

Battery ESPS Reactive Power Capability Test Procedure

[Insert PPM Name]

Version 0.1

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# Document Version History

EirGrid test procedure template version published July 2021.

|  |
| --- |
| **Document Version History** |
| **Version** | **Date** | **Comment** |
| 0.1 | dd/mm/yyyy | First submission for review/approval |
| 1.0 |  |  |
|  |  |  |

# Introduction

|  |  |
| --- | --- |
| ESPS Name | ESPS to Specify(name per connection agreement) |
| ESPS Test Coordinator and contact number: | ESPS to Specify |
| Associated 110 kV Station | ESPS to Specify  |
| ESPS connection point | ESPS to Specify (*i.e.* T121 in XXX Distribution or Transmission Station) |
| ESPS connection voltage | ESPS to Specify |
| ESPS Connection Type  | ESPS to Specify (TSO, DSO Topology 1, DSO Topology 2 etc.) |
| Installed module type, MW size and quantity | ESPS to Specify |
| Contracted MEC | ESPS to Specify |
| Contracted MIC | ESPS to Specify |
| Registered Capacity | ESPS to Specify |
| Energy Storage Capacity | ESPS to Specify |
| % Charge maintained in normal operation | ESPS to Specify |
| Limiter applied to Exported MW | ESPS to Specify |
| Limiter applied to AAP | ESPS to Specify |
| Minimum Leading MVAr requirement at the connection point above 12% Active Power Output per Grid Code *Figure PPM1.4 (or equivalent Implementation Note requirement)* | ESPS to Specify |
| Minimum Lagging MVAr requirement at the connection point above 12% Active Power Output per Grid Code *Figure PPM1.4 (or equivalent Implementation Note requirement)* | ESPS to Specify |
| Maximum Leading MVAr at connection point | ESPS to Specify |
| Maximum Lagging MVAr at connection point | ESPS to Specify |
| Grid Connected Transformer Tap range | ESPS to Specify |

## Test Execution

**PPM shall highlight any changes made to this document or approval will be void.**

The PPM shall submit the latest version of this test procedure template as published on the EirGrid website[[1]](#footnote-2).

All yellow sections shall be filled in before the test procedure shall be approved. All grey sections shall be filled in during testing. If any test requirements or steps are unclear, or if there is an issue with meeting any requirements or carrying out any steps, please contact generator\_testing@eirgrid.com.

Where a site consists of two separate controllable PPM with a single connection point, this may impact on the test procedure outlined below.

The ESPS representative shall coordinate testing. On the day of testing, suitably qualified technical personnel may be needed at the ESPS to assist in undertaking the tests. Such personnel shall have the ability to fully understand the function of the ESPS and its relationship to the network to which the ESPS is connected. Furthermore, such personnel shall have the ability to set up the control system of the ESPS so as to enable Grid Code compliance test to be correctly undertaken. In addition, the function of the technical personnel is to liaise with NCC.

The availability of personnel at NCC will be necessary in order to initiate the necessary instructions for the test. NCC shall determine if network conditions allow the testing to proceed.

All battery modules shall be available. If on the day of the testing all battery modules are not available, then the test may proceed where the unavailable modules make up <20% of Registered Capacity. All test results shall be based on tested performance only and shall not be extrapolated in the case of reduced availability. Resource conditions need to be sufficient in order adequately perform the test. The ESPS should, where possible, ensure the unit has sufficient state of charge in advance of commencing testing each day. Before each test section, the state of charge of the ESPS should be checked and adjusted if required, following approval by NCC.

Throughout the test procedure, for instances where APC is OFF the TSO accepts that there may be some level of import required to manage house load in this scenario. The battery should not be discharging or charging while APC is OFF, but may import due to house load.

## Notes

If Automated Test Scripts are being used, Automated Test Scripts generated by the ESPS shall meet the following requirements:

* It must be possible to pause the script at any point.
* The MW Test Profile has been submitted and agreed in advance
* The MW Test Profile must account for timing of each step (note 1 minute is not appropriate for all steps).

Please note a site specific PQ chart is to be provided in Section 4.

Following testing, the following shall be submitted to generator\_testing@eirgrid.com:

|  |  |
| --- | --- |
| **Submission** | **Timeline** |
| A scanned copy of the test procedure, as completed and signed on site on the day of testing | 1 working day |
| Test data in CSV or Excel format | 1 working day |
| Test report | 10 working days |

## Site Safety requirements

The following is required for the EirGrid witness to attend site:

|  |  |
| --- | --- |
| Personnel Protection Gear Requirements1. Site Safety boots
2. Hard Hat with chin strap
3. Hi Vis
4. Arc Resistive clothing
5. Safety Glasses
6. Gloves
7. Safe Pass
 | 1. Yes / No
2. Yes / No
3. Yes / No
4. Yes / No
5. Yes / No
6. Yes / No
7. Yes / No
 |
| Site Induction requirements | Yes / No (If Yes, PPM to specify how and when the induction shall be carried out) |
| Any further information | PPM to specify |

# Abbreviations

APC Active Power Control

AVR Automatic Voltage Regulation

ESPS Energy Storage Power Station

HV High Voltage

MEC Maximum Export Capacity

MIC Maximum Import Capacity

MVAr Mega Volt Ampere – reactive

MW Mega Watt

NCC National Control Centre

PF Power Factor

PPM Power Park Module

TSO Transmission System Operator

Leading MVAr Absorbing MVAr from System

Lagging MVAr Producing MVAr

# Reactive Power Capability chart at connection point

The PQ chart provided below chart shall be site specific.

If there are any differences between the PQ chart submitted within this procedure and the studied capability provided in Phase A, this should be highlighted and discussed with Generator Testing.

**If any limiters apply in any of the three control modes, the operation of those limiters shall be detailed here.**

|  |  |
| --- | --- |
| The PQ chart is based on | Modelled / Real data(If the data is based on modelled results the ESPS shall specify the model reference and confirm that this is as submitted to EirGrid through the connection process) |
| The PQ chart shows the capability at the connection point and accounts for all losses. | Yes / No  |
| The PQ chart shows the following.1. Grid Code Requirements per *Figure PPM 1.4 of Grid Code/Battery Implementation Note*
2. Maximum capability of the ESPS
3. Breakdown of reactive power devices e.g. battery modules or STATCOM
 | 1. Yes / No
2. Yes / No
3. Yes / No
 |
| Any further information | ESPS to specify how reactive power capability is achieved i.e. fixed / switched cap banks, STATCOM, etc. |
| Note: 1. The PQ chart shall be site specific.
2. Generic PQ charts are not accepted.
 |

ESPS shall Insert PQ chart

**Any limiters applied shall also be displayed**

# Grid Code References

|  |  |
| --- | --- |
| Grid Code Version:  | ESPS to specify |
| Please also refer to the published Battery ESPS Grid Code Implementation Note[[2]](#footnote-3) for guidance on technical requirements for Battery ESPS and applicability of specific PPM clauses within the Grid Code. |  |



Figure 1 Minimum Reactive Capability Characteristic of Battery ESPS at Connection Point

# Test desciption and pre conditions

## Purpose of the Test

The purpose of this test is to demonstrate the limits of the ESPS reactive power capability curve at the connection point. The test is undertaken at various load levels for both the export of reactive power from the ESPS and for the import of reactive power to the ESPS.

## Pass Criteria

The following is the pass criteria for the test. Any subsequent report for this test shall be assessed against each of these criteria.

| **Criteria** |
| --- |
| **Reactive Power Capability** |
| Demonstration that the measured P-Q capability is in line with the submitted P-Q capability diagram |
| Demonstration that the measured P-Q capability meets or exceeds the minimum expected reactive power capabilities of the controllable ESPS, as defined in the Grid Code and in the published Battery Implementation Note, as measured at the Connection Point |
| Completion of cable charging measurement  |
| Reactive power import availability and reactive power export availability signals provide the real-time availability of MVAr that can be imported/consumed at point of connection, taking into account any relevant factors such as active power output (or import), module availability, faults etc. |

## Instrumentation and onsite data trending

All of the following trends shall be recorded by the ESPS during the test. The ESPS may capture any other signals as necessary to demonstrate compliance.

The ESPS shall specify the resolution of these signal recordings. As a minimum the resolution should be as specified in the table below.

| **No.** | **Data Trending and Recording** | **Resolution** | **Check On Day Of Test** |
| --- | --- | --- | --- |
| 1 | ESPS Available Active Power Export (MW) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 2 | ESPS Available Active Power Import (MW) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 3 | ESPS Total Useable Storage Capacity (MWhr) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 4 | ESPS Useable Energy Remaining (MWhr) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 5 | Actual active power from the ESPS in MW  | PPM to Specify (≥ 1 Hz) | Yes / No |
| 6 | APC set-point from NCC (MW) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 7 | ESPS voltage measured at the lower voltage side of the grid connected transformer  | PPM to Specify (≥ 1 Hz) | Yes / No |
| 8 | Grid voltage measured at the connection point  | PPM to Specify (≥ 1 Hz) | Yes / No |
| 9 | Reactive power measured at the lower voltage side of the grid connected transformer  | PPM to Specify (≥ 1 Hz) | Yes / No |
| 10 | Reactive power measured at the connection point  | PPM to Specify (≥ 1 Hz) | Yes / No |
| 11 | Reactive Power Export Availability (MVAr) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 12 | Reactive Power Import Availability (MVAr) | PPM to Specify (≥ 1 Hz) | Yes / No |
| 13 | Grid transformer tap position | PPM to Specify (≥ 1 Hz) | Yes / No |
| 14 | MVAr (Q) set-point | PPM to Specify (≥ 1 Hz) | Yes / No |

## MVAr changes and calculations

|  |  |
| --- | --- |
| **Calculation** | **Value** |
| 1kV change in system voltage with Voltage Regulation System slope of 4% | \_\_\_\_ MVAr(ESPS to specify calculation and formula used) |
| 3kV change in system voltage with Voltage Regulation System slope of 4% | \_\_\_\_ MVAr(ESPS to specify calculation and formula used) |

## Initial Conditions

If “No” is answered to any of the following, contact NCC and agree next steps in advance of making any corrective actions.

| **Conditions** | **Check on day of test** |
| --- | --- |
| All battery modules are available(or as outlined in Section 2.1 above) | # modules installed: \_\_\_\_# modules available: \_\_\_\_ |
| State of charge | \_\_\_\_\_ % |
| MW Profile has been submitted if Test Script is automated | Yes / No / N/A |
| Automated Test Script can be paused. | Yes / No / N/A |
| Test PNs have been submitted Note this will not be applicable if the unit is not registered in the market | Yes / No / N/A |
| Grid Connected Transformer Tap range | Tap range: \_\_\_\_ to \_\_\_\_ |

# Test Steps



Option 1

Option 2

Depending on state of charge, the ESPS can follow the red or blue path to complete this test. Each option is shown on one side of the capability curve only for illustration purposes.

ESPS to start from a 0MW active power position at MVAr output close to 0 MVAr and increase MVAr set-points until max lagging/leading capability as noted in Section 4 is reached. Note that this set-point shall be large enough to cover the max capability over all of the MW range, such that as the MW output is varied in subsequent test steps, the MVAr output is not limited by the MVAr set-point.

Option 1 (Blue solid line): Once at max leading/lagging capability, the MVAr set-point should be set to ensure the maximum capability as per the PQ chart in Section 4 is achievable. Active power set-points are then issued to increase from 0MW to 100% registered capacity, and then down to full import. Note depending on the capability curve, the MVAr output may vary as MW output is varied.

Option 2 (Red dashed line): Once at max leading/lagging capability, the MVAr set-point should be set to ensure the maximum capability as per the PQ chart in Section 4 is achievable. Active power set-points are then issued to decrease from 0MW to full import, and then increase to 100% registered capacity. Note depending on the capability curve, the MVAr output may vary as MW output is varied.

After each option the MW output is returned to 0MW and the MVAr output is returned to 0MVAr in steps. The size of these steps shall be confirmed with NCC.

## Reactive Power Capability (Importing / Leading MVAr)

The ESPS is brought from 0 MVAr (or as agreed with NCC) to maximum leading MVAr. Once at maximum leading MVAr, the active power is adjusted in steps to max MW output or full MW import, and then full MW import or max MW output, as per options above.

The MW output is returned to 0 MW and the MVAr output is returned to 0 MVAr in steps. The size of these steps shall be confirmed with NCC.

\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied. Close co-ordination shall be maintained with NCC on expected changes in capability during the steps involving changes in MW output.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 6.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the Reactive Power Capability (Inductive / Leading MVAr) test and confirms the following with NCC: 1. MW output of the ESPS
2. APC is OFF
3. Frequency Response is OFF
4. MVAr (Q) control mode is ON
5. The transformer tap position
6. On Load Tap Changer Mode
7. System Voltage
8. Maximum leading MVAr capability of the ESPS
9. MVAr Export at the connection point
10. ESPS Reactive Power Export Availability (MVAr)
11. ESPS Reactive Power Import Availability (MVAr)
12. ESPS to confirm which path it wishes to follow for testing, based on state of charge
 |  | 1. \_\_\_\_ MW
2. Status \_\_\_\_
3. Status \_\_\_\_
4. \_\_\_\_ Mode
5. Tap # \_\_\_\_
6. \_\_\_\_ Mode
7. \_\_\_\_ kV
8. \_\_\_\_ MVAr
9. \_\_\_\_ MVAr
10. \_\_\_\_ MVAr
11. \_\_\_\_ MVAr
12. Option 1/ Option 2
 |
| 3 | ESPS requests NCC to decrease the MVAr set-point in steps as agreed with NCC until the ESPS has reached its maximum leading MVAr limit at the connection point |  | \_\_\_\_ MVAr\_\_\_\_ kV |
| 4 | ESPS requests NCC to reduce the MVAr set-point by a further step (s).\*Note: Refer to PQ chart submitted in Section 4. Ensure that the MVAr set-point is sufficient to cover the max capability over all of the MW range, such that as the MW output is varied in subsequent test steps, the MVAr output is not limited by the MVAr set-point. |  | ESPS shall remain at maximum leading MVAr\_\_\_\_ MVAr\_\_\_\_ kV |
| 5 | ESPS requests NCC to turn APC ON and issue a set-point of [insert 100% Registered Capacity / MIC] MW \*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps. |  | ESPS shall ramp at APC ramp rate\_\_\_\_ MW\_\_\_\_ MVAr |
| 6 | ESPS requests NCC to issue a set-point of 0 MW\*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps. |  | ESPS shall ramp at APC ramp rate.\_\_\_\_ MW\_\_\_\_ MVAr |
| 7 | ESPS requests NCC to issue a set-point of [insert 100% of MIC/Registered Capacity here] \*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps.  |  | \_\_\_\_ MW\_\_\_\_ MVAr |
| 8 | ESPS requests NCC to issue a set-point of 0MW and turn APC OFF and waits until output reaches 0 MW.\*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps. |  | \_\_\_\_ MW\_\_\_\_ MVAr |
| 9 | ESPS requests NCC to increase the MVAr set-point in steps as agreed with NCC until the ESPS is exporting 0 MVAr at the connection point, or as agreed with NCC |  | MVAr output shall be at 0 MVAr, or as agreed with NCC\_\_\_\_\_ MVAr |
| 10 | ESPS ends data recording |  |  |
| 11 | ESPS informs NCC that the Reactive Power Capability (Inductive / Leading MVAr) test is complete If further testing is not being completed, go to Section 7.4 Return to Standard Settings |  |  |
| Note any issues or deviations from test procedure.For example changes in step size, duration, test operators, parameter changes on site.Mark as “No Comment” if test proceeded as per procedure. |  |

## Reactive Power Capability (Exporting / Lagging MVAr)

The ESPS is brought from 0 MVAr (or as agreed with NCC) to maximum lagging MVAr. Once at maximum lagging MVAr, the active power is adjusted in steps to max MW output or full MW import, and then full MW import or max MW output, as per options above.

The MW output is returned to 0 MW and the MVAr output is returned to 0 MVAr in steps. The size of these steps shall be confirmed with NCC.

\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied. Close co-ordination shall be maintained with NCC on expected changes in capability during the steps involving changes in MW output.

| **Step No.** | **Action** | **Time** | **Comments** |
| --- | --- | --- | --- |
| 1 | ESPS begins data recording for all trends noted in Section 6.3, above |  | Operator Name \_\_\_\_\_\_\_\_\_\_\_\_Date \_\_\_\_\_\_\_\_\_\_\_\_ |
| 2 | ESPS requests permission from NCC to proceed with the Reactive Power Capability (Capacitive / Lagging MVAr) test and confirms the following with NCC: 1. MW output of the ESPS
2. APC is OFF
3. Frequency Response is OFF
4. MVAr (Q) control mode is ON
5. The transformer tap position
6. On Load Tap Changer Mode
7. System Voltage
8. Maximum lagging MVAr capability of the ESPS
9. MVAr Export at the connection point
10. ESPS Reactive Power Export Availability (MVAr)
11. ESPS Reactive Power Import Availability (MVAr)
12. ESPS to confirm which path it wishes to follow for testing, based on state of charge
 |  | 1. \_\_\_\_ MW
2. Status \_\_\_\_
3. Status \_\_\_\_
4. \_\_\_\_ Mode
5. Tap # \_\_\_\_
6. \_\_\_\_ Mode
7. \_\_\_\_ kV
8. \_\_\_\_ MVAr
9. \_\_\_\_ MVAr
10. \_\_\_\_ MVAr
11. \_\_\_\_ MVAr
12. Option 1/ Option 2
 |
| 3 | ESPS requests NCC to increase the MVAr set-point in steps as agreed with NCC until the ESPS has reached its maximum lagging MVAr limit at the connection point. |  | \_\_\_\_ MVAr |
| 4 | ESPS requests NCC to reduce the MVAr set-point by a further step (s).\*Note: Refer to PQ chart submitted in Section 4. Ensure that the MVAr set-point is sufficient to cover the max capability over all of the MW range, such that as the MW output is varied in subsequent test steps, the MVAr output is not limited by the MVAr set-point. |  | ESPS shall remain at maximum lagging MVAr\_\_\_\_ MVAr |
| 5 | ESPS requests NCC to turn APC ON and issue a set-point of [insert 100% Registered Capacity / MIC] MW \*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps. |  | \_\_\_\_ MW\_\_\_\_ MVAr |
| 6 | ESPS requests NCC to issue a set-point of 0 MW \*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps. |  | \_\_\_\_ MW\_\_\_\_ MVAr |
| 7 | ESPS requests NCC to issue a set-point of [insert 100% of MIC/Registered Capacity here] \*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps. |  | \_\_\_\_ MW\_\_\_\_ MVAr |
| 8 | ESPS requests NCC to issue a set-point of 0 MW and turn APC OFF and waits until the output reaches 0MW.\*Note if Registered Capacity/MIC is larger than 10MW – this step may be split into multiple steps\*Note depending on the ESPS PQ curve, the MVAr output may vary as MW output is varied for subsequent steps. |  |  |
| 9 | ESPS requests NCC to decrease the MVAr set-point in steps as agreed with NCC, until the ESPS is exporting 0 MVAr at the connection point, or as agreed with NCC |  | MVAr output shall be at 0 MVAr, or as agreed with NCC\_\_\_\_ MVAr |
| 10 | ESPS ends data recording |  |  |
| 11 | ESPS informs NCC that the Reactive Power Capability (Capacitive / Lagging MVAr) test is completeIf further testing is not being completed, go to Section 7.4 Return to Standard Settings |  |  |
| Note any issues or deviations from test procedure.For example changes in step size, duration, test operators, parameter changes on site.Mark as “No Comment” if test proceeded as per procedure. |  |

## Establish Battery Cable Network Charging Capacitance

The steps below establish the charging capacitance of the cable network and balance of plant.

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | ESPS requests permission from NCC and shuts down all Battery Modules |  |  |
| 2 | ESPS records the MVAr at the connection point |  | \_\_\_\_\_ MVAr |
| 3 | ESPS requests permission from NCC and restarts all Battery Modules |  |  |

## Return to Standard Settings

The steps below return the ESPS to standard settings at the completion of testing.

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 2 | ESPS confirms the following with NCC: 1. APC set point is 0MW
2. MW output of the ESPS
3. APC is OFF
4. Frequency Response is ON
5. Frequency Response is in Mode 1 (or as agreed with NCC)
6. AVR (kV) control mode is ON
7. The transformer tap position
8. On Load Tap Changer is in Automatic mode
9. System Voltage
10. kV Set-point = system voltage at connection point
11. Voltage slope setting = 4%
12. MVAr Export at the connection point
 |  | 1. \_\_\_\_ MW
2. \_\_\_\_ MW
3. Status \_\_\_\_
4. Status \_\_\_\_
5. Curve \_\_\_\_
6. \_\_\_\_ Mode
7. Tap # \_\_\_\_
8. \_\_\_\_ Mode
9. \_\_\_\_ kV
10. \_\_\_\_ kV
11. \_\_\_\_%
12. \_\_\_\_ MVAr
 |
| 3 | ESPS informs NCC that Reactive Power Capability testing is complete |  |  |

## Comments & Signatures

|  |
| --- |
| **Comments:**  |
| ESPS Witness signoff that this test has been carried out according to the test procedure, above.Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| EirGrid Witness signoff that this test has been carried out according to the test procedure, above.Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

1. <http://www.eirgridgroup.com/library> [↑](#footnote-ref-2)
2. <http://www.eirgridgroup.com/site-files/library/EirGrid/Integration-of-Batteries-Implementation-Note.pdf> [↑](#footnote-ref-3)