Fault Ride Through
Options for Progression

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Summary

- Options considered by the Workshop
- Suggested way forward proposed by Workshop
- Review of the current ENTSO-E RfG Fault Ride Through Requirements

Options Considered by the Workshop

- Do Nothing
- Await Implementation of European Network Code Requirements for Generators (2016/2017)
- Adopt the European Network Code Requirements for Generators early
- Retain the current GB Grid Code wording but amend the voltage duration profiles
- Develop specific voltage duration profiles on a site specific basis.
- Others?

Way Forward - Option

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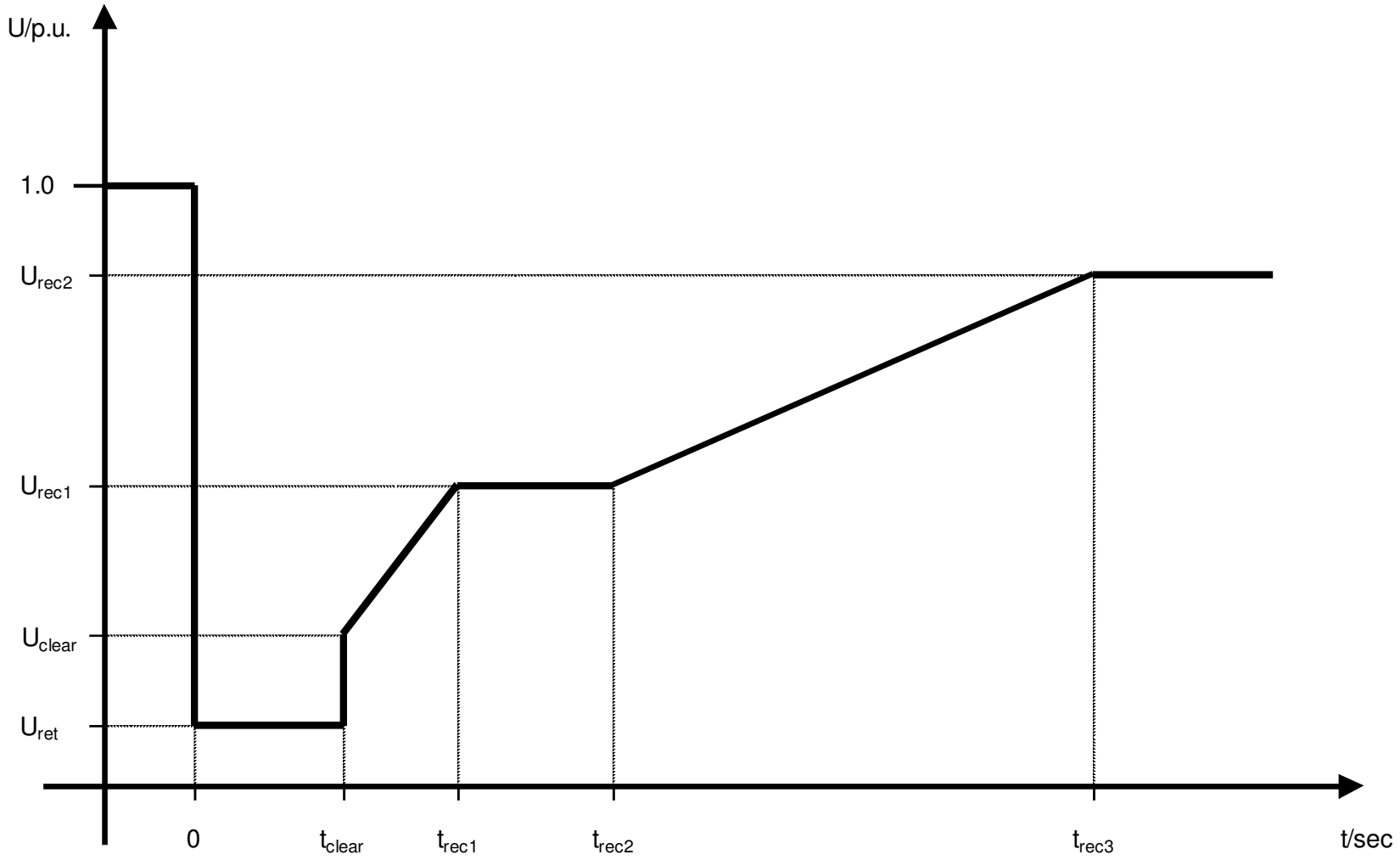
- Consider early adoption of the ENTSO-E Fault Ride Through Requirements (Type D) for Large and Medium Power Stations utilising Synchronous Generators
- Leave the requirements for Power Park Modules unchanged (ie as per the Current Grid Code) until the ENTSO-E Requirements are formally adopted and implemented to all Codes (2016/2017).
- Develop Grid Code wording to reflect the ENTSO-E RfG for Synchronous Generating Units including selection of voltage against time curves and national parameters
- Any FRT wording would need to adopt the ENTSO-E RfG in total and not in part.
- Any proposal would be under the existing GB Grid Code terminology – ie it is only the technical performance requirements that are being adopted not the entirety of the ENTSO-E RfG Code

General Requirements for Type B Power Generating Modules

- Article 8 - Type A Power Generating Modules (800W – 1MW) – There are no Fault Ride Through requirements for Type A Power Generating Modules.
- Article 9 – Type B Power Generating Modules (1MW – 10MW)
  - Specified under Article 9(3)
  - Each TSO will define a voltage – against time profile at the Connection Point (Figure 3) in which each Power Generating Module shall be capable of staying connected to the network and continuing stable operation after the power system has been disturbed by secured faults on the Network
  - The voltage against time profile shall be expressed by a lower limit of the course of the phase to phase voltages on the Network Voltage level at the Connection Point during a symmetrical fault, as a function of time before, during and after the fault. This lower limit is defined by the TSO using the parameters in Figure 3 according to Tables 3.1 and 3.2
  - Requirements equally apply to Type C and D Power Generating Modules although some additional amendments apply to the voltage against time curve for Type D Power Generating Modules

ENTSO-E RfG - Fault Ride Through Requirements – Voltage Against Time Profile – Figure 3 (Types B and C)



Interpretation of Voltage against time profile

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- Figure 3 defines the Fault Ride Through profile of a Power Generating Module (Synchronous and Asynchronous). The diagram represents the lower limit of a voltage-against time profile by the voltage at the Connection Point, expressed by the ratio of its actual value and its nominal value in per unit before, during and after a fault. Uret is the retained voltage at the connection point during a fault, tclear is the instant when the fault has been cleared. Urec1, Urec2, trec1, trec2 and trec3 specify certain points of lower limits of voltage recovery after fault clearance.

ENTSO-E RfG - Voltage Against Time Parameters – Table 3.1 – Type B & C Synchronous Power Generating Units

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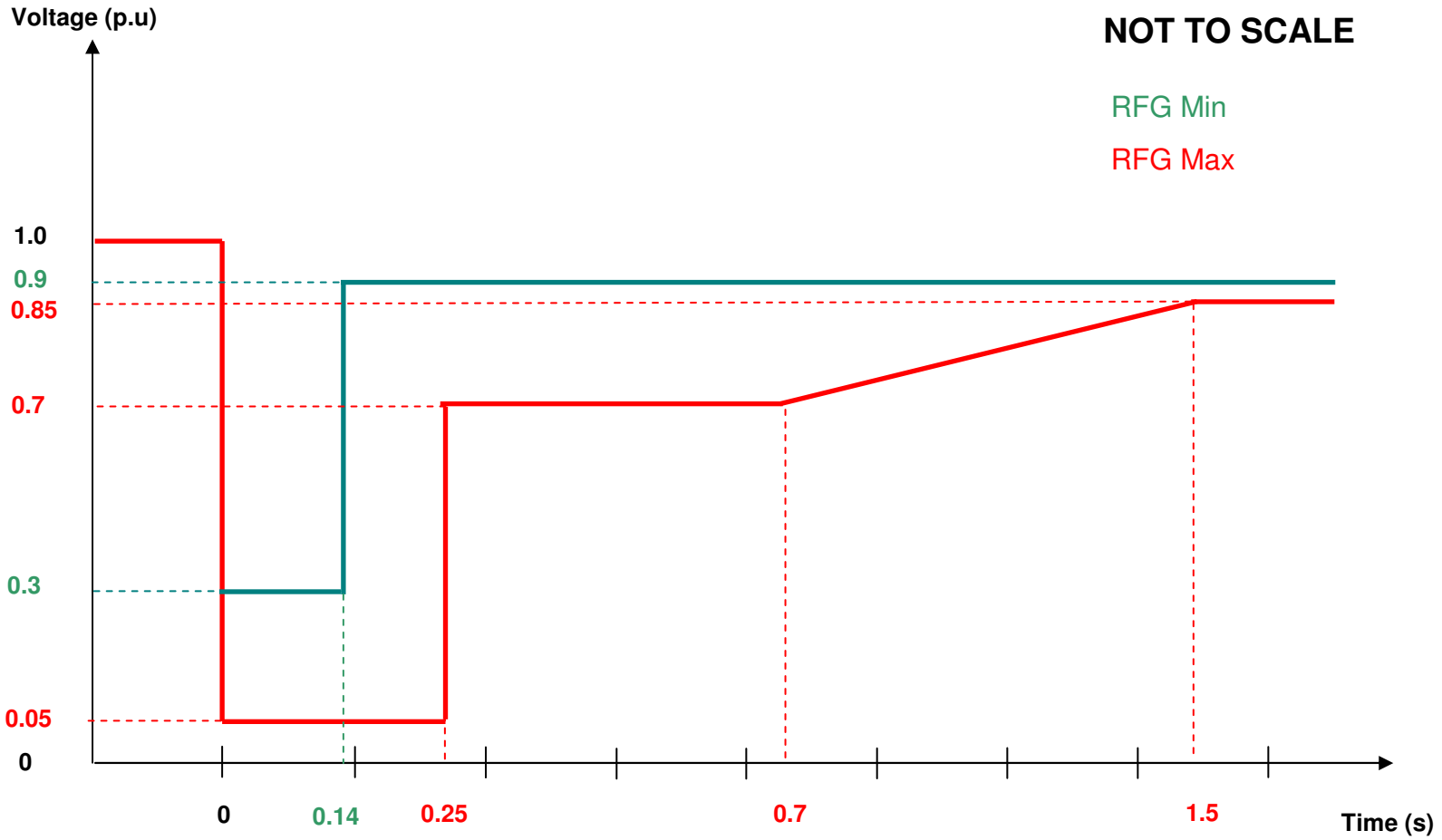
Voltage parameters [pu]		Time parameters [seconds]	
Uret:	0.05 – 0.3	tclear:	0.14 – 0.25
Uclear:	0.7 – 0.9	trec1:	tclear
Urec1:	Uclear	trec2:	trec1 – 0.7
Urec2:	0.85 – 0.9 and ≥ Uclear	trec3:	trec2 – 1.5

Table 3.1 – Fault Ride Through Capability of Synchronous Power Generating Modules

ENTSO-E RfG - Voltage Against Time Profile

Type B & C Synchronous Power Generating Modules - Table 3.1



Additional Requirements for Type B & C Power Generating Modules

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- Each TSO shall define the pre and post fault conditions for fault ride through in terms of:-
  - Conditions for the calculation of the pre-fault minimum short circuit capacity at the Connection Point
  - Conditions for pre-fault Active and Reactive Power operating point of the Power Generating Module at the Connection Point and Voltage at the Connection Point
  - Conditions for the calculation of the post fault minimum short circuit capacity at the Connection Point

Additional Requirements for Type B & C Power Generating Modules

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- Each Network Operator shall provide on request by the Generator the pre and post fault conditions to be considered for fault ride through as an outcome of the calculations at the Connection Point as defined in Article 9(3)(a).
  - The pre fault minimum short circuit capacity at each Connection Point expressed in MVA;
  - The pre-fault operating point of the Power Generating Module expressed in Active Power output and Reactive Power output at the Connection Point and Voltage at the Connection Point and
  - The Post – Fault minimum short circuit capacity at each Connection Point expressed in MVA.
  - Alternatively generic values for the above conditions derived from typical cases may be provided by the Relevant Network Operator.

Additional Requirements for Type B & C Power Generating Modules

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- The Power Generating Module shall be capable of staying connected to the Network and continue stable operation when the actual course of the phase to phase voltages on the Network Voltage level at the Connection Point during a symmetrical fault, given the pre fault and post fault conditions according to Article 9(3) (a) point 2), unless the protection scheme for internal electrical faults requires the disconnection of the Power Generating Module from the Network. The protection schemes and settings for internal electrical faults shall be designed not to jeopardise fault ride through performance.
- While still respecting Article 9(3) point 5), undervoltage protection (either fault ride through capability or minimum voltage defined at the connection point voltage shall be set by the Power Generating Facility Owner to the widest possible technical capability of the Power Generating Module unless the Relevant Network Operator requires a less wide setting according to Article 9(5)(b). The settings shall be justified by the Power Generating Facility Owner in accordance with this principle.
- Fault Ride Through capabilities in case of asymmetrical faults shall be defined by each TSO whilst respecting the provisions of Article 4(3).

ENTSO-E RfG - Voltage Against Time Parameters – Table 7.1 – Type D Synchronous Power Generating Modules

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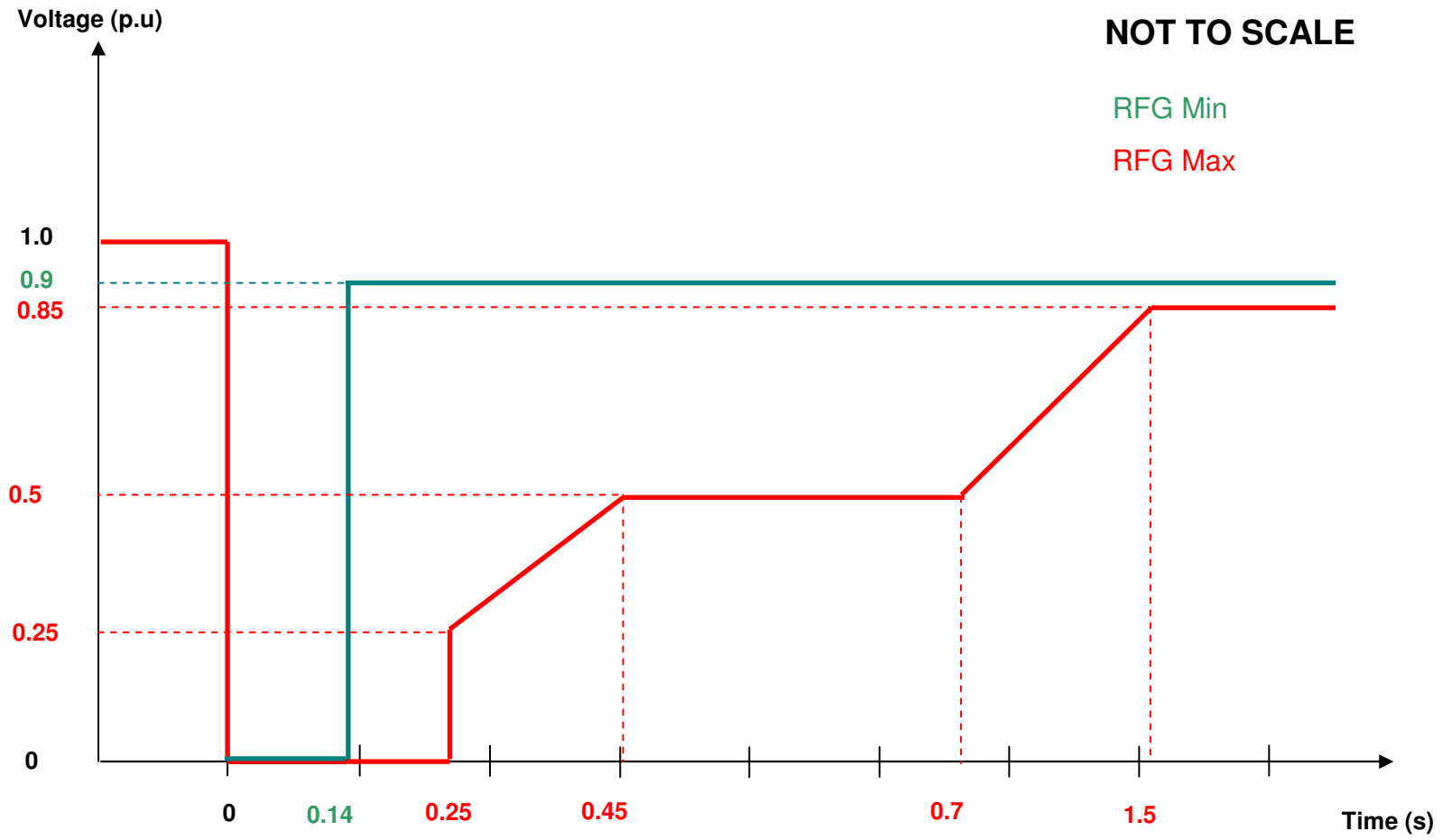
Voltage parameters [pu]		Time parameters [seconds]	
Uret:	0	tclear:	0.14 – 0.25
Uclear:	0.25	trec1:	tclear – 0.45
Urec1:	0.5 – 0.7	trec2:	trec1 – 0.7
Urec2:	0.85 – 0.9	trec3:	trec2 – 1.5

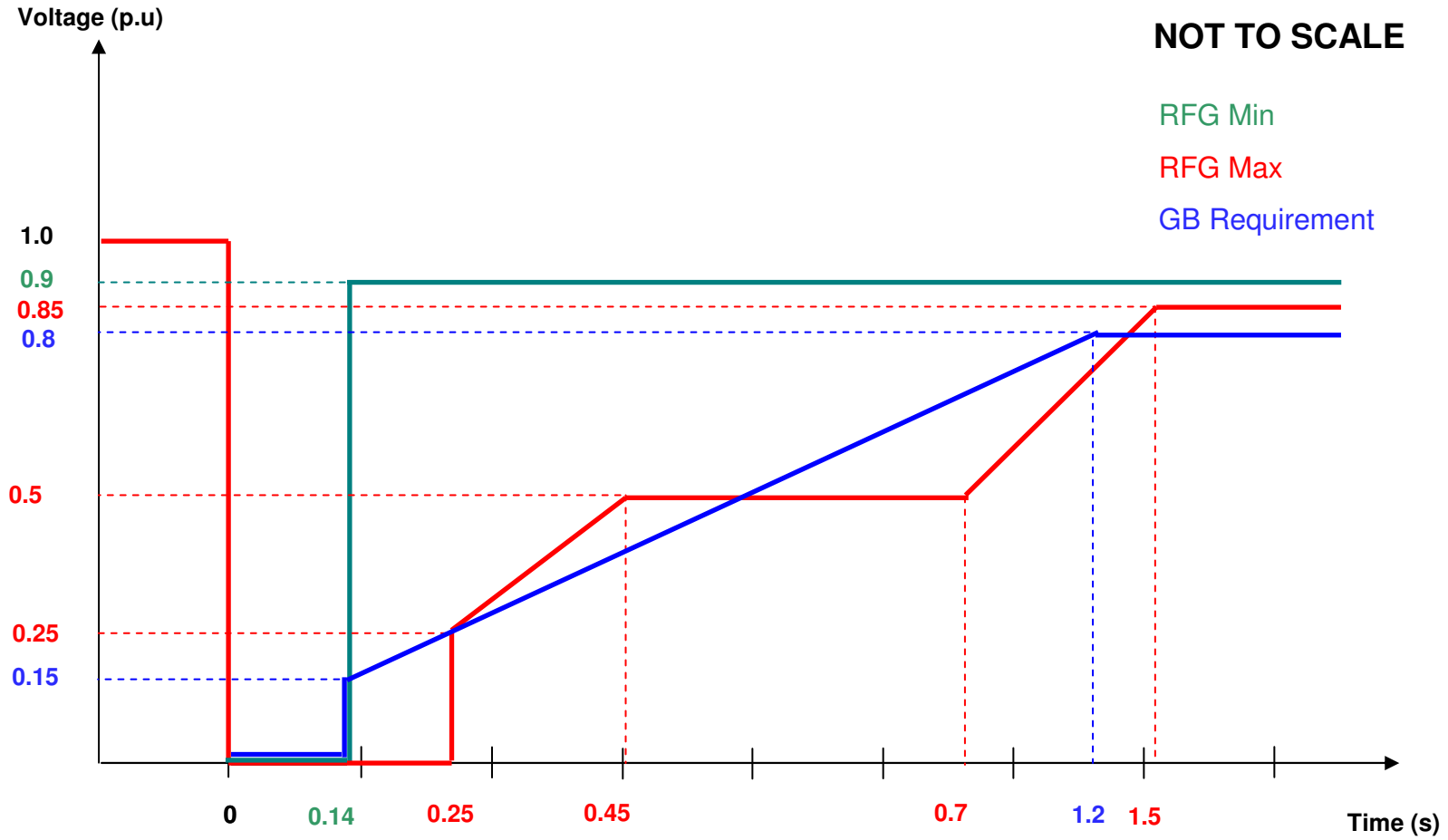
Table 7.1 – Fault Ride Through Capability of Synchronous Power Generating Modules

ENTSO-E RfG - Voltage Against Time Profile

Type D Synchronous Power Generating Modules Table 7.1



ENTSO-E RfG - Voltage Duration Profile – Range compared with GB Requirement



Explanation of ENTSO-E Fault Ride Through Requirements

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- Each TSO shall define the pre and post fault conditions at the Connection Point.
- The requirements are defined at the Connection Point
  - It is not clear if this would be on an individual basis for each Connection Point or globally across the System where each Connection Point is treated in the same way.
  - The implication is that the TSO should select the worst case which will require study work. Separate voltage profiles will be required for Synchronous Generators and Power Park Modules.

Explanation of ENTSO-E Fault Ride Through Requirements

- Additional guidance summarised in Question 24 of the ENTSO-E Frequently Asked Questions Document
- The FRT requirement is based on a voltage against time profile at the connection point which reflects the worst voltage variation during a fault and after its clearance. Power Generating Modules are required to stay connected to the Grid for voltages above these worst case conditions and shall continue stable operation after a secured fault on the network
- The requirements for Synchronous Generators are different to Power Park Modules.
- The reasons for Fault Ride Through are the same as in GB but the requirements are specified in a different way.

ENTSO-E RfG - Voltage against Time Parameters – Table 3.2 – Type B & C Power Power Modules

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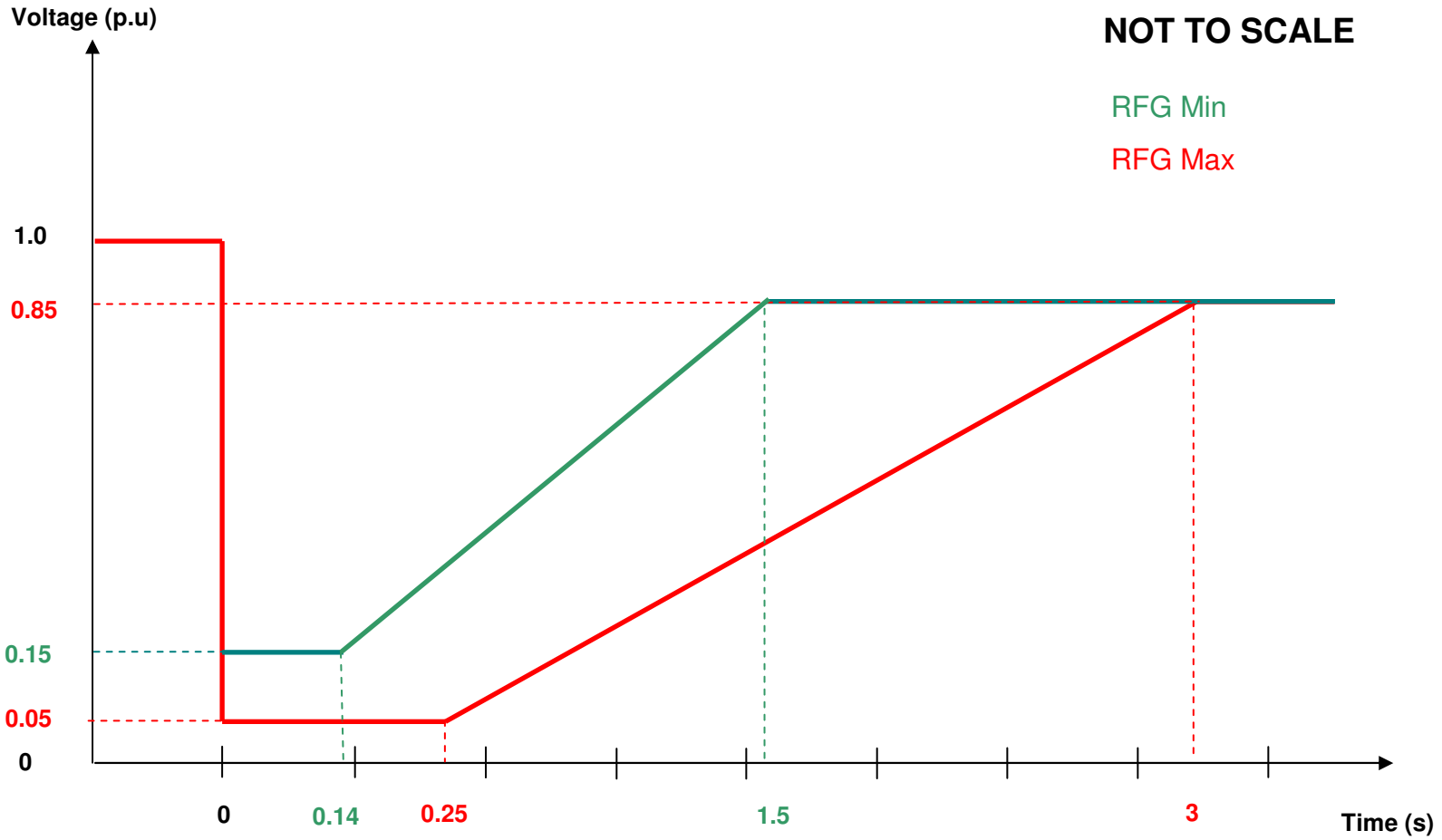
Voltage parameters [pu]		Time parameters [seconds]	
Uret:	0.05 – 0.15	tclear:	0.14 – 0.25
Uclear:	Uret – 0.15	trec1:	tclear
Urec1:	Uclear	trec2:	trec1
Urec2:	0.85	trec3:	1.5 – 3.0

Table 3.1 – Fault Ride Through Capability of Synchronous Power Generating Modules

ENTSO-E RfG - Voltage Against Time Profile

Type B & C Power Park Modules - Table 3.2



Example – Figure 9 – Taken from FAQ 24 – Power Park Module

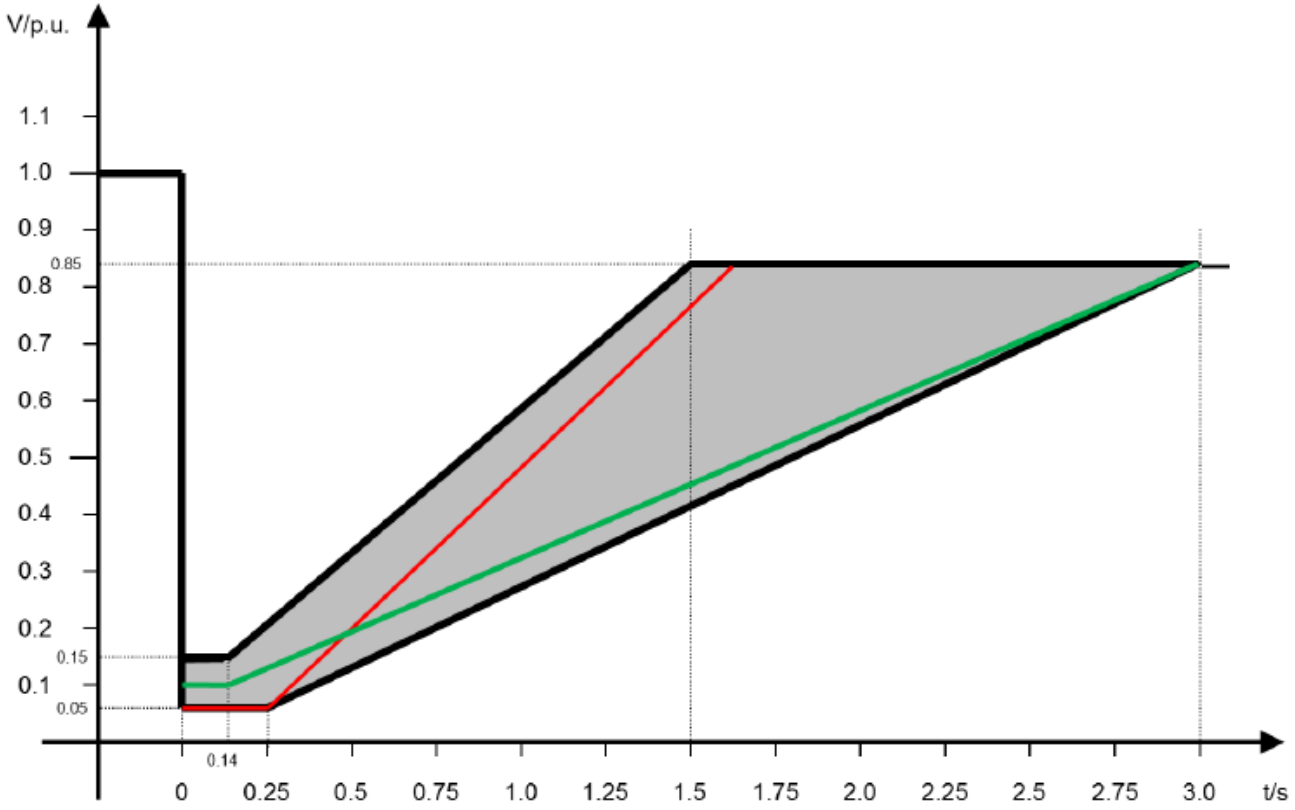


Figure 9: Area (grey) within which a voltage-against-time curve can be defined by the TSO for a Type B PPM, e.g. the given green or red curve

Example – Figure 10 – Taken from FAQ 24 – Power Park Module

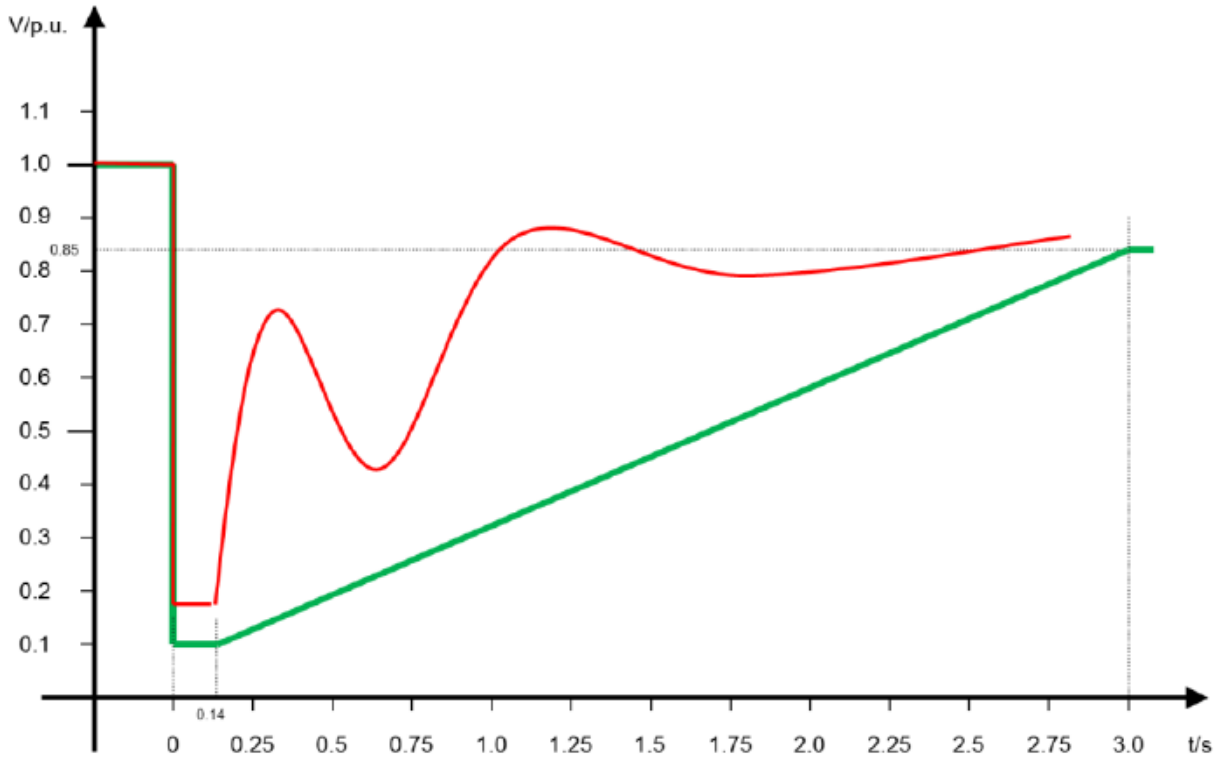


Figure 10: Case in which the recovery voltage (red curve) remains above the defined voltage-against-time curve (green curve) and because of which automatic disconnection of the Power Generating Module is not allowed.

Example – Figure 11 – Taken from FAQ 24 – Power Park Module

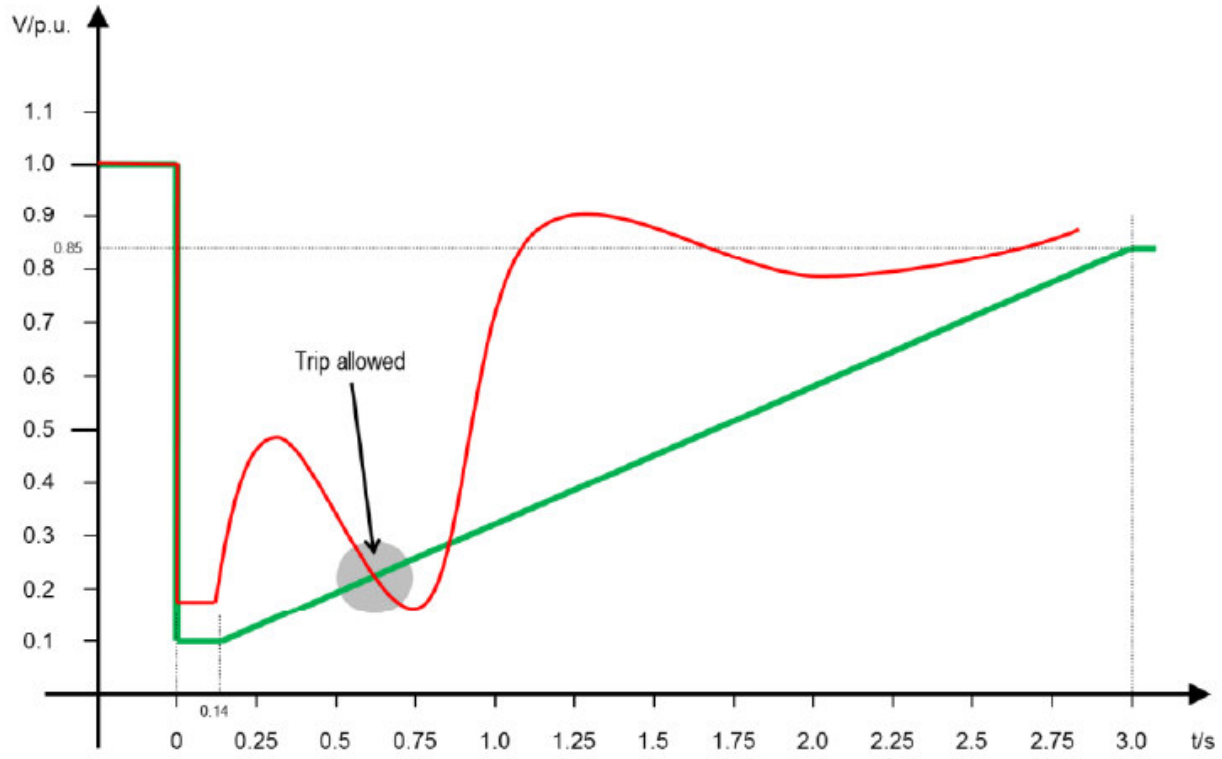


Figure 11: Case in which the recovery voltage (red curve) goes lower than the defined voltage-against-time curve (green curve) and because of which automatic disconnection of the Power Generating Module is allowed.

Explanation of ENTSO-E Fault Ride Through Requirements – FAQ 24

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- FAQ 24 clearly states that the TSO is not requiring the actual voltage recovery curve to be the shape of the voltage against time profile.
- The Voltage recovery curve will have a free controlled response during the post disturbance recovery period that will depend on the PPM technology (eg full converter, doubly fed etc) and the short circuit power of the Grid Connection Point.
- The voltage against time profile just expresses the lower limit for the actual voltage recovery curve for FRT capability

High Level differences with GB Grid Code FRT Requirements

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- The Fault Ride Through Requirements in GB apply only to faults at Supergrid Voltages (ie 200kV) or above
- Split into two sections – faults up to 140ms in duration and faults in excess of 140ms.
- For voltage dips in excess of 140ms a voltage – duration profile is defined which is not a voltage response curve that would be obtained by plotting the transient voltage response at a point on the Onshore Transmission System to a disturbance but rather each point on the profile (ie the heavy black line) represents a voltage level and an associated time duration which connected Generating Units and Power Park Modules must ride through (CC.A.4A.3).
- The same requirement applies to both Power Park Modules and Synchronous Generating Units.
- Requirements exist for Reactive Power Injection during the fault and Active Power recovery on fault clearance

GB Grid Code Voltage Duration Curve - CC.6.3.15.1 (b) (i)

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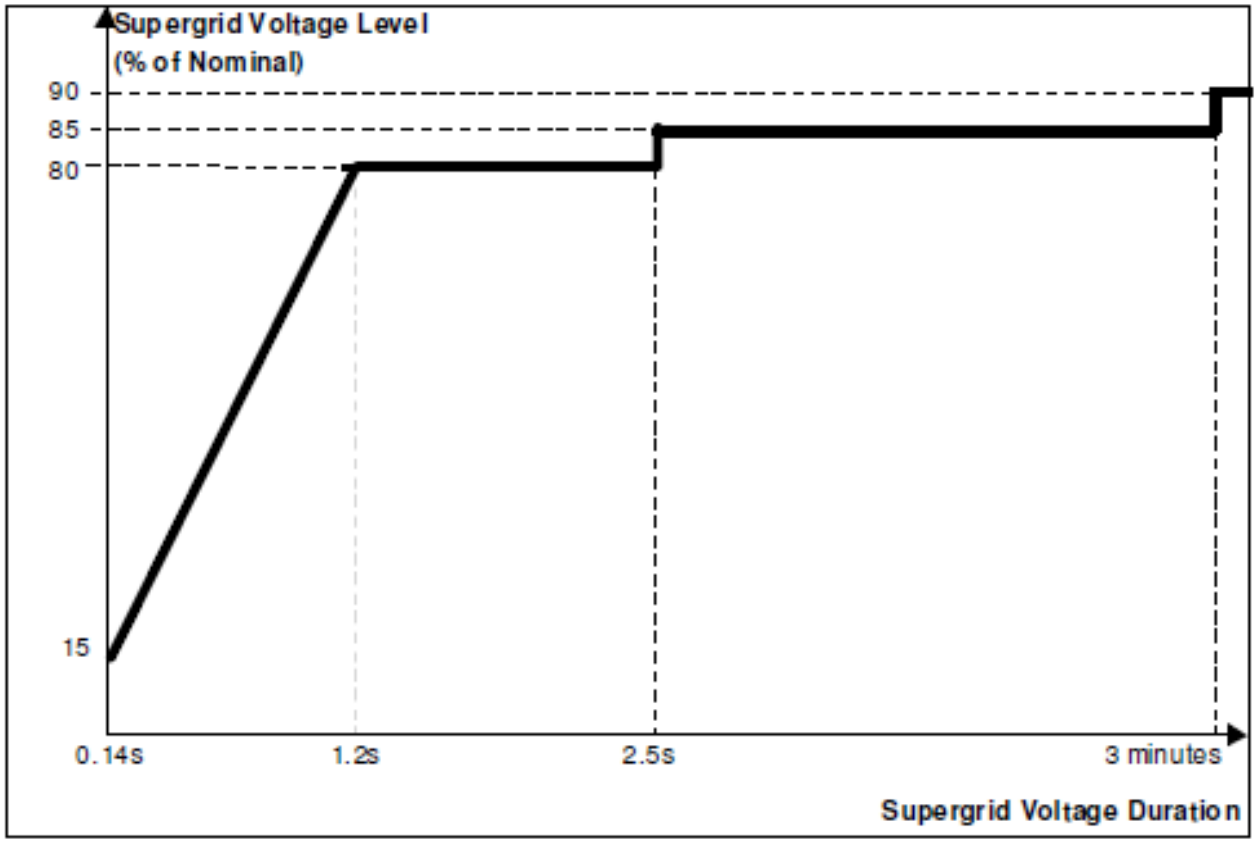

Figure 5

Suggested Way Forward

- Consider the National parameters for a voltage against time curve for a Large Directly Connected Synchronous Generator.
- Consider the wider implications and requirements of the ENTSO-E Fault Ride Through Requirements
  - What is mandatory (Exhaustive)
  - Subject to National Choice (Non Exhaustive)
- Once developed extend similar processes to Large and Medium Embedded Synchronous Generators.

Discussion