1. The current fault ride through requirements are that generation needs to ride through faults where the voltage dip is above the line specified in the Grid Code. With no upper limit on how the much voltage rise would happen subsequent to a fault, any power station would need to ride through whatever the network presents it with.
2. There are several indications within the Grid Code to suggest that overvoltages above the steady state voltage levels are likely to be exceeded. This includes
   1. TS01
   2. Earth fault factors specified for unbalanced faults
   3. Requirements to trip for certain overvoltages in Scotland

1. The expectation is that the Generator
   1. will take realistic overvoltage levels into account when designing the plant with appropriate safety margins to ensure that their plant would not need to become non-compliant within a short period of time of its commissioning
   2. will ensure that their plant continues to comply with the fault ride through requirement as the network changes. This may require them to reconsider changes to the limits of overvltages that are likely to materialise and modify their plant to ensure continuous compliance.
2. The issue
   1. Some Generators have designed their plant with no consideration to potential overvoltages (for example by setting their plant to 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 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.
3. The objectives
   1. Setting a realistic upper cap on what overvoltage a plant could be exposed to so that Generators can design their plant with this cap in mind.
   2. Ensuring that this cap would not be violated so as not to affect the security of supply for consumers and not to require excessive/unrealistic increase in Balancing Services costs.
   3. Ensuring that existing plant do not need to be modified unless it is necessary to do so.
   4. Ensuring that upper cap is realistic to maintain without uneconomic transmission reinforcements.
4. The proposal
   1. Define TOV as a system characteristic. This would place a requirement on Transmission Owners to ensure that their system is designed in a way such that the cap on TOV is not violated for all reasonable background conditions (including outages + secured faults).

Notes:

* + - * The proposal uses the limits of TGN288 as these have been used by Generators in England and Wales since 2016 with no issues. It also uses the 132kV data provided by SPT. The final values are yet to be agreed.
      * The lower the cap is, the higher the cost of investment that would be required to maintain it.
      * The use of a cap that cannot be guaranteed by TOs is not feasible.
      * The requirements are defined at the Grid Entry Point not at the turbine terminals. Hence, it does not necessarily mean that a turbine that has a capability lower than what is defined cannot be used provided that the User’s system is designed appropriately.
  1. Specify a requirement on Generators that they do not contribute to a TOV in excess of the cap and that they continue to regulate the voltage during high voltage excursions.

Note: Engagement with manufacturers suggest that this condition is either already met or could be met by enabling an existing control system functionality. This is true for existing and future plant.

* 1. Allow units that are subjected to TOV beyond the limits to trip.
  2. Ensure that the requirements are such that plant that cannot ride through the specified cap are not deemed non-compliant unless the TOV expected to arise at their terminals is above their capability (up to the cap specified).

Notes:

* + - * We expect that all existing plant would undertake any minor works that would maximise their ability to ride through TOV. For example, where the plant is set to trip unnecessarily for a minor increase in voltage levels, these would need to be revised. Also, if the plant does not have the function that allows it to provide voltage control during high voltage events enabled, this would need to be rectified.
      * Generators would need significant engagement with TOs/NGESO to provide the details of realistic potential TOV at the connection site.
      * If the TOV specified is within the plant capability, there will be no need to modify the plant. However, if the TOV increases in the future, there may be a need to modify the plant.
      * If the TOV specified is above the plant capability, the Generator would need to either modify their plant or accept that they could be constrained prefualt if the post fault TOV is likely to cause the plant to trip.

**Connection Conditions**

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 Site connected at a voltage level below 275kV in England and Wales or 132kV in Scotland, the temporary power frequency overvoltage requirements apply only at the HV side of the transformer.



Figure CC.6.1.11

CC.A.7.2.3.3 During voltage transients where the voltage at the connection site exceeds the levels specifies in CC.6.1.4, an Onshore Non-Synchronous Generating Unit, Onshore DC Converter, OTSDUW Plant and Apparatus or Onshore Power Park Module shall

1. not cause any voltage rise above the limits specified in CC.6.1.11 and
2. continue to regulate the voltage in order to reduce the magnitude of voltage excursion without exceeded the transient rating limits of the Onshore Non-Synchronous Generating Unit, Onshore DC Converter, OTSDUW Plant and Apparatus or Onshore Power Park Module.

CC.6.3.15.1 Fault Ride through applicable to Generating Units, Power Park Modules and DC Converters and OTSDUW Plant and Apparatus

(a) Short circuit faults on the Onshore Transmission System (which may include an Interface Point) at Supergrid Voltage up to 140ms in duration.

(i) Each Generating Unit, DC Converter, or Power Park Module and any constituent Power Park Unit thereof and OTSDUW Plant and Apparatus shall remain transiently stable and connected to the System without tripping of any Generating Unit, DC Converter or Power Park Module and / or any constituent Power Park Unit, OTSDUW Plant and Apparatus, and for Plant and Apparatus installed on or after 1 December 2017, reactive compensation equipment, for a close-up solid three phase short circuit fault or any unbalanced short circuit fault on the Onshore Transmission System (including in respect of OTSDUW Plant and Apparatus, the Interface Point) operating at Supergrid Voltages for a total fault clearance time of up to 140 ms. A solid three-phase or unbalanced earthed fault results in zero voltage on the faulted phase(s) at the point of fault. The duration of zero voltage is dependent on local Protection and circuit breaker operating times. This duration and the fault clearance times will be specified in the Bilateral Agreement. Following fault clearance, recovery of the Supergrid Voltage on the Onshore Transmission System to 90% may take longer than 140ms as illustrated in Appendix 4A Figures CC.A.4A.1 (a) and (b) and may involve temporary power frequency overvoltages of up to the levels specified in CC.6.1.11. 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.~~

(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,
* is order to protect itself from a temporary overvolateg in excess of the levels specified in CC.6.1.11, or
* 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.

(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

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~~ below the limits specified in CC.6.1.4, each Generating Unit or Power Park Module or OTSDUW Plant and Apparatus shall generate maximum reactive current 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. It should be noted that, for Synchronous Generating Units, the magnitude of the maximum reactive current to be provided is dependent on the voltage at the Grid Entry Point.

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 limits 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) Supergrid Voltage dips on the Onshore Transmission System greater than 140ms in duration

(1b) Requirements applicable to Synchronous Generating Units subject to Supergrid Voltage dips on the Onshore Transmission System greater than 140ms in duration.

(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 (where the voltage at the Grid Entry Point is ~~outside~~ below the limits specified in CC.6.1.4) and absorb reactive current (where the voltage at the Grid Entry Point is above the limits specified in CC.6.1.4) in proportion to the voltage excursion without exceeding the transient rating limits of the Synchronous Generating Unit and,

:

:

(2b) Requirements applicable to OTSDUW Plant and Apparatus and Power Park Modules subject to Supergrid Voltage dips on the Onshore Transmission System greater than 140ms in duration

(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 (where the voltage at the Grid Entry Point, or in the case of an OTSDUW Plant and Apparatus, the Interface Point voltage, is ~~outside~~ below the limits 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; and

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 limits 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

**European Connection Conditions**

ECC.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 an EU 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 ECC.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 Site connected at a voltage level below 275kV in England and Wales or 132kV in Scotland, the temporary power frequency overvoltage requirements apply only at the HV side of the transformer.

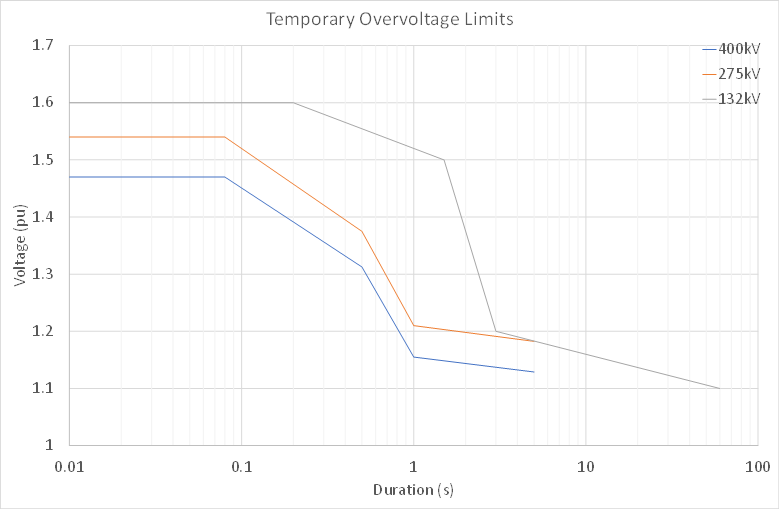


Figure CC.6.1.11

ECC.6.3.15.8 In addition to the requirements in ECC.6.3.15.1 – ECC.6.3.15.7:Converters and OTSDUW Plant and Apparatus

(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,
* is order to protect itself from a temporary overvolateg in excess of the levels specified in ECC.6.1.11, or
* 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 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).

(vii) Each Type B, Type C and Type 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

(a) Short circuit faults on the Onshore Transmission System (which may include an Interface Point) at Supergrid Voltage up to 140ms in duration.

(i) Each Generating Unit, DC Converter, or Power Park Module and any constituent Power Park Unit thereof and OTSDUW Plant and Apparatus shall remain transiently stable and connected to the System without tripping of any Generating Unit, DC Converter or Power Park Module and / or any constituent Power Park Unit, OTSDUW Plant and Apparatus, and for Plant and Apparatus installed on or after 1 December 2017, reactive compensation equipment, for a close-up solid three phase short circuit fault or any unbalanced short circuit fault on the Onshore Transmission System (including in respect of OTSDUW Plant and Apparatus, the Interface Point) operating at Supergrid Voltages for a total fault clearance time of up to 140 ms. A solid three-phase or unbalanced earthed fault results in zero voltage on the faulted phase(s) at the point of fault. The duration of zero voltage is dependent on local Protection and circuit breaker operating times. This duration and the fault clearance times will be specified in the Bilateral Agreement. Following fault clearance, recovery of the Supergrid Voltage on the Onshore Transmission System to 90% may take longer than 140ms as illustrated in Appendix 4A Figures CC.A.4A.1 (a) and (b) and may involve temporary power frequency overvoltages of up to the levels specified in CC.6.1.11. 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.~~

(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,
* is order to protect itself from a temporary overvolateg in excess of the levels specified in ECC.6.1.11, or
* in accordance with ECC.6.3.15.10 (vi),

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.

ECC.6.3.16.1.2 For any balanced fault which results in the positive phase sequence voltage falling below the voltage levels specified in ECC.6.1.4 at the Grid Entry Point or User System Entry Point (if Embedded), each Type B, Type C and Type D Power Park Module or each Power Park Unit within a Type B, Type C and Type D Power Park Module or HVDC Equipment shall, as a minimum (unless an alternative type registered solution has otherwise been agreed with The Company), be required to inject a reactive current above the heavy black line shown in Figure ECC.16.3.16(a).

Following voltage recovery, during the period for which the voltage at the Grid Entry Point or User System Entry Point (if Embedded) or Interface Point (in the case of OTSDUW Plant and Apparatus) is above the limits specified in ECC.6.1.4, each Type B, Type C and Type D Power Park Module or each Power Park Unit within a Type B, Type C and Type D Power Park Module or HVDC Equipment shall progressively absorb reactive current in proportion to the voltage excursion without exceeding its transient rating limit.

ECC.6.3.16.1.6 For any planned or switching events (as outlined in ECC.6.1.7 of the Grid Code) or unplanned events which results in temporary power frequency over voltages (TOV’s), each Type B, Type C and Type D Power Generating Module or each Power Park Unit within a Type B, Type C or Type D Power Park Module or HVDC Equipment ~~will be required to satisfy the transient overvoltage limits specified in the Bilateral Agreement.~~ shall

1. not cause any voltage rise above the limits specified in CC.6.1.11 and
2. continue to regulate the voltage in order to reduce the magnitude of voltage excursion without exceeded the transient rating limits of Type B, Type C and Type D Power Generating Module or each Power Park Unit within a Type B, Type C or Type D Power Park Module or HVDC Equipment.

ECC.6.3.16.1.8 Each Type B, Type C and Type D Power Park Module or HVDC Equipment shall be designed to reduce the risk of transient over voltage levels arising following clearance of the fault and in order to mitigate the risk of any form of instability which could result. EU Generators or HVDC System Owners shall be permitted to block or employ other means where the anticipated transient overvoltage would otherwise exceed the maximum permitted values specified in ECC.6.1.7. Figure ECC.16.3.16(b) and Figure ECC.16.3.16(c) shows the impact of variations in fault clearance time. For main protection operating times this would not exceed 140ms. ~~The requirements for the maximum transient overvoltage withstand capability and associated time duration, shall be agreed between the EU Code User and The Company as part of the Bilateral Agreement~~. Where the EU Code User is able to demonstrate to The Company that blocking or other control strategies are required in order to prevent the risk of transient over voltage excursions as specified in ECC.6.3.16.1.5, EU Generators and HVDC System Owners are required to both advise and agree with The Company the control strategy, which must ~~also~~ include the approach taken to de-blocking and the provision of any voltage regulation required by ECC.6.3.16.1.6.