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| Workgroup Consultation | | | |
| **GC0155:**  **Clarification of Fault Ride Through Technical Requirements**  **Overview:** An alternative to GC0151 which addressed the Fault Ride Through (FRT) compliance process and proposed minor improvements to the FRT technical requirements. This alternative was insufficiently scrutinised as part of the GC0151 urgent modification process hence Ofgem, while rejecting it in their decision letter dated 8 November 2021, noted that it had merit and should be brought forward subsequently*.* | | **Modification process & timetable**    **Proposal Form**  16 December 2021  **Workgroup Consultation**  xxx  **Workgroup Report**  xxx  **Code Administrator Consultation**  xxx  **Draft Modification Report**  xxx  **Final Modification Report**  xxx  **Implementation**  xxxx decision  **1**  **2**  **3**  **4**  **5**  **6**  **7** | |
| **Have 5 minutes?** Read our [Executive summary](#_Executive_summary_1)  **Have 20 minutes?** Read the full [Workgroup Consultation](#_Why_change?)  **Have 30 minutes?** Read the full Workgroup Consultation and Annexes. | | | |
| **Status summary:** The Workgroup are seeking your views on the work completed to date to form the final solution(s) to the issue raised. | | | |
| **This modification is expected to have a:** medium impact on Generators, Transmission System Operators, Interconnectors, Transmission Owners, Distribution Owners  High: Developers, Consumers | | | |
| **Modification drivers:** GB Compliance, Ofgem-led Code Review, System Operability, System Security,Efficiency,New Technologies; System stability | | | |
| **Governance route** | Standard Governance modification with assessment by a Workgroup | | |
| **Who can I talk to about the change?** | **Proposer:**  Terry Baldwin  [Terry.Baldwin@nationalgrideso.com](mailto:Terry.Baldwin@nationalgrideso.com)    0781 4778 118 | | **Code Administrator** **Chair**:  Milly Lewis  [Milly.Lewis@nationalgrideso.com](mailto:Milly.Lewis@nationalgrideso.com)    07811036380 |
| **How do I respond?** | Send your response proforma to[grid.code@nationalgrideso.com](mailto:grid.code@nationalgrideso.com) **by 5pm on** | | |

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# Executive summary

What is the issue?

This proposal is based on an alternative proposal (WAGCM2) to [GC0151](https://www.nationalgrideso.com/industry-information/codes/grid-code-old/modifications/gc0151-grid-code-compliance-fault-ride) *‘Grid Code Compliance with Fault Ride Through Requirements (FRT)’* proposed by Drax Power Ltd to clarify the technical requirements for FRT capability set out in the Grid Code to improve consistency, accuracy and understanding and to help prevent non-compliance with the Grid Code.

This Modification therefore proposes minor changes and improvements to the existing Grid Code FRT requirements as a minimum but not limited to the following:

* To clarify instances where User Plant is permitted to trip where required in order to clear the fault from the transmission system.
* To amend requirements for generating maximum reactive current during faults which may be unachievable for many Generators.
* To amend post fault Active Power requirements to reflect that low Load Generators may have greater oscillations than the requirements currently allow for.

Bigger deal:

* To provide requirements for overvoltage events following a fault.

## Why change?

To enable Generators to assess better their compliance with FRT requirements, which will enhance system security during fault conditions, and to avoid unnecessary compliance proceedings following an incident where a Generator may have tripped for allowable reasons by achieving greater clarity for all parties.

What is the solution and when will it come into effect?

**Proposer’s solution:**

The sections of the code to which changes are proposed are CC.6.3.15 and ECC.6.3.15 which together form the FRT technical conditions for all applicable plant. There are several other issues within the existing legal text in the Grid Code relating to FRT – stemming from the current drafting and understanding of the legal text.

**Implementation date:**

10 days after authority approval.

**Summary of potential alternative solution(s) and implementation date(s):**

WAGCM1 In general this Alternative Modification Proposal will have the same effect as the Original Modification Proposal except that it will not retrospectively apply (whereas the Original would) the over voltage ride though requirements.

WAGCM2 The alternative solution proposed is the Original GC0155 solution which contains the Fault Ride Through clarifications identified within the terms of reference minus the temporary overvoltage requirements which are recommended to be resolved via its own new modification.

What is the impact if this change is made?

System wide operational impact (this is if retrospectivity is to be considered)

Interactions

This modification proposal if implemented, will have no impacts on the Electricity Balancing Regulations or on other codes.

Potential STC changes required.

Potential CUSC for cost recovery if retrospective application to be considered

Potential impact on the future stability market design

What is the issue?

This proposal is based on an alternative proposal (WAGCM2) to GC0151 ‘Grid Code Compliance with Fault Ride Through Requirements’. It was proposed during the GC0151 workgroup by Drax Power Ltd and aimed to clarify the technical requirements for FRT capability set out in the Grid Code to improve consistency, accuracy and understanding and to help prevent non-compliance with the Grid Code.

Ofgem in its decision letter on [GC0151](https://www.nationalgrideso.com/document/218331/download) noted the views of various stakeholders and Panel members that while WAGCM2 had merit it had been insufficiently scrutinised as part of the urgent development process undertaken for GC0151. Following the implementation of GC0151, the ESO agreed to raise a proposal embodying the GC0151 WAGCM2 proposals which the ESO had also broadly supported.

This modification therefore proposes minor changes and improvements to the existing Grid Code Fault Ride Through requirements as a minimum but not limited to the following:

* To clarify instances where User Plant is permitted to trip where required in order to clear the fault from the Transmission System.
* To amend requirements for generating maximum reactive current during faults which may be unachievable for many Generators.
* To amend post fault Active Power requirements to reflect that low Load Generators may have greater oscillations than the requirements currently allow for.

Also in GC0151 the original proposal had overvoltage, but was withdrawn and therefore the Workgroup has considered

* To provide requirements for overvoltage events following a fault.

## Why change?

To enable Generators to assess more completely their compliance with FRT requirements, which will enhance system security during fault conditions, and to avoid unnecessary compliance proceedings, following an incident where a Generator may have tripped for allowable reasons, by achieving greater clarity for all parties.

What is the solution?

## Proposer’s solution

The sections of the code to which changes are proposed are CC.6.3.15 and ECC.6.3.15 and the addition of CC.6.1.11 and ECC.6.1.11; and ANNEX which together form the FRT technical conditions for all applicable plant.

There are several clarifications required to support the understanding and fix some technical requirement of the FRT technical compliance processes within the Grid Code.

**Clarification of Fault Ride Through Requirements**

The way the current clauses CC.6.3.15 and ECC.6.3.15 are written does not acknowledge that there are instances when a generating plant may be required to be disconnected from the system as part of the necessary actions required to clear a fault or to maintain system integrity following fault clearance. This may lead to plant being deemed non-compliant with the fault ride through requirement during instances when the said requirements were not intended to apply.

With the last section of clause CC.6.3.15(a)(i) containing a clarification on how a fault on the onshore system would be reflected at the Grid Entry Point of an Offshore Power Station connected through a HVDC link, it is proposed that this clarification is extended to include two items. Item (a) would contain the clarification that is already included in the current clause with some revised wording to ensure that this could not be misinterpreted. Item (b) would include a list of instances where the de-energisation of a User’s Plant, or part thereof, following a fault would not constitute a non-compliance with fault ride through requirements.

For clause ECC.6.3.15, there is already an exclusion stipulated in ECC.6.3.15.8 item (vi) to deal with internal faults. It is proposed to extended this exclusion to provide the additional clarity required.

**The existing clarification – clause CC.6.3.15(a)(i) only**

The last two sentences of clause CC.6.3.15 (a) (i) aim to clarify a difference between how an Offshore Power Station would experience a fault on the Transmission System depending on whether this Power Station is connected to the Onshore Transmission System via an AC connection or via a DC connection. Whereas an AC connected Offshore Power Station would experience a voltage dip at the Grid Entry Point as a result of the fault, a DC connected Offshore Power Station would not necessarily experience such dip. Therefore, any control action required to be triggered on the Power Station side of a DC connected Offshore Power Station to facilitate fault ride through should not assume the presence of a voltage dip as the trigger signal.

The 2nd sentence of this clarification is meant to indicate that during the fault, although the voltage at the Grid Entry Point could remain within operational range, the Offshore Power Station would not be able to inject power into the system for the duration of the fault. However, during the workgroup discussions, it was identified that the analogy made in this sentence with load rejection could be misinterpreted to mean that the Offshore Power Station is not required to ride through such an event. To address this, it is proposed to delete this sentence.

CC.6.3.15.1 (a) (i)

It should be noted that

(a) in the case of an **Offshore Generating Unit**, **Offshore DC Converter** or **Offshore Power Park Module** (including any **Offshore Power Park Unit** thereof) which is connected to an **Offshore Transmission System** which includes a **Transmission DC Converter** as part of that **Offshore Transmission System**, the **Offshore Grid Entry Point** voltage may not indicate the presence of a fault on the **Onshore Transmission System**. ~~The fault will affect the level of~~ **~~Active Power~~** ~~that can be transferred to the~~ **~~Onshore Transmission System~~** ~~and therefore subject the~~ **~~Offshore Generating Unit~~**~~,~~ **~~Offshore DC Converter~~** ~~or~~ **~~Offshore Power Park Module~~** ~~(including any Offshore Power Park Unit thereof) to a load rejection.~~

**The additional clarification required – clause CC.6.3.15(a)(i) and clause ECC.6.3.15.8**

In general, plants are required to be designed to ride through the worst-case fault on the Transmission System. This worst-case fault is likely to be a fault at the connection point. An example of this is shown in Figure 1. This guarantees that the plant will be capable of riding through faults that would be cleared by transmission circuit breakers that would not disconnect the plant from the system. An example of this scenario is shown in Figure 2.

Diagram, schematic

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Figure 1 showing an example of a theoretical worse case fault which plant must be capable of riding though

Diagram, schematic

Description automatically generated with medium confidence

Figure 2 showing a fault which can be cleared by transmission system breakers TCB3 & 4.

There are situations when the operation of the circuit breakers required to clear the fault would result in the physical disconnection of the plant from the main system. Examples of these situations are in Figure 3 where the fault is on the Generator’s equipment, Figure 4 where fault clearance would require that the operation of the Generator’s circuit breaker and the disconnection of the Generator’s plant from the Transmission System, and Figure 5 where fault clearance would require the operation of a transmission circuit breaker (TCB1) which would isolate the section of the Transmission System to which the Generator’s plant is connected from the remainder of the Transmission System without any sufficient options to balance generation and demand in the isolated section.

The requirements to ride through the fault were never intended to apply during the scenarios shown in Figures 3, 4, and 5, or similar equivalent scenarios. However, some Generators expressed concerns that the requirements could be misinterpreted and requested a clarification to be added to the Grid Code to prevent such eventuality.

Also, some Generators expressed another concern that the requirements could be misinterpreted such that the operation of intertripping schemes agreed with NGESO and similar operational arrangements, e.g., to protect cascade tripping, following a fault may be interpreted as failure to ride through the fault.

Timeline

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Figure 3 showing a fault which can only be cleared by generation breakers GCB1.

Timeline

Description automatically generated

Figure 4 showing a fault which can only be cleared by generator breaker GCB1 & transmission circuit breaker TCB1.

Diagram, schematic

Description automatically generated

Figure 5 showing a fault which can be cleared by Transmission breakers TCB1,2&3, however this results in the Generator being islanded.

NGESO notes that that the risk of misinterpreting the requirements is minimal. However, provided that these concerns could be addressed without any unintended consequences, it remains reasonable to provide further assurance for Generators through an additional clarification of the requirements. It is therefore proposed to

* add item (b), as below, to clauses CC.6.3.15 (a) (i)

CC.6.3.15 (a) (i)

(b) A **Generating Unit**, **DC Converter**, or **Power Park Module** and any constituent **Power Park Unit** thereof and **OTSDUW Plant and Apparatus** is not required to ride through a fault if it is required to be disconnected

* in order to clear the fault,
* in response to a signal from an intertripping scheme that is armed in accordance to an instruction from **The Company**,
* in order to protect itself from a temporary overvoltage in excess of the levels specified in CC.6.1.11, or[[1]](#footnote-2)
* in accordance with CC.6.3.15.3 (iv),

or if it has become isolated from the **Total System** with no sufficient frequency response margins to regulate the frequency within the range specified in CC.6.1.3 following fault clearance.

* Modify clause ECC.6.3.15.8 (vi) as below

ECC.6.3.15.8 In addition to the requirements in ECC.6.3.15.1 – ECC.6.3.15.7:

:

:

(vi) Each **EU Generator** (in respect of **Type B**, **Type C**, **Type D** **Power Generating Modules** and **DC Connected Power Park Modules**) and **HVDC System Owners** (in respect of **HVDC Systems**) shall satisfy the requirements in ECC.6.3.15.8(i) – (vii) ~~unless the protection schemes and settings for internal electrical faults trips the~~ **~~Type B~~**~~,~~ **~~Type C~~** ~~and~~ **~~Type D~~****~~Power Generating Module~~**~~,~~ **~~HVDC Equipment~~** ~~(~~**~~or OTSDUW Plant and Apparatus~~**~~) from the~~ **~~System~~**~~.~~ except for situations where it is required to be disconnected

* in order to clear the fault,
* in response to a signal from an intertripping scheme that is armed in accordance to an instruction from The Company,
* in order to protect itself from a temporary overvoltage in excess of the levels specified in ECC.6.1.11, or
* in accordance with ECC.6.3.15.10 (iv),

or if it has become isolated from the **Total System** with no sufficient frequency response margins to regulate the frequency within the range specified in ECC.6.1.3 following fault clearance.

The protection schemes and settings should not jeopardise **Fault Ride Through** performance as specified in ECC.6.3.15.8(i) – (vii). The undervoltage protection at the **Grid Entry Point** or **User System Entry Point** (or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Stations** or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) shall be set by the **EU Generator** (or **HVDC System Owner** or **OTSDUA** in the case of **OTSDUW Plant and Apparatus**) according to the widest possible range unless **The Company** and the **EU Code User** have agreed to narrower settings. All protection settings associated with undervoltage protection shall be agreed between the **EU Generator** and/or **HVDC System Owner** with **The Company** and **Relevant Transmission Licensee**’s and relevant **Network Operator** (as applicable).

In both clauses, the reference to temporary overvoltage and references to CC.6.1.11 and ECC.6.1.11 are added for completeness. Discussion on that item follows in a subsequent section.

Consultation question \* Do you see any problems with these additions or can you see any other justifiable reason for a party disconnecting which is not cover by this text?

**Further Compliance Issues (Original Proposal & WAGCM2)**

Two further issues were identified with the current fault ride through requirements. The first issue is that compliance with the letter of fast fault current injection requirements in CC.6.3.15 (a) (ii) and ECC.6.3.15.9.2.1(a)(i) is not only not feasible for most generation plant but also counterproductive during overvoltages. This has been previously highlighted by Workgroup GC0111 on Fast Fault Current Injection and Workgroup GC0137 on VSM and were addressed appropriately for the clauses relevant to these workgroups with a view to address the remaining clauses in a subsequent modification. The second issue is related to the assessment of compliance with clause CC.6.3.15.1 a) ii) and ECC.6.3.15.8(vii) when a power station is running at very low output.

**Fault Current Injection**

The phrasing of clauses CC.6.3.15.1 (a)(ii) and ECC.6.3.15.9.2.1(a)(ii) at face value could be interpreted by some such that the requirement to inject reactive current during the fault is as shown in Figure 6. That is, once the voltage is below or above its steady state limits specified in ECC.6.1.4/CC.6.1.4, the plant is required to inject its maximum possible reactive current irrespective of the voltage level. This introduces two problems:

* it exacerbates high voltage excursions as it requires generation to inject maximum reactive current into the system if the voltage exceeds the steady state limit, and
* it requires the delivery of the maximum reactive current immediately following fault inception and irrespective of any retained voltage. That is a requirement that cannot be met by any Synchronous Generating Unit.

Chart

Description automatically generated

Figure 6 showing an interpretation of the existing legal text requiring the current to either be in the green box or on the red line.

Neither of the two clauses were intended to require reactive power injection during periods of high voltage or to require the immediate delivery of the full reactive current (applicable at zero voltage) irrespective of the level of retained voltage when it is not feasible to do so. i.e., both issues arise as a result of an oversight at the time when the requirements were introduced.

The proposal is to substitute the word “outside” by the word “below the lower limit” and to clarify that the maximum reactive current is a function of the retained voltage. Further discussion of what the performance during overvoltages is addressed later in the proposal. However, text is provided here for completeness

CC.6.3.15.1 (a) (ii) :

:

During the period of the fault as detailed in CC.6.3.15.1 (a) (i)(a) for which the voltage at the **Grid Entry Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) is ~~outside the limits~~ below the lower limit specified in CC.6.1.4, each **Generating Unit** or **Power Park Module** or **OTSDUW Plant and Apparatus** shall generate maximum reactive current possible for the voltage retained at the **Grid Entry Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) without exceeding the transient rating limit of the Generating Unit, OTSDUW Plant and Apparatus or Power Park Module and / or any constituent Power Park Unit or reactive compensation equipment.

Following fault clearance, during the period for which the voltage at the **Grid Entry Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) is above the upper limit specified in CC.6.1.4, each **Generating Unit** or **Power Park Module** or **OTSDUW Plant and Apparatus** shall progressively absorb reactive current in proportion to the voltage excursion without exceeding the transient rating limit of the **Generating Unit**, **OTSDUW Plant and Apparatus** or **Power Park Module** and / or any constituent **Power Park Unit** or reactive compensation equipment.

(b) (1b) (ii)

provide **Active Power** output at the **Grid Entry Point**, during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 5a, at least in proportion to the retained balanced voltage at the **Onshore Grid Entry Point** (for **Onshore Synchronous Generating Units**) or **Interface Point** (for **Offshore Synchronous Generating Units**) (or the retained balanced voltage at the **User System Entry Point** if **Embedded**) and shall generate maximum reactive current possible for the voltage retained at the **Grid Entry Point** in the case of **Onshore Synchronous Generating Units** (or **Interface Point** in the case of **Offshore Synchronous Generating Units**) (where the voltage at the **Grid Entry Point** in the case of **Offshore Synchronous Generating Units** or **Interface Point** in the case of **Offshore Synchronous Generating Unit** is ~~outside~~ below the ~~limits~~ lower limit specified in CC.6.1.4) without exceeding the transient rating limits of the **Synchronous Generating Unit.**Following voltage recovery, during the period for which the voltage at the **Grid Entry Point** in the case of **Onshore Synchronous Generating Units** (or **Interface Point** in the case of **Offshore Synchronous Generating Unit**) is above the upper limit specified in CC.6.1.4, each **Synchronous** **Generating Unit** shall progressively absorb reactive current to reduce the voltage excursion without exceeding the transient rating limit of the **Synchronous Generating Unit** and,

(b) (2b) (ii)

provide **Active Power** output at the **Grid Entry Point** or in the case of an **OTSDUW**, **Active Power** transfer capability at the **Transmission Interface Point**, during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure 5b, at least in proportion to the retained balanced voltage at the **Onshore Grid Entry Point** (for **Onshore Power Park Modules**) or **Interface Point** (for **OTSDUW Plant** **and Apparatus** and **Offshore Power Park Modules**) (or the retained balanced voltage at the **User System Entry Point** if **Embedded**) except in the case of a **Non-Synchronous Generating Unit** or **OTSDUW Plant and Apparatus** or **Power Park Module** where there has been a reduction in the **Intermittent Power Source** or in the case of **OTSDUW Active Power** transfer capability in the time range in Figure 5b that restricts the **Active Power** output or in the case of an **OTSDUW Active Power** transfer capability below this level and shall generate maximum reactive current possible for the voltage retained at the **Grid Entry Point** in the case of **Onshore Power Park Modules** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) (where the voltage at the **Grid Entry Point** in the case of **Onshore Power Park Modules**, or in the case of an **OTSDUW Plant and Apparatus**, the **Interface Point** voltage, is ~~outside~~ below the ~~limits~~ lower limit specified in CC.6.1.4) without exceeding the transient rating limits of the **OTSDUW Plant and Apparatus** or **Power Park Module** and any constituent **Power Park Unit.**Following voltage recovery, during the period for which the voltage at the **Grid Entry Point** (or **Interface Point** in the case of **OTSDUW Plant and Apparatus**) is above the upper limit specified in CC.6.1.4, progressively absorb reactive current in proportion to the voltage excursion without exceeding the transient rating limit of the **OTSDUW Plant and Apparatus** or **Power Park Module** and / or any constituent **Power Park Unit** or reactive compensation equipment; and

ECC.6.3.15.9.2.1 (a) (ii)

provide **Active Power** output at the **Grid Entry Point**, during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure ECC.6.3.15.9(a), at least in proportion to the retained balanced voltage at the **Onshore Grid Entry Point** (for **Onshore Synchronous Power Generating Modules**) or **Interface Point** (for **Offshore Synchronous Power Generating Modules**) (or the retained balanced voltage at the **User System Entry Point** if **Embedded**) and, where the voltage at the **Grid Entry Point** for **Onshore Synchronous Power Generating Modules** or **Interface Point** for **Offshore Synchronous Power Generating Modules** is ~~outside~~ below the ~~limits~~ lower limit specified in ECC.6.1.4, shall generate ~~as much~~ the maximum reactive current ~~as~~ possible for the voltage retained at the **Onshore Grid Entry Point** (in the case of **Onshore Synchronous Power Generating Modules)** or **Interface Point** (in the case of **Offshore Synchronous Power Generating Modules**) without exceeding the transient rating limits of the **Synchronous Power Generating Module** then**,** following voltage recovery, during the period for which the voltage at the **Grid Entry Point** (in the case of **Onshore Synchronous Power Generating Modules)** or **Interface Point** (in the case of **Offshore Synchronous Power Generating Modules**) is above the upper limit specified in ECC.6.1.4, each **Synchronous** **Power** **Generating Module** shall progressively absorb reactive current in proportion to the voltage excursion without exceeding the transient rating limit of the **Synchronous Power** **Generating Module** and, [I suggest the above para is split into two and redrafted as:

(ii) provide during **Supergrid Voltage** dips on the **Onshore Transmission System** as described in Figure ECC.6.3.15.9(a):

* **Active Power** output at the **Grid Entry Point**, at least in proportion to the retained balanced voltage at:
  + the **Onshore Grid Entry Point** (for **Onshore Synchronous Power Generating Modules**) or;
  + the **Interface Point** (for **Offshore Synchronous Power Generating Modules**);
  + the **User System Entry Point** if **Embedded,**
* the maximum reactive current possible for the voltage retained at
  + the **Onshore Grid Entry Point** (in the case of **Onshore Synchronous Power Generating Modules);** or
  + the **Interface Point** (in the case of **Offshore Synchronous Power Generating Modules**); or
  + the **User System Entry Point** if **Embedded**
    - * where that voltage is below the lower limit specified in ECC.6.1.4, and without exceeding the transient rating limits of the **Synchronous Power Generating Module.**

(iii) Following voltage recovery, during the period for which the voltage at

* the **Onshore** **Grid Entry Point** (in the case of **Onshore Synchronous Power Generating Modules);** or
* **Interface Point** (in the case of **Offshore Synchronous Power Generating Modules**); or
* the **User System Entry Point** if **Embedded,**

is above the upper limit specified in ECC.6.1.4, each **Synchronous** **Power** **Generating Module** shall progressively absorb reactive current in proportion to the voltage excursion without exceeding the transient rating limit of the **Synchronous Power** **Generating Module**.

(iv) restore **Active Power** output following **Supergrid Voltage** dips on the **Onshore Transmission System…….]**

**Restoration of Active Power Following Fault Clearance**

Both CC.6.3.15.1 a) ii) and ECC.6.3.15.8(vii) require that, once the voltage at the Grid Entry Point, or the User System Entry Point – if embedded, is restored to 90% of the nominal level, the active power output should be restored to at least 90% of the pre-fault level within 0.5s. Active power oscillations are allowed provided that they do not reduce the total energy delivered over the period of oscillation and that they are appropriately damped.

With Power Park Modules operating at very low output for extended periods of time and with synchronous condensers operating at no load, it is difficult to assess compliance with the two clauses as the output level may be lower that the tolerance of measurement equipment. For example, Figure 8 shows a typical response for a unit operating at a pre-fault output of 0.02pu. In this example, assessing whether the output was restored to 0.018pu or not could be prohibitive.

Chart

Description automatically generated

Figure 8 showing a typical active power response of a unit at low load to a fault

To address this, it is proposed to relax the tolerance levels at low output to ±5% of the Registered Capacity. This would mitigate the issue without relaxing the requirements for units operating at high output.

CC.6.3.15.1 (a)

(ii) Each **Generating Unit**, **Power Park Module** and **OTSDUW Plant and Apparatus**, shall be designed such that upon both clearance of the fault on the **Onshore Transmission System** as detailed in CC.6.3.15.1 (a) (i)(a) and within 0.5 seconds of the restoration of the voltage at the **Onshore Grid Entry Point** (for **Onshore Generating Units** or **Onshore Power Park Modules**) or **Interface Point** (for **Offshore Generating Units**, **Offshore Power Park Modules** or **OTSDUW Plant and Apparatus**) to the minimum levels specified in CC.6.1.4 (or within 0.5 seconds of restoration of the voltage at the **User System Entry Point** to 90% of nominal or greater if **Embedded**), **Active Power** output or in the case of **OTSDUW Plant and Apparatus**, **Active Power** transfer capability, shall be restored to either at least 90% of the level available immediately before the fault or the level available immediately before the fault within a tolerance of plus or minus 5% of the Registered Capacity whichever is feasible. Once the **Active Power** output, or in the case of **OTSDUW Plant and Apparatus**, **Active Power** transfer capability, has been restored to the required level, **Active Power** oscillations shall be acceptable provided that: - the total **Active Energy** delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant - the oscillations are adequately damped

ECC.6.3.15.8 In addition to the requirements in ECC.6.3.15.1 – ECC.6.3.15.7:

(vii) Each **Type B**, **Type C** and T**ype D Power Generating Module**, **HVDC System** and **OTSDUW Plant and Apparatus** at the **Interface Point** shall be designed such that upon clearance of the fault on the **Onshore Transmission System** and within 0.5 seconds of restoration of the voltage at **the Grid Entry Point** or **User System Entry Point** or **HVDC Interface Point** in the case of a **Remote End HVDC Converter Stations** or **Interface Point** in the case of **OTSDUW Plant and Apparatus** to 90% of nominal voltage or greater, **Active Power** output (or **Active Power** transfer capability in the case of **OTSDW Plant and Apparatus** or **Remote End HVDC Converter Stations**) shall be restored to either at least 90% of the level immediately before the fault or the level available immediately before the fault within a tolerance of plus or minus 5% of the Registered Capacity whichever is feasible. Once **Active Power** output (or **Active Power** transfer capability in the case of **OTSDUW Plant and Apparatus** or **Remote End HVDC Converter Stations**) has been restored to the required level, **Active Power** oscillations shall be acceptable provided that:

- The total **Active Energy** delivered during the period of the oscillations is at least that which would have been delivered if the **Active Power** was constant

- The oscillations are adequately damped.

- In the event of power oscillations, **Power Generating Modules** shall retain steady state stability when operating at any point on the **Power Generating Module Performance Chart**.

For AC Connected **Onshore** and **Offshore Power Park Modules** comprising switched reactive compensation equipment (such as mechanically switched capacitors and reactors), such switched reactive compensation equipment shall be controlled such that it is not switched in or out of service during the fault but may act to assist in post fault voltage recovery.

**Operation During Temporary Overvoltages**

This element of the proposal is based on the Proposer’s view that the existing fault ride through requirements cover an enduring requirement on Generators to ensure that their Plant is capable of riding through any fault that is presented by the system (assuming appropriate outage background – i.e., N-1-D). This means that the proposal includes reducing the requirements on Generators by introducing a cap on the worst-case overvoltage. Therefore, applying the requirements retrospectively should not be controversial.

However, it is acknowledged that some Generator’s Plant might not be able to meet the explicit requirements in the proposal. To address this, the proposal should allow maximum flexibility and should not require any modifications, neither to the Transmission System nor to the Generator’s Plant and Apparatus unless these are necessary.

It is also acknowledged that there are other views within the industry about whether the voltage ride through requirements cover post-fault temporary overvoltages or not. This view should not affect what the requirements are and whether they would apply retrospectively or not. Failing to do that would transfer all the risk to Transmission Owners, if the temporary overvoltage limits are set too tightly, and to the Electricity System Operator, if some plant is relived from the requirement to ride through a fault. It would also remove any requirement on Generators to engage in the process of identifying any existing risks, and in the process of identifying the means of mitigating such risks, and in implementing any modifications that may be required to their plant. However, any such views should be considered when agreeing what actions would need to take place following the identification of instances of non-compliance and any funding mechanisms, if applicable, that would support the resolution of this non-compliance.

**The Issue with The Current Requirements**

Overvoltage related requirements

The Grid Code specifies limits on voltage levels that Users’ plant is expected to experience both under steady state conditions (CC.6.4.1 and ECC.6.4.1) and during fast transients associated with switching events (CC.6.1.7 and ECC.6.1.7).

On the other hand the Grid Code, , does not specify any limits for temporary overvoltage. However, it includes information that suggest that overvoltages are likely to be encountered on the National Electricity Transmission System. Examples of this information are

* the 140%/150% earth fault factor for unbalanced faults (CC.6.2.1.1 and ECC.6.2.1.1);
* the requirement that non-synchronous generation in Scotland trips if subjected to an overvoltage of 120% (115% for 275kV) lasting for more than 1s (CC.6.3.15.3 and ECC.6.3.15.10)
* the references to the Relevant Electrical Standards (e.g. TS01 for NGET’s System) which specify a certain level of overvoltage that needs to be considered in certain design elements.

Further requirements in relation to overvoltage are included the European Connection Conditions.

* ECC.6.3.16.1.6 provides for the specification of overvoltage limits and other requirements related to overvoltage in the Bilateral Agreement. This has been exercised in several connection agreements since 2017. In these agreements, the overvoltage limits specified in an NGET Technical Specification (TGN 288) were passed onto the User and a requirement to ensure that the User’s plant does not contribute to overvoltages beyond these limits was placed on the User.
* ECC.6.3.16.1.8 requires that Power Park Modules and HVDC Equipment are designed such that they do not result in overvoltages in excess of the values specified in ECC.6.1.7 following fault clearance. This latter clause requires that the User agrees the control strategy required to manage the overvoltage with NGESO and the approach for de-blocking, where blocking is to be used. The clause also allows for the specification of overvoltage limits in the Bilateral Agreement.

Fault Ride Through Requirements

The Grid Code requires that following solid three phase short circuit faults of up to 140ms, and following longer voltage dips where the voltage remain above a certain level with no upper limit specified, the requirement to ride through the fault applies for any level of post fault temporary overvoltage that the network presents

To that extent, Generators are expected to

* 1. Design their plant to be able to ride through the worst-case realistic overvoltage they can expect to experience plus any margins they consider appropriate to ensure future compliance, and
  2. Where system changes increase the magnitude and/or the duration of the overvoltage their plant is expected to experience, modify their plant to ensure continuous compliance.

This approach allows for efficient designs in parts of the network where overvoltages are very unlikely to take place. However, it exposes Users to the risk that, if the position changes, significant investment may be required to ensure enduring compliance.

It is noted that

1. Some Generators have designed their plant with no consideration to potential overvoltages (for example by setting their plant to deload, but not necessarily trip, during transients if the upper limit of steady state voltage level is exceeded)
2. It is not clear whether Generators consistently meet the expectation that they review their compliance position while taking into account potential changes to the maximum temporary overvoltage that could reasonably be expected.
3. There could be a risk that some Generators’ plant may be exposed to a level of overvoltage that they could not be reasonably expected to withstand.
4. Failure to ride through a temporary overvoltage is likely to mean that some secured events could result in the simultaneous loss of multiple power stations.

The Proposal - General

To address the issues described above, it is proposed to

1. Specify an upper limit on the magnitude and the duration of any overvoltage Users may experience. Beyond this level, the requirement to ride through a fault would not apply. This is to

* cap the risk that an existing plant may require significant investment to remain compliant if the system changes, and
* ensure that no Generators’ plant would be expected to remain through an overvoltage they wouldn’t be reasonably expected to withstand.

1. Ensure that there is an obligation on Transmission Owners to ensure that no Users’ plant experience overvoltage beyond the limits agreed. This is to guarantee that, following any secured event, no plant would trip due to overvoltage.
2. Explicitly state that faults and voltage dips may include subsequent temporary overvoltage. This is to ensure that the requirements to ride through a fault or a voltage dip applies through any subsequent overvoltage.
3. Ensure that there is an obligation on Generators to actively control the voltage during temporary overvoltage events. This is to further reduce the risk of tripping due to a temporary overvoltage and to reduce the investment Transmission Owners may need to ensure the limits agreed are met.
4. Ensure that the plant would be compliant if it is capable of riding through a post fault overvoltage of a magnitude and duration that is up to

* the values agreed as a limit on the magnitude and duration of temporary overvoltage, or
* the value that reflects the worst-case overvoltage that the plant would be exposed to in real time.

This is to provide Generators with clarity in relation to new generation plant while ensuring they are not required to undertake any investment in relation to existing plant unless there is a real need for such investment.

The consultation document is yet to be developed beyond this point to accommodate the development of the proposal to deal with overvoltages

The Proposal – Specification of Temporary Overvoltage Limits

Similar to the limits applicable for steady state voltages and voltage transients following planned events, The limits on temporary overvoltage that User’s plant would be exposed to constitute a c system characteristic. Therefore it will have to be specified in Section

CC.6.1.11 Under normal operating conditions following any unplanned **Secured Event**, the magnitude of any temporary power frequency overvoltage at a **Connection Site** on the **Onshore Transmission System** with a **GB Code User** (and in the case of **OTSDUW Plant and Apparatus**, a **Transmission Interface Point**) measured in per unit with basis equal to the nominal voltage at the site shall not exceed the levels specified in Figure CC.6.1.11. Where the **Secured Event** is a fault, the duration of the overvoltage is measured from the time of fault clearance. For a **User’s Site** connected at a voltage level below 275kV in **England and Wales** or below 132kV in **Scotland**, the temporary power frequency overvoltage limits will be met at the closet node at 400kV or 275kV in **England and Wales** or at 400kV or 275kV or 132kV in **Scotland**.



Figure CC.6.1.11



Workgroup considerations

The Workgroup convened XX times to discuss the perceived issue, detail the scope of the proposed defect, devise potential solutions and assess the proposal in terms of the Applicable Code Objectives. Industry experts were well represented in the Workgroup and in some cases other stakeholders were consulted by the ESO as required.

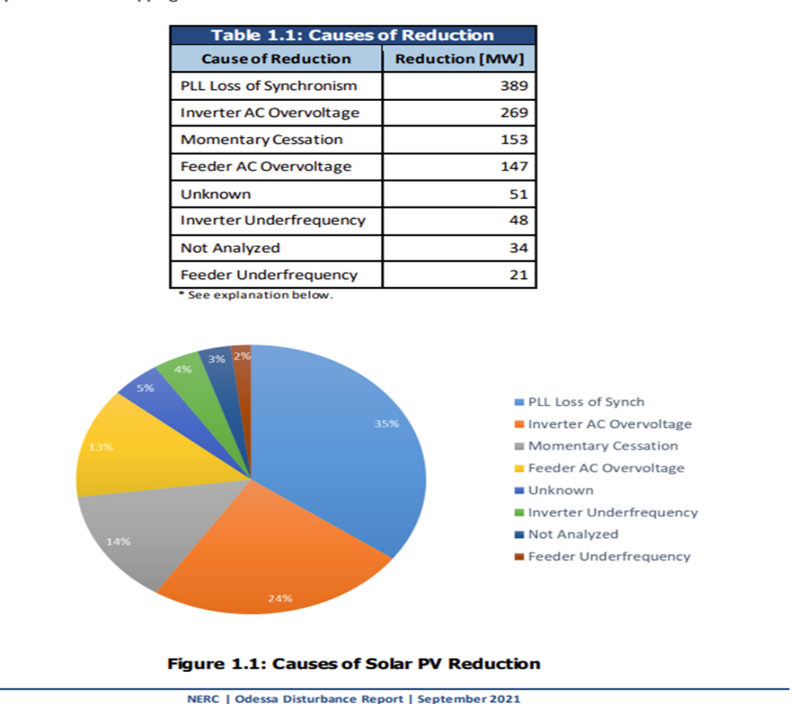
**Clarification of requirements for over-voltage during a fault**

The Proposer confirmed that the current expectation is that systems will be designed in accordance to the definition in [TGN288.](https://www.nationalgrid.com/sites/default/files/documents/TGN%28E%29_288_0.pdf) The ESO representative acknowledged that there is no requirement for compliance for over voltage in the Grid Code but, there is provision for compliance to outages.

There were mixed views as to whether the overvoltage requirement if considered within this modification, should apply retrospectively. Some Workgroup members suggested that this will raise an element of cost and would need to be considered in detail and decided by the ESO. However, it was highlighted that concerns about costs do not only apply where the requirements are retrospective because overvoltage ride through requirements would bring about significant cost of new equipment especially if the requirements are onerous. Some Workgroup members suggested that a comparison with other international standards (and commercially available equipment) could help minimise over or under specifying requirements affecting cost and security of supply respectively. This international comparison should not just be waiting for a new, as yet unpublished standard from ENTSO–E which may not fit with the timescale of this modification but, it could form part of the justification for limits proposed within any future strawman.

**Phase Angle Jumps and Short Circuit Level**

The topic of phase angle jumps was raised specifically with respect to phased locked loop fault ride through capability. A Workgroup member shared the table below, an example given was of large phase angle jumps in Scotland being caused by Transmission network faults in North Wales, showing that this is already a problem in the GB grid as generation with PLL is not designed for these conditions and this could lead to the generation tripping. It was discussed that there are no specified FRT requirements for phase angle jumps but, whilst the ESO expressed support for such requirements, it was clearly stated that this subject area was out of scope and would not be considered within this modification.



A Workgroup member suggested that if these topics of phase steps and SCL are not to be considered with this modification it should be decided whether they would be addressed in later modifications, or whether these issues posed such low risk that they could be safely ignored. The ESO representative requested that, to understand the issues better and identify whether needed to be addressed or investigated further, the Workgroup members should share examples of issues caused by sudden changes in phase angles; how they affect control systems and if there are any implications associated with retuning these control systems.

**Multiple Fault Ride Through Scenarios**

Some Workgroup members raised concerns over lack of clear requirements in the case of multiple FRTs. This had been highlighted as a concern due to incidents that occurred in other countries. The ESO representative advised that, following a review, it was established that it would be highly unlikely that this would occur in GB due to the weather conditions. It was therefore noted that as multiple FRT currently has a low needs case, the ESO is not looking to progress it within this modification.

**ENTSO-E High Voltage Ride Through (HVRT) Requirements**

It was mentioned that ENTSO-E are looking at adding HVRT requirements to the Requirement for Generators (RfG). This would consider creating thresholds for duration and voltage level. The ESO representative confirmed that the ESO are no longer members of ENTSO-E and have no visibility of the draft document in relation to this but advised that the ENTSO-E document should be published sometime in 2023 and once published, the ESO will review the document and determine elements that need to be added into the Codes.

**Implementation Costs**

…….If the overvoltage compliance requirements will not be considered within this modification, there are no associated implementation costs.

**Operating Requirements during a fault**

The Proposer highlighted concerns that the current text could be interpreted that the Plant should remain connected feeding the fault for 140ms which could lead to dangerous outcomes. But the intention is that Plant should trip during these circumstances hence, it was proposed that 3 subclauses should be added to section CC.6.3.15(a) to clarify each situation where tripping is permitted. This was agreed by the Workgroup.

**Expectations to clear Transmissions System faults**

The instances where User plant is required to trip in order to clear Transmission System faults were clarified in section CC.6.3.15(a)(i)(a) of the legal text available in Annex 3.

**Maximum Reactive Current during faults & Short Circuit Levels (SCL)**

The proposed requirements for generating maximum reactive current during faults were agreed and are documented in sec xxxxxx of the legal text available in Annex 3. A Workgroup member highlighted concerns around transient overvoltages stating that during fault clearance through to the transient state where the voltage is recovering to its steady state value, there are significant voltage oscillations before the voltage settles back down. Another Workgroup member stated that to tackle this the ESO may need to refine the requirements for reactive current injection within that recovery time along with defining the minimum SCL required various generating unit capacities..

The ESO representative acknowledged that there is an issue with decreasing SCL and that whilst it may impact achieving the clarifications identified within this modification, it is a much bigger piece of work than the scope of this modification and was being assessed within the System Operability Framework (SOF). It was noted that NGESO had published a [paper](https://www.nationalgrideso.com/document/238741/download) as an adjunct to the SOF to discuss the current and future requirements for SCL data and was seeking feedback from stakeholders on this topic including whether a minimum SCL needs to be defined.The ESO representative advised the Workgroup that if the need for Grid Code changes is identified a new Grid Code modification would be raised to address them.

The ESO representative highlighted interactions with Frequency management and explained that reactive current injection during a fault supports the System voltage and contributes towards rapid voltage recovery. This reduces the risk of further generation tripping and changes to this could increase simultaneous tripping of generation (low frequency demand disconnection). This last occurred on 9 August 2019 and had significant repercussions. The ESO would find it very difficult to manage this risk as they would either have to:

1. Carry out further EMT simulations – which they do not have the resource or time to do.
2. Set a low limit and procure frequency response to manage the risk – which would cost too much.

**Post-active fault power requirements**

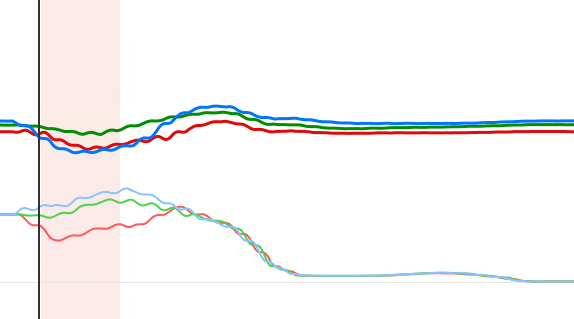
There was an initial discussion on post-fault active power requirements and consideration as to whether Generators at low load may have greater levels of oscillation than permitted and, it was noted that ……………………………

**SSE HVRT Strawman**

A workgroup member presented a strawman (available in annex 2) in relation to HVRT and outlined the following points for discussion:

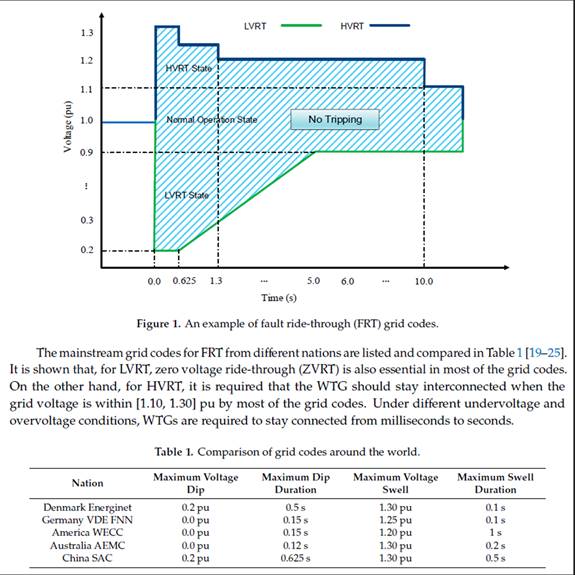
Weaker Grids Transient Stability Issues: Background

* During a Fault Ride Through event, a transient over-voltage often develops on fault recovery which can often exceed 1.10pu – particularly in weaker grids.
* Phase angle jump on fault recovery due to weak grid conditions: existing Users should not be penalised for not being able to ride through large phase jumps, as this was not an original requirement.
* Lack of detail in the GB Grid Code on appropriate overvoltage generation Protection settings.
  + ENA Standard G99 contains requirements for over-voltage Protection settings for generation connected to the distribution System and introduces a delay to ‘avoid nuisance tripping for short duration excursions’
* The intention of GC0155 is to clarify what *minimum* over-voltage Protection settings should be applied by Users, irrespective of connection voltage, in particular to avoid WTG tripping following a low-voltage FRT event.



High-Voltage Ride Through: ‘Strawman’ Proposal

* Proposed technical strawman is as shown below, based on different Grid Codes. However, it should be NGESO’s operational requirements that should be setting the final HVRT requirements.
* **Forward-looking only:**
  + WG consultation to ask about practicality of retrospective changes to HV settings.
  + Confirm if HVRT requirements will be applied across GB and if so confirm whether HVRT requirements set out in BCAs (for connections in England & Wales) would be updated.
* HVRT requirements to apply at the Connection Point, rather than at the HV terminals of User’s Plant/equipment.
* Requirement for repeatability of response to be defined (also required for low-voltage ride-through requirements).



The Workgroup discussed these points and concluded that this strawman should be considered by the ESO. It requested that the ESO take away the following questions and provide feedback:

* Clarity on how User’s plant/equipment should respond during over-voltage transient e.g., reactive power set point could vary upon reaching 1.0pu during recovery
* What happens with TGN 288 if HVRT requirements are included in the Grid Code
* Whether WTG manufacturers need to carry out type tests or just simulations to demonstrate HVRT compliance
* Currently there is set of scenarios for FRT simulations (refer to ECP.A.3.5), what would be the set of scenarios for HVRT simulations?
* What types of faults HVRT definition will apply to (e.g., single phase, phase to phase, etc); is it is a TGN 288 requirement that only aims to define overvoltage withstand capabilities of the plant or a requirement during fault clearance only
* The requirement shall be technology neutral, so what will the HVRT requirement be for Synchronous Plant?

The ESO’s response to the above strawman and the discussions on it was that the ESO recognised that whilst the overvoltage requirements in the Grid Code on Generators following a fault are not clear and require further guidance, overvoltage is also addressed in TGN288 and setting out the right Grid Code details is likely to mean considering both these and the relationships between System security and consumer value. The ESO therefore proposes that, to be able to properly assess this requirement, it would be best to progress this it via a separate Grid Code modification rather than within GC0155 which was intended to agree on reasonably straightforward clarifications to the technical detail of FRT requirements. This will enable the ESO to allocate resources to scrutinise the issue fully, assess potential solutions and consult with industry.

Following the ESO response, some Workgroup members (from SSE, Drax and Scottish Power Renewables) expressed that the high-voltage ride through requirements should be clarified for Users as part of this modification. They developed a draft legal text which was discussed with the rest of the Workgroup. Their proposal – which requires an EU Generator to ride through 1.3pu for 0.1s and 1.25pu for 60s was based on an extract from the German Grid Code and their rationale is outlined below:

* The requirement would be applicable to all EU Generators. The exact numbers, wording, and graphical representation were to be decided.
* The fact that the high voltage transient typically occurs immediately following fault clearance has been accounted for in the voltage-against-time graphs by using equations for ‘tov1’ and ‘tov2’, such that they depend on the time at which fault clearance occurs. For overvoltage transient faults which do not have a preceding low-voltage element, the requirement applies from the instant the voltage exceeds normal limits.
* The proposal will apply on a forward-looking basis only. A comprehensive check of the over-voltage ride through capabilities of those WTG models which must adhere to the ECCs is still ongoing, but at present our understanding is that 1.3pu for 0.1s and 1.25pu for 60s is easily achievable.
* It would be beneficial (for all parties) to have clarity on the HVRT requirements, but, any equivalent addition to the CCs on a retrospective basis ought to be set at a level which does not then necessitate further action, i.e. the HVRT requirement should be based on the existing HVRT capability.

**ESO proposed approach to address Temporary Overvoltage Requirements**

The ESO and NGET Workgroup members explained to the rest of the Workgroup how they propose to set the expected TOV level using TGN 288 (which was presented at a previous Workgroup) as a starting point. proposed that the Workgroup considered these two steps when setting requirements for FRT:

1) TOV withstand capability of equipment; and

2) Power Electronic (PE) equipment performance during and after an event.

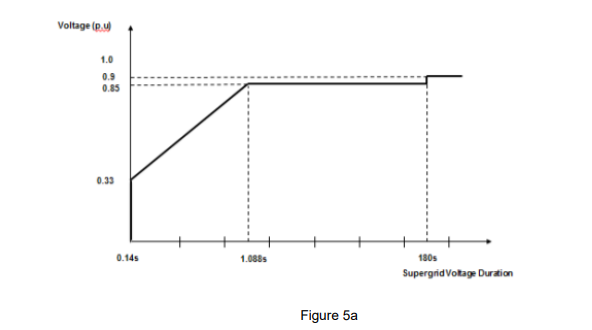
It was also suggested that the Grid Code definition of Earth Fault Factor should be considered when establishing these requirements.

The ESO representative explained that a significant drop in voltage means that a Generating Unit will not be able to deliver its full output for that period. This is because the mechanical input for the Generating Unit is unlikely to change fast enough so the power imbalance will cause the rotor of a Synchronous machine to accelerate, as well as a rise within the DC link voltage within a wind turbine. If this persists for a long period of time, the under voltage is likely to cause pole slipping for Synchronous machines and excessive heating for the DC link chopper resistor. Currently, there are no limits on over voltages within the Grid Code and Users were required to ride through any faults above the black line within the diagram below.

It was decided that the following steps will be taken to define overvoltage requirements:

* Define a ceiling for TOV which would have to be guaranteed by design by the Transmission Owners (TO’s) for the network. There would also be a requirement on generators not to cause it to exceed those values. The ESO preference is to use the limits already available within TGN 288 as the ceiling, as this is consistently used by all the TOs and should also be the minimum capability of Users’ Plant.
* Review other related Plant performance and FRT requirements to understand how the Plant is going to respond to TOV and not exacerbate any such an event.

A Workgroup member noted that these requirements had not been included in any previous grid compliance simulations, so they were already in a situation where it is unclear what the HVRT capability of the equipment installed to date is. Therefore, the ESO may still need to procure some Frequency response reserve in case there is tripping within these overvoltage limits. The Workgroup member also suggested a more pragmatic approach to address the capability of equipment installed to date and future Plant installations separately.



Some of the comments from Workgroup members were:

* On the query as to whether the withstand capability implies ride through, the ESO and NGET representative clarified that the expectation is that the equipment will need to have design and performance capability to withstand and ride through faults - the problem had been categorised in two parts.
* In relation to challenges posed by high voltage FRT and capability at the point of connection, several Workgroup members questioned whether the ESO had carried out simulations for overvoltage FRT as part of their Grid Code compliance checks before allowing parties to connect. They felt that parties should have been informed at that stage that their equipment was non-compliant, rather than permitting them to connect and then expecting them to ride though.
* The Earth Fault Factor would need to be considered in future simulations. There is a physical limit to design constraint; silicon convertors are more sensitive to over voltage than other devices in High Voltage networks. Thus, to make them more robust the ESO would need to design for that and explore the relationship between high voltage tolerance over specific periods of time.
* During a HVRT, there is a reverse power flow from the grid to the DC link, which causes a stress on it. This can only be tuned and managed to a certain degree, beyond which there is a threat to the wind turbine which causes it to De-Load. They advised that it is globally acknowledged that there is an upper limit, beyond which parties should be allowed to trip, and from assessment this is currently 1.3 pu.

**Traditional HVDC System Configuration For The Connection of a PPM**

The configuration and operation of a voltage source converter (VSC) HVDC converter system that is used to connect an offshore Power Park Module (PPM). The high level description provided relates to a traditional configuration and it should be noted that alternative configurations and operation are possible.

**Overview of a Traditional VSC HVDC System for PPM Connection**

The onshore converter station is configured in *grid following* mode and controls the DC voltage by varying its active power exchange with the onshore AC system. The offshore converter is configured in *grid forming* modetoprovide a voltage reference for the PPM to synchronize to.

When an AC fault occurs in the onshore system, the converter may be unable to exchange the full amount of active power required with the onshore system, and this causes the DC voltage to rise. To protect the HVDC system during a DC voltage rise, a dynamic braking system (DBS) is often included and dissipates the excess energy to reduce the DC voltage during this period. The DBS is designed to be operated for short periods of time.



If the DC voltage rise is too great, then the offshore grid forming converter may alter its offshore voltage reference (reduce the voltage magnitude) to reduce the active power exchanged with the offshore system in order to protect itself. This could cause a voltage dip on the offshore system; however, the PPM is already required to comply with the FRT requirements specified in ECC.6.3.15.

**WAGCM1 Outline**

WAGCM1 solution seeks clarification for the expected upper threshold of transient overvoltage (TOV) at point of connection (POC) that the generator or power park module (PPM) needs to ride through during fault clearance or recovery. Reactive Power injection/absorption profile required to manage TOV conditions efficiently. As well as alignment with international standard requirements to enable procurement of generators and power park modules that can meet NGESO’s TOV requirements at the cheapest cost for end consumers in GB.

It will not retrospectively require existing Generators to modify their plant to achieve the proposed Original solution.

The proposed GC0155 Original solution assumes retrospectivity automatically, which will put huge financial burden on developers without any suitable cost recovery mechanism. The retrospective implementation may not be possible at many sites in GB. Hence, this alternate proposal which focuses on forward looking (not retrospective) ECC clauses to be applicable to generators connecting after implementation of GC0155 modification.

The attached draft legal text proposes changes to the clauses under ECC6.3.15 to introduce high voltage ride through (HVRT) requirements into the Grid Code.

Additionally, we propose a discussion on ECC.6.3.16 fast fault current injection requirement, to efficiently manage TOV conditions during fault recovery. The updated fast fault current injection could be developed in line with the German Grid Code requirements, which proposes a smooth transition from reactive current injection to absorption during transition between fault low voltage and TOV conditions. The generator shall return to normal voltage control once the voltage is stabilised within normal operating conditions as per CC6.1.4/ECC6.1.4 after fault clearance.

Commercial availability – procurement

A majority of the workgroup members constituting of developers proposed WAGCM1. The need for WAGCM1 stems from the following differences to the ESO’s approach to TOV and high voltage ride through (HVRT).

The proposers of WAGCM1 maintain that the current Grid Code is silent about the HVRT requirements. The clauses under CC 6.3.15 and ECC 6.3.15 refer to ride through above the thick black line strictly for voltage “dips” and not for voltage “rises.” Hence, the proposers raise concern regarding the ESO’s position that every existing plant is expected to ride through any TOV occurring on the GB power system. The proposers understand there is no explicit ride through requirements for voltage rises following a fault in the current Grid Code, except for the steady state conditions defined under CC and ECC 6.1.11.

The ESO and certain TOs in the working group also refer to TGN 288 as an established standard which is included for high voltage withstand capability in BCAs in England and Wales: reference to TGN288 is a recent addition to NGESO Appendix F and OF templates (available on NGESO website) unilaterally included by NGESO without industry review: there is no reference to such standard in the Grid Code. This standard cannot be used as reference in BCAs without further investigation and wide assessment similar to all Grid Code clauses.

Besides, the proposers of WAGCM1 maintain that there is a clear difference between high voltage withstand capabilities and high voltage ride through capability. High voltage withstand capability as the proposers understand is the ability of a plant to be able to withstand TOV on the power system without any failure or damage to its components. HVRT, which is not currently defined in GB Grid Code but proposed to be added in through WAGCM1, will require generators and PPMs to remain connected to be able to continue producing active and reactive power against specific performance related requirements following a temporary fault on the system, similar to Low Voltage Ride Through as defined in CC 6.3.15 and ECC 6.3.15.

Another standard referred to by the ESO is the TS01. The proposers of WAGCM1 understand TS01 to be specifically referring to insulation requirements for TOV and HVRT. The tests required in TS01 will not be applicable to establishing fault ride through compliance.

The proposers do not support the ESO’s approach to adopt the TGN 288 requirements directly in the Grid Code as these requirements have not been assessed against commercially available converter capabilities to ride through voltage “rises” following a fault. The proposers of WAGCM1 instead propose alignment with internationally standardised requirements for HVRT. This will enable procurement of commercially available wind turbine and other generators, converters, and power park modules, that can meet the proposed HVRT requirements under WAGCM1 at the cheapest cost for end consumers in GB.

The high voltage “rise” thresholds (voltage magnitudes and durations) in the original proposal are a direct adoption of high voltage withstand capabilities from TGN 288. It needs to be highlighted, that the proposed high voltage “rise” thresholds (voltage magnitudes and durations) in WAGCM1 are lower than those proposed by the ESO in the original proposal.

WAGCM1 solution seeks clarification for the expected upper threshold (voltage magnitudes and durations) of TOV at the user’s point of connection (POC) that the generator or power park module (PPM) needs to ride through during fault clearance or recovery. The limits should allow future GB users to remain connected under multiple fault conditions and provide voltage stiffness to the grid.

The proposers also challenge the ESO’s approach to curtail generation of existing plants that will not be able to meet the new TOV or HVRT requirements in the original proposal, when applied retrospectively (as is the case in the original proposal). The proposers of WAGCM1 do not agree it is economic or efficient to modify existing plant designs to retrospectively enable HVRT capability. Hence, WAGCM1 does not retrospectively require existing Generators to modify their plant to achieve the new HVRT requirements proposed in WAGCM1. The ESO has presented no cost benefit analysis to justify their claim that without retrospective application of the original proposal or WAGCM1 the system balancing costs will be significantly higher, as compared to imposing non-standardised HVRT requirements which will significantly increase generator equipment and plant costs.

The proposers believe the intention should be to manage residual risk using other means, such as stability market procurement, after future application of HVRT requirements. The Grid Code has not been adapted in accordance with changing weak grid conditions and the onus should be on the ESO to maintain system operability.

The proposers of WAGCM1 identify that review of fast fault current injection under clause “ECC.6.3.16” is required, to define the reactive power absorption profile during voltage “rises” following a fault as part of a separate Grid Code modification. The proposers disagree with the ESO’s view that a statement in the Grid Code stating users should not make a TOV condition on the grid worse will provide the required clarity regarding limits of fast fault current injection for voltage at the PoC above 1.1 pu.

As a final point, the proposers push back on the ESO’s assumption that developers need to design their plants to future proof against future grid conditions. Developers do not have access to the whole GB system model and generation/demand data (present and future) to accurately predict future system dynamics beyond their own point of connection. This is the role of the ESO/FSO, hence the proposers maintain it is their responsibility to modify the Grid Code and compliance requirements in a timely manner to enable users to build plants that will remain compliant under future system conditions.

**WAGCM2 Outline**

Workgroup discussion and research identified that this is a far reaching topic that has many impacts and differences of opinion and as such it has not been possible to come to an agreement between parties in regards to finding an agreed position on clarifying existing Temporary Overvoltage requirements.

WAGCM2 solution utilises the Original GC0155 solution which contains the fault ride through clarifications identified within the Terms of reference minus the temporary overvoltage requirements which are recommended to be resolved via its own new modification.

Enabling industry to fully debate TOV with all interested stakeholders and consider future as well as existing Temporary Overvoltage Requirements rather than just clarifying existing requirements as per the terms of reference.

**Ofgem Legal Opinion on the current Grid Code**

The Workgroup asked Ofgem for their interpretation of the Grid Code on the FRT requirements. Whilst this has not been completed due to Ofgem waiting on further information from the Proposer, it was felt that this delay should not prohibit the development of an enduring solution.

**Cross code impacts**

The Workgroup considered whether there were potential impacts on the G99 requirements and it was noted that there were no consequential impact.

**Workgroup consultation question: Xxxxx?**

## Draft legal text

The draft legal text created as part of GC0151 WAGCM2 Alternative Proposal Legal Text has been further developed and is available in Annex 3.

What is the impact of this change?

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| **Proposer’s assessment against Grid Code Objectives** | |
| **Relevant Objective** | **Identified impact** |
| (a) To permit the development, maintenance and operation of an efficient, coordinated and economical system for the transmission of electricity | **Positive**  By improving Generator confidence in their ability to comply with FRT requirements and lessening the likelihood of compliance proceedings including following an incident where a Generator has tripped for allowable reasons. |
| (b) Facilitating effective competition in the generation and supply of electricity (and without limiting the foregoing, to facilitate the national electricity transmission system being made available to persons authorised to supply or generate electricity on terms which neither prevent nor restrict competition in the supply or generation of electricity); | **Neutral**  [Please provide your rationale] |
| (c) Subject to sub-paragraphs (i) and (ii), to promote the security and efficiency of the electricity generation, transmission and distribution systems in the national electricity transmission system operator area taken as a whole; | **Positive**  By providing clearer guidance on expected behaviour following a fault, Generators are able to prepare more effectively and be more resilient as a result so improving system security. |
| (d) To efficiently discharge the obligations imposed upon the licensee by this license and to comply with the Electricity Regulation and any relevant legally binding decisions of the European Commission and/or the Agency; and | **Neutral**  [Please provide your rationale] |
| (e) To promote efficiency in the implementation and administration of the Grid Code arrangements | **Positive**  By improving clarity in FRT requirements this will help to improve efficiency. |

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| **Proposer’s assessment of the impact of the modification on the stakeholder / consumer benefit categories** | |
| **Stakeholder / consumer benefit categories** | **Identified impact** |
| Improved safety and reliability of the system | **Positive**  This change should improve compliance to FRT as the obligations will be clearer meaning a more stable system during fault conditions. |
| Lower bills than would otherwise be the case | **Positive**  By reducing non-conformities this should reduce the need to constrain Generators following a fault. |
| Benefits for society as a whole | **Positive**  Reducing tripping will provide a more stable network ensuring security of supply. |
| Reduced environmental damage | **Neutral**  No Impact |
| Improved quality of service | **Positive**  Providing clearer guidance to new and existing connections on their obligations. |

**Standard Workgroup consultation question:** Do you believe that GC0155 Original proposal better facilitates the Applicable Objectives?

When will this change take place?

### Implementation date

10 days after authority approval*.*

### Date decision required by

The decision is required from the Authority as soon as reasonably practicable

### Implementation approach

The implementation approach will depend on the level of change required by industry following clarifications provided by the workgroup.

Interactions

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| --- | --- | --- | --- |
| ☐Grid Code | ☐BSC | ☐STC | ☐SQSS |
| ☐European Network Codes | ☐ EBR Article 18 T&Cs[[2]](#footnote-3) | ☐Other modifications | ☐Other |

How to respond

The Workgroup is seeking the views of Grid Code Users and other interested parties in relation to the issues noted in this document and specifically in response to the questions above.

Please send your response to [grid.code@nationalgrideso.com](mailto:grid.code@nationalgrideso.com) using the response pro-forma which can be found on the [GC0155](https://www.nationalgrideso.com/industry-information/codes/grid-code-old/modifications/gc0155-clarification-fault-ride-through) modification page.

In accordance with Governance Rules if you wish to raise a Workgroup Consultation Alternative Request please fill in the form which you can find at the above link.

*If you wish to submit a confidential response, mark the relevant box on your consultation proforma. Confidential responses will be disclosed to the Authority in full but, unless agreed otherwise, will not be shared with the Panel, Workgroup or the industry and may therefore not influence the debate to the same extent as a non-confidential response.*

## Standard Workgroup consultation questions

1. Do you believe that GC0155 Original proposal better facilitates the Applicable Objectives?
2. Do you support the proposed implementation approach?
3. Do you have any other comments?
4. Do you wish to raise a Workgroup Consultation Alternative request for the Workgroup to consider?

## Specific Workgroup consultation questions

1. Implementation date if retrospectivity is a thing – timeline/ costs and differences between solutions
2. Agree with who’s interpretation?
3. Potential impact on the future stability market design
4. What types of active overvoltage protection does your plant have and can you provide the following details:-

* Plant type (synchronous / non-synchronous)
* Protection type (protection relay / control system / other)
* Settings (Voltage and time durations)
* Resulting action (trip / block / deload / other)

1. Do you agree with the proposer’s suggestion that TOV needs to be defined a system characteristic so that it is part of system design?
2. Looking at values specified in OG proposals, do you see any compliance issues in existing or future plant, when looking individual generating units and power park units
3. Looking at values specified in OG proposals, do you see any compliance issues in existing or future plant, when looking at the entire users plant while taking into account network typology
4. Do you agree with WAGCM1 base assumption that the current Grid Code does not impose any fault ride through requirements for voltage “rises” beyond those defined in CC.6.1.11 and ECC.6.1.11 on GB system users?
5. Do you agree that there is a difference between ‘high voltage withstand capability’ and ‘high voltage ride through capability’? If so, please briefly describe your understanding of each.
6. Do you agree that the HVRT requirements should be aligned with generators and power park modules available through supply-chain market and those with international Grid Code requirements to enable GB system users to procure standardised and commercially available plant equipment?
7. Do you agree with the high voltage thresholds (magnitude and duration) in the original proposal, the high voltage thresholds (magnitude and duration) in WAGCM1, or neither of these?
8. Do you have views regarding the economic viability and technical feasibility of designing new generators and PPMs which will need to comply with the Original proposal as compared to WAGCM1?
9. Do you agree with the WAGCM1 proposal to not impose retrospectivity on existing plants?
10. The WAGCM1 proposal is to apply the new HVRT requirements to new connections from a date in future, with the implementation date yet to be determined (as early as possible within reason). What do you think the implementation date should be?
11. Do you agree that the fast fault current injection requirements under clause “ECC.6.3.16” need additional development to establish a common approach to reactive power exchange for voltage “rises” during or following a fault condition?
12. Do you agree that timely definition of future Grid Code requirements under changing system dynamics such as phase angle jumps and multiple fault ride throughs should be given priority to allow GB system users to future proof their plants?
13. Do you agree that if the original proposal is implemented and retrospectivity is required from existing plants, then a suitable cost recovery mechanism should be established for users?

Acronyms, key terms and reference material

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| **Acronym / key term** | **Meaning** |
| BSC | Balancing and Settlement Code |
| CC | Connection Conditions |
| CP | Compliance Process |
| CUSC | Connection and Use of System Code |
| EBR | Electricity Balancing Regulation |
| ECP | European Compliance Process |
| FRT | Fault Ride Through |
| GC | Grid Code |
| NGESO | National Grid Electricity System Operator |
| PLL | Phase Lock(ed) Loop |
| RfG | Request for Generators |
| SCL | Short Circuit Levels |
| SOF | System Operability Framework |
| STC | System Operator Transmission Owner Code |
| SQSS | Security and Quality of Supply Standards |
| T&Cs | Terms and Conditions |
| TO | Transmission Owner |
|  |  |

### Reference material

* [GC0151](https://www.nationalgrideso.com/industry-information/codes/grid-code-old/modifications/gc0151-grid-code-compliance-fault-ride)
* [OFGEM Decision](https://www.ofgem.gov.uk/sites/default/files/2021-11/GC0151%20Authority%20Decision.pdf)

Annexes

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| **Annex** | **Information** |
| Annex 1 | Proposal form |
| Annex 2 | SSE HVRT Strawman |
| Annex 3 | Draft legal text |
| Annex X |  |
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1. Discussion related to this exclusion is in the Temporary Over Voltage – Is not included in WAGCM2 [↑](#footnote-ref-2)
2. If the modification has an impact on Article 18 T&Cs, it will need to follow the process set out in Article 18 of the Electricity Balancing Regulation (EBR – EU Regulation 2017/2195) – the main aspect of this is that the modification will need to be consulted on for 1 month in the Code Administrator Consultation phase. N.B. This will also satisfy the requirements of the NCER process. [↑](#footnote-ref-3)