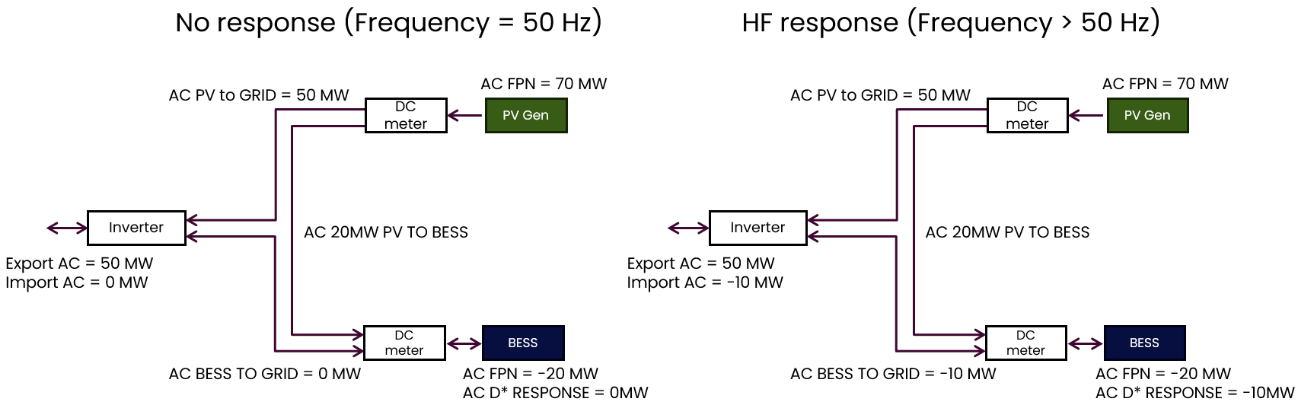


Figure 4: Comparison between baseline and response flows (AC lossless)

The dynamic response means that the flows within the site will change. Some response requirements may cause impossible flows. Therefore, just like under the baseline conditions, the flows may have to be re-arranged (see Figure 5 below)

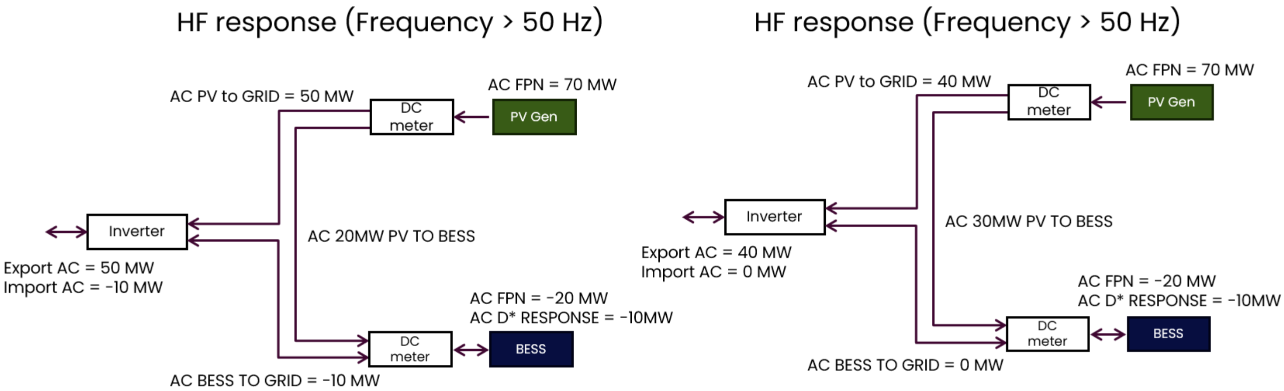


Figure 5: Creating a feasible flow solution for response

The dynamic response should only affect the instruction sent to the BESS. The PV is not the asset providing the dynamic response and therefore its instruction should not be modified. Only the BESS instruction should be modified when providing response. This principle is demonstrated in *Figure* 6.

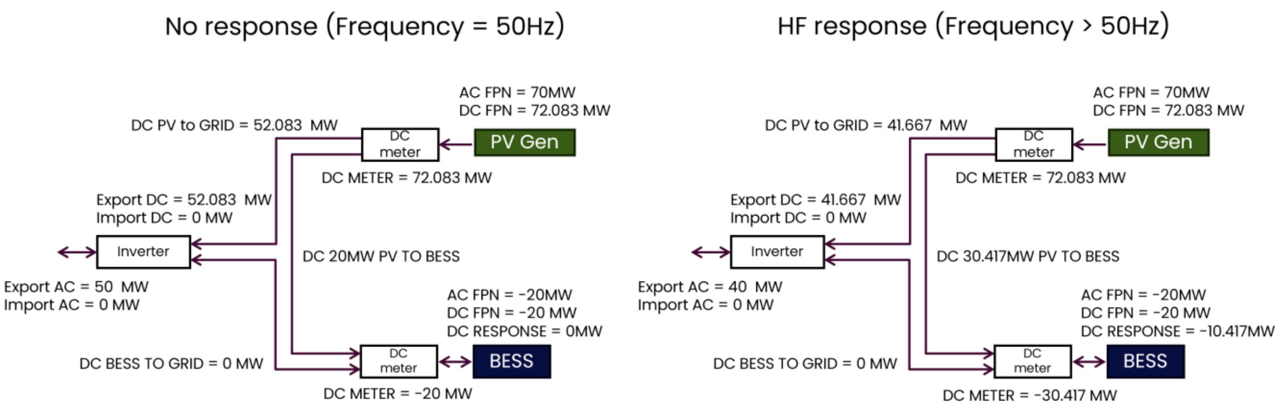


Figure 6: Loss-adjusted Modification of BESS DC instruction to generate response

Through this process the following additional values are generated:

- *dyn_BESS_AC_resp*: The dynamic response required based on the frequency measurement and active dynamic response contracts (as expected at the boundary in AC terms).
- *ins_BESS_DC_all*: BESS controller instruction that ensures that both the PV and BESS PN and BOA obligations are satisfied, and the Dynamic Response is correct for the measured frequency and active contracts (in DC terms).

Since the BESS is the unit contracted to provide dynamic response, and the PV is not contracted for dynamic response, the modified BESS instruction must consider the baseline condition loss adjustments. In Figure 6, we can see that the PV to BESS flow increases by more than 10MW, this is to ensure that the net flow at the boundary is correct. Since the PV DC instruction assumes losses for a 50MW AC CCL, the BESS dynamic response must compensate for the reduction of inverter losses. If the PV to BESS flow only increased by 10MW, the PV to GRID flow would be 40.40MW at the boundary point, 0.4MW too much. Increasing the PV to BESS flow by 0.417 MW results in the correct 40MW flow at the boundary point.

Under perfect conditions the DC meter reading should be equal to the *ins_BESS_DC_all* instruction.

Data derived performance monitoring

In the performance monitoring submission, as per the guidance, two values must be submitted which are then used to determine the response provided by the unit.

These values are:

- *baseline_mw*: Baseline in MW to 4 decimal places
- *p_mw*: Measured active power output or demand in MW to 4 decimal places

For standard BESS sites, the *p_mw* value is taken at the AC boundary meter, and the *baseline_mw* value is the PN and BOA requirement of the site in AC terms.

For the a co-located site, these values will be data derived from DC instructions and DC meter reading and loss adjusted back to AC equivalent values.

The values used to derive the performance monitoring are:

- *ins_PV_DC_pnsboas*: PV generation instruction that ensures the PV PN and BOA obligations are satisfied (in DC terms).
- *mtr_PV_DC*: PV DC meter reading.

- *ins_BESS_DC_pnsboas*: BESS instruction that ensures that the BESS PN and BOA obligations are satisfied (in DC terms).
- *mtr_BESS_DC*: BESS DC meter reading.

The *baseline_mw* value will be derived from the instruction values, *ins_PV_DC_pnsboas* and *ins_BESS_DC_pnsboas*. The p_mw value is calculated from metered values (mtr_PV_DC and mtr_BESS_DC) using inverter loss factors in simple scenarios, such as PV export only. In more complex cases, further information on instructions is needed to identify which flows incur losses and which do not, for example when both PV exports and charges BESS.

The metering diagram in Figure 7 illustrates the data and metering flow across four operational phases. It shows how power and energy data for PV and BESS units are managed from initial FPN/BOA submission through to post-delivery performance monitoring, including both AC and DC metering systems. In the stage of ahead of time until Gate Closure and within Gate, the forecasted or scheduled data are provided, including FPN, BOA, PN etc. In real time, the site flow solution converts AC dispatch instructions into DC-level control signals. In the post-delivery analysis, baselines and performance data are captured and evaluated to ensure accuracy and compliance across AC and DC domains.

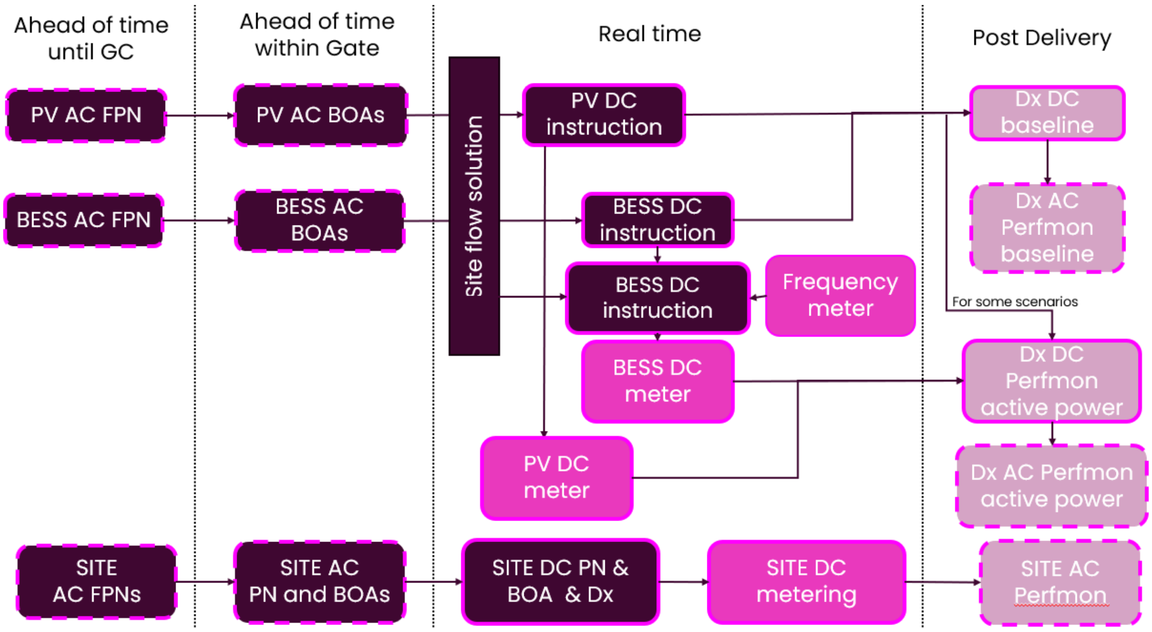


Figure 7: Data flow of the calculation process.

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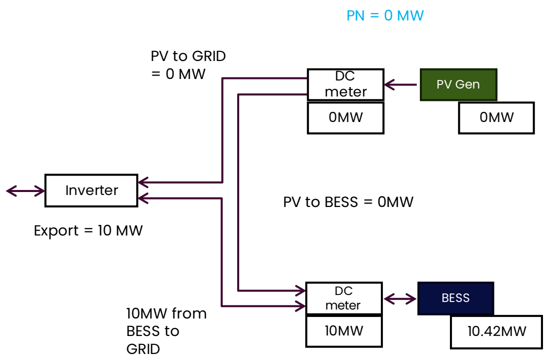
Appendix

Public

1) Overnight BESS exporting

Frequency = 50Hz



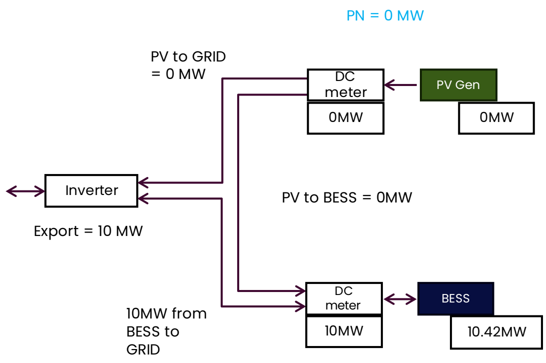
All DC meter values are loss adjusted

1

Public

1) Overnight BESS exporting – LF response considered

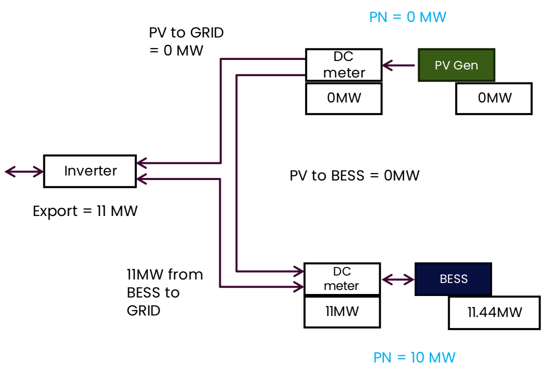
Frequency = 50Hz



All DC meter values are loss adjusted

5

Frequency = 49.5Hz – LF response delivered (BESS only)

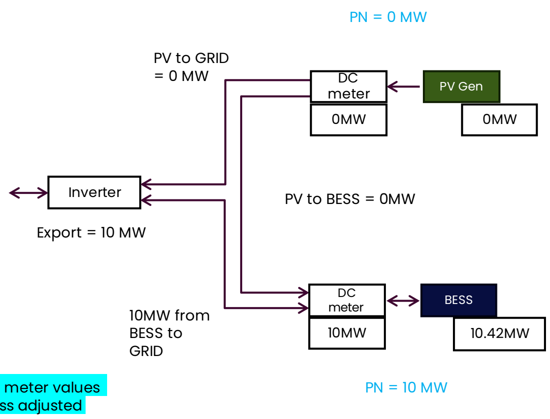


LF response delivered = 1MW

Public

1) Overnight BESS exporting – LF response considered

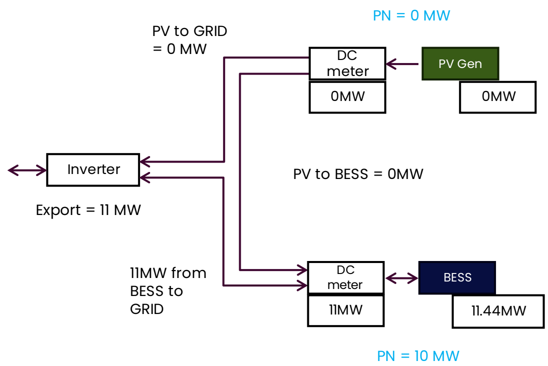
Frequency = 50Hz



All DC meter values are loss adjusted

5

Frequency = 49.5Hz – LF response delivered (BESS only)

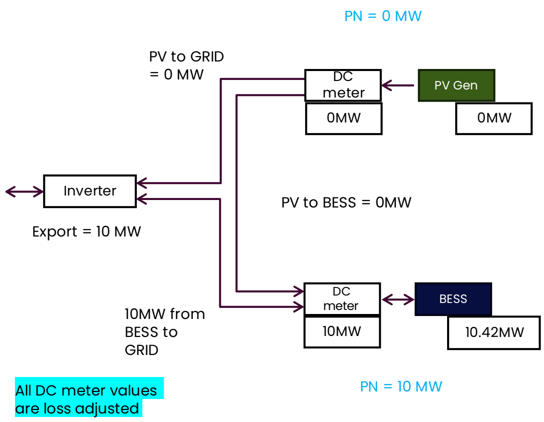


LF response delivered = 1MW

Public

1) Overnight BESS exporting + BOA

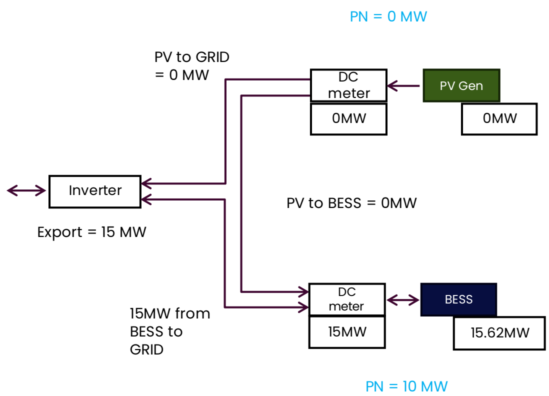
Frequency = 50Hz



All DC meter values are loss adjusted

7

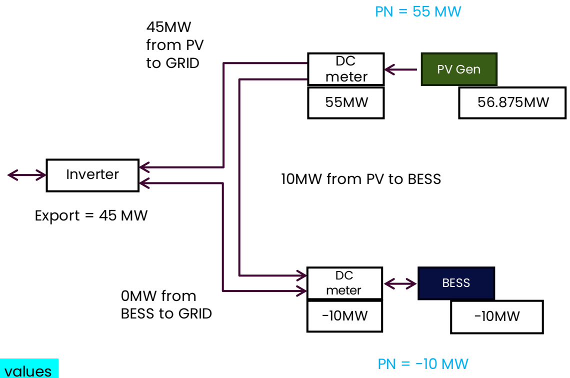
Frequency = 50Hz



BOA to 15MW Export (CCL = 15MW)

2) Peak daytime (PV export + PV to BESS)

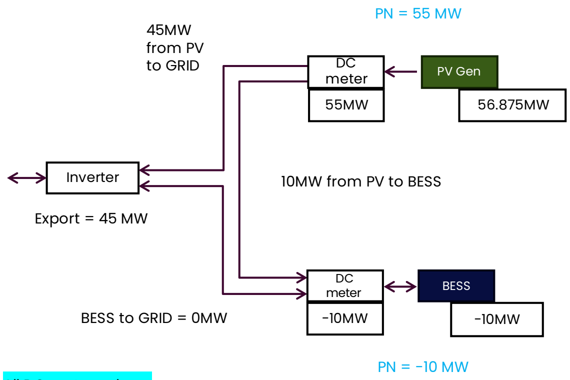
Frequency = 50Hz



All DC meter values are loss adjusted

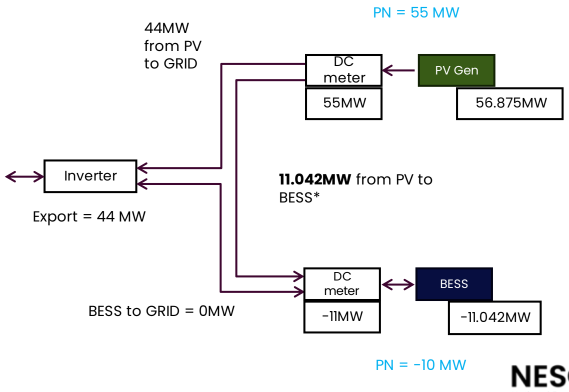
2) Peak daytime (PV export + PV to BESS) – HF considered

Frequency = 50Hz



All DC meter values are loss adjusted

Frequency = 50.5Hz – HF response delivered (BESS only)

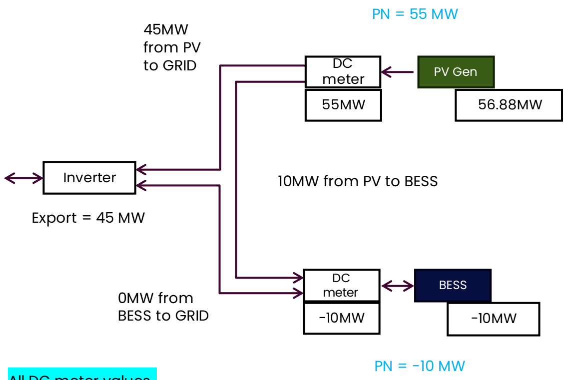


HF response delivered = 1MW

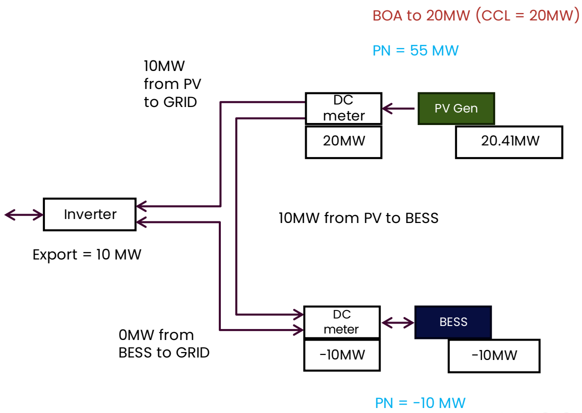
Public

2) Peak daytime (PV export + PV to BESS) + BOA

Frequency = 50Hz



Frequency = 50Hz



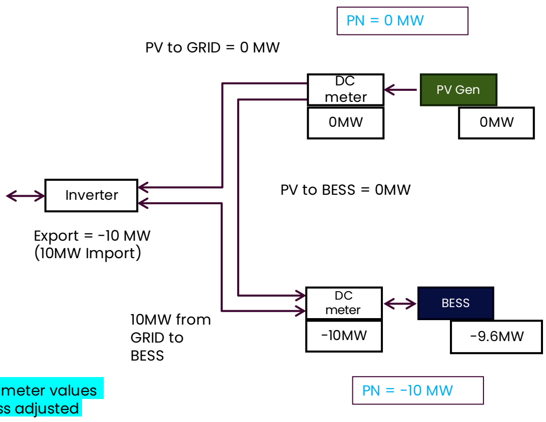
All DC meter values are loss adjusted

10

Public

3) Overnight BESS importing

Frequency = 50Hz



All DC meter values are loss adjusted

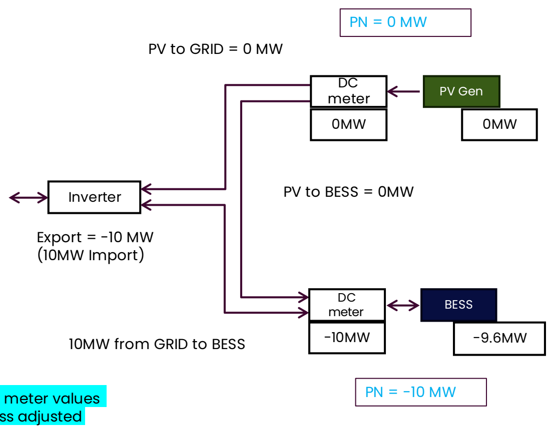
11

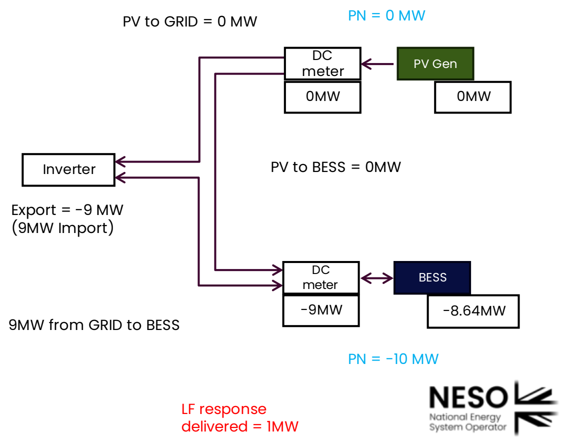
Public

3) Overnight BESS importing – LF response considered

Frequency = 50Hz

Frequency = 49.5Hz – LF response delivered





All DC meter values are loss adjusted

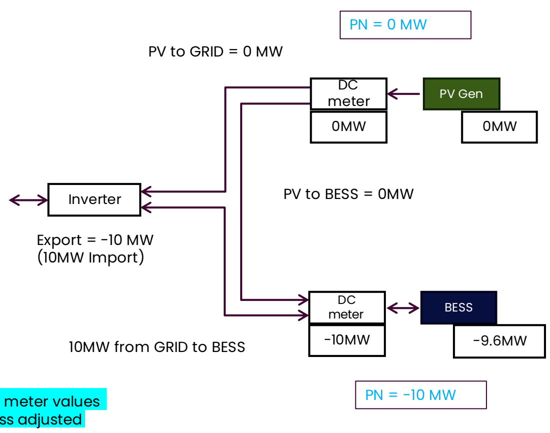
12

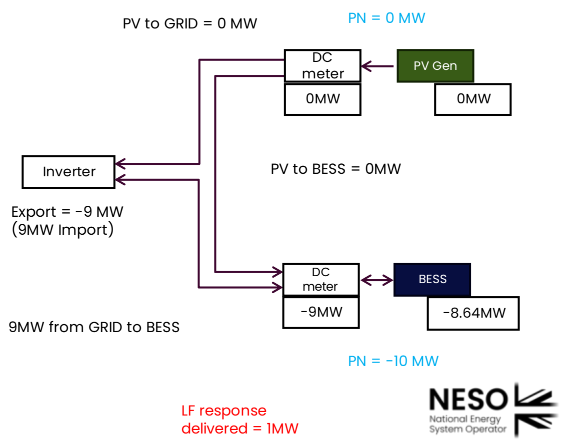
Public

3) Overnight BESS importing – LF response considered

Frequency = 50Hz

Frequency = 49.5Hz – LF response delivered





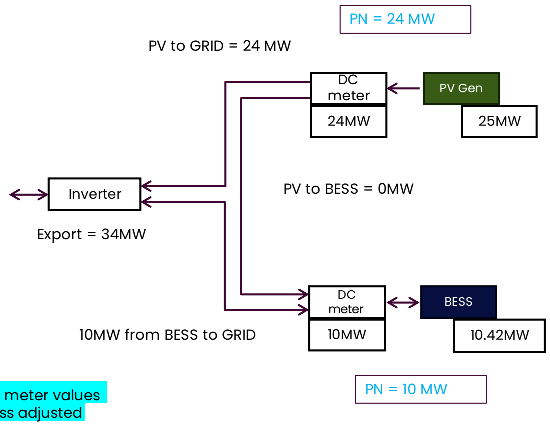
All DC meter values are loss adjusted

12

Public

4) PV and BESS exporting

Frequency = 50Hz



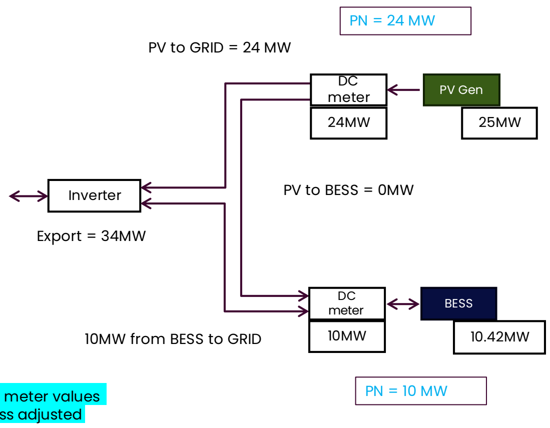
All DC meter values are loss adjusted

14

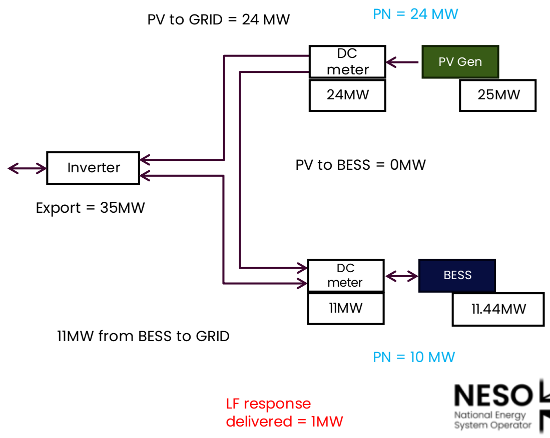
Public

4) PV and BESS exporting – LF response considered

Frequency = 50Hz



Frequency = 49.5Hz – LF response delivered (BESS only)



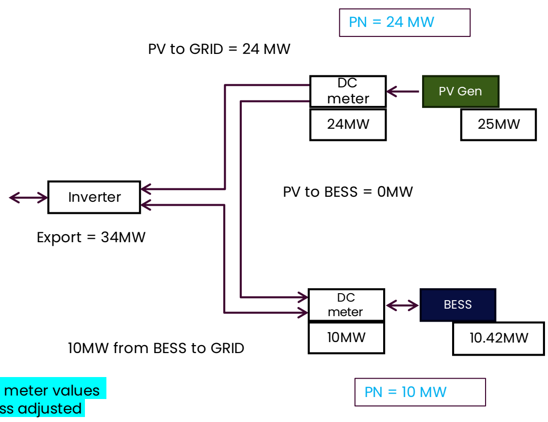
All DC meter values are loss adjusted

15

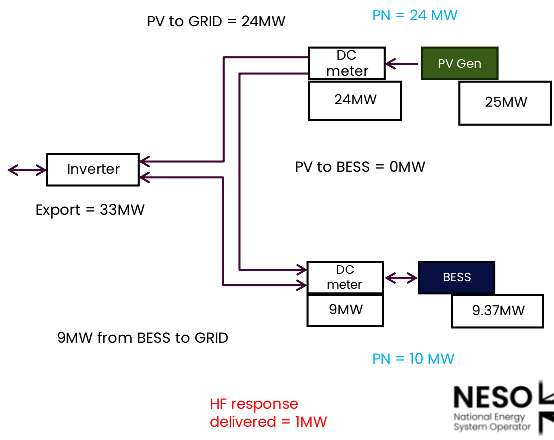
Public

4) PV and BESS exporting – HF response considered

Frequency = 50Hz



Frequency = 50.5Hz – HF response delivered (BESS Only)



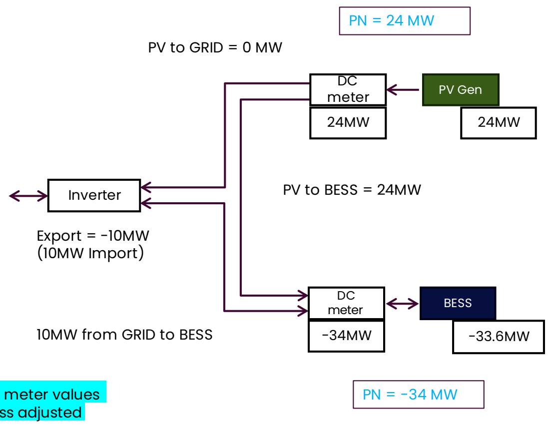
All DC meter values are loss adjusted

16

Public

5) BESS charging from PV and Grid

Frequency = 50Hz



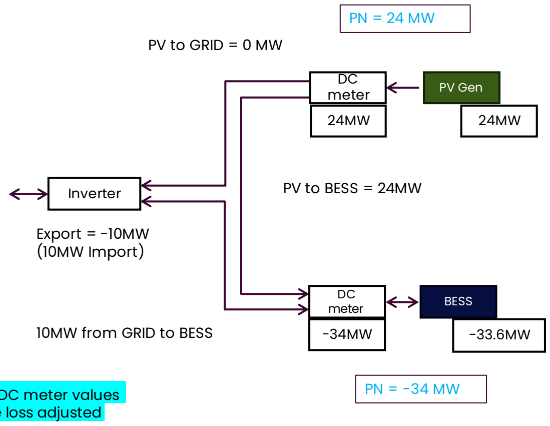
All DC meter values are loss adjusted

17

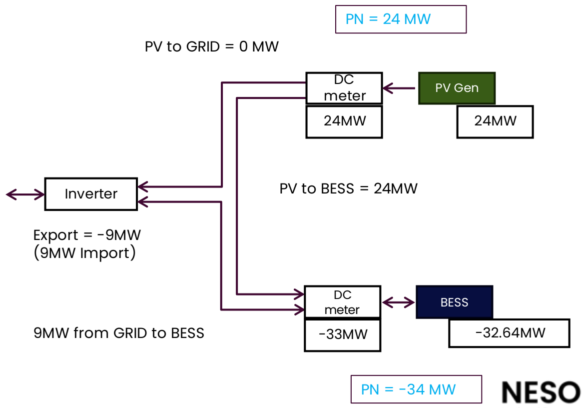
Public

5) BESS charging from PV and Grid – LF response considered

Frequency = 50Hz



Frequency = 49.5Hz – LF response delivered (BESS only)



All DC meter values are loss adjusted

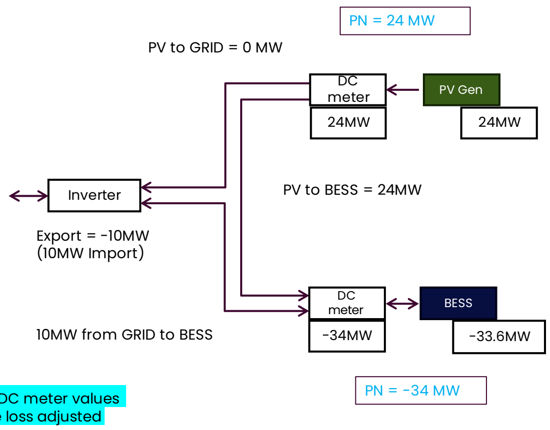
18

LF response delivered = 1MW

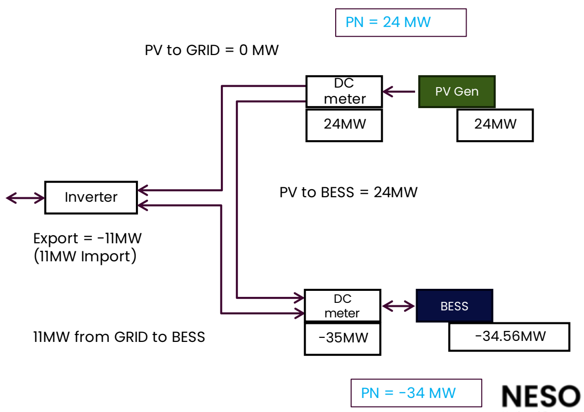
Public

5) BESS charging from PV and Grid – HF response considered

Frequency = 50Hz



Frequency = 50.5Hz – HF response delivered (BESS only)



All DC meter values are loss adjusted

19

HF response delivered = 1MW