

# Fault Ride Through



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# Summary

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- Resume of Actions
- Assumptions
- Overall Proposals
- Summary

## Resume of Actions

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- Industry are invited to engage with NGET to ensure National Grid are appropriately modelling the new large nuclear fleet in System studies (Extended at WG 6)
- NGET to check GB interpretation of RFG to allow 'Mode A' (Secured) and 'Mode B' (Unsecured) faults with ENTSO-E – *Checked with Ofgem – Where RfG is silent National Legislation can be applied*
- Review Emergency Restoration Code for overlapping requirements with FRT and RFG – *Checked*
- Work group report to be prepared reflecting interim position pre-final RFG draft.

# Modelling - Nuclear

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- Industry are invited to engage with NGET to ensure National Grid are appropriately modelling the new large nuclear fleet in System studies (Extended at WG 6)

# High Level Summary of Fault Ride Through Proposals

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- Mode A Faults – As per RfG with National Parameters selected
- Mode B Faults – Based on GB text with revised voltage duration curve.
- Scope – These proposals only apply to Large Power Stations directly connected at 200kV or above. For Large, Medium and Small Power Stations connected at 132kV and below, the requirements will be addressed through the second phase of this working group.

- Type D power generating modules shall fulfil the following requirements in relation to robustness:-
  - (a) Power generating modules shall be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults. The capability shall be in accordance with a voltage against time profile at the connection point for fault conditions defined by the relevant TSO in accordance with paragraph 1 of Article 7.
  - The Voltage-against time profile shall express a lower limit of the actual 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.
  - The lower limit shall be defined by the relevant TSO in accordance with paragraph 1 of Article 7, using the parameters set out in Figure 3 and within the ranges set out in Tables 7.1 and 7.2 for Type D power generating modules connected to the transmission network.

## *Extract from RfG Type D – 21 January 2015 (2)*

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- The lower limit shall also be defined by the relevant TSO in accordance with paragraph 1 of Article 7 using parameters set out in Figure 3 and within the ranges set out in Tables 3.1 and 3.2 for Type D power generating modules connected to the distribution or closed distribution system
- (ii) Each TSO shall define in accordance with paragraph 1 of Article 7, the pre and post fault conditions for the fault ride through capability referred to in point (iv) of Article 11(3). The defined pre-fault and post fault conditions for the fault ride through capability shall be made publically available.
- (b) At the request of a power generating facility owner, the relevant network operator shall provide the pre and post fault conditions to be considered for fault ride through capability as an outcome of the calculations at the connection point as defined in point (iv) of Article 11(3) regarding.

- (i) Pre-fault minimum short circuit capacity at each connection point expressed in MVA.
- (ii) pre-fault operating point of the power generating module expressed as active power output and reactive power output at the connection point and voltage at the connection point: and
- (iii) post –fault minimum short circuit capacity at each connection point expressed in MVA
- (c) Fault-ride through capabilities in case of asymmetrical faults shall be defined by each TSO in accordance with paragraph 1 of Article 7.

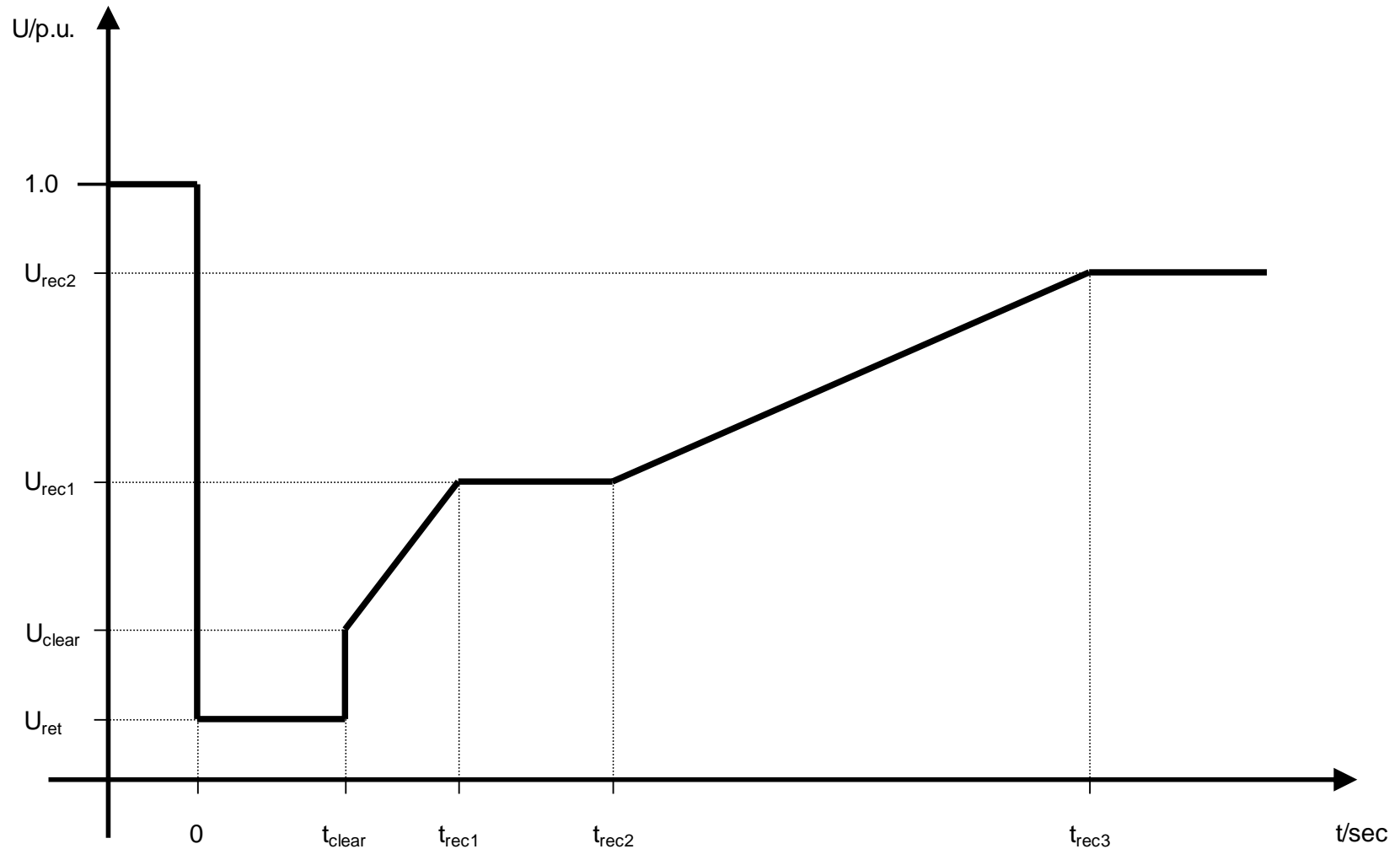


## *Extract from RfG Type B – Article 11 (3)(a)(iv)*

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- Article 11 (3)(a)(iv) – Each TSO, in accordance with paragraph 1 of Article 7 shall define and make publically available the pre-fault and post fault conditions for the fault ride through capability in terms of:
  - The calculation of the pre-fault minimum short circuit capacity at the connection point;
    - Pre-fault active and reactive power operating point of the power generating module at the connection point and voltage at the connection point and
    - Calculation of the post fault minimum short circuit capacity at the connection point.

# ENTSO-E RfG - Fault Ride Through Requirements – Voltage Against Time Profile – Figure 3



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

Voltage parameters [pu]		Time parameters [seconds]	
Uret:	0	tclear:	0.14 – 0.15 (or 0.14 – 0.25 if System protection and secure operation security require)
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 – Parameters for Figure 3 for fault ride through capability of synchronous power generating modules.

# GB Mode A Requirements (1)

## Short Circuit Faults applicable to Synchronous Generating Units

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- Each Generating Unit to remain transiently stable and connected to for any close up solid three phase short circuit fault or unbalanced fault.
- The Generating Unit shall remain connected and stable for any fault in which the post fault voltage profile remains above the line shown in the Voltage against time curve.
- During the period of the fault, the Generating Unit shall generate maximum reactive current without exceeding the transient rating of the Generating Unit
- Following clearance of the fault on the Onshore Transmission System, each Generating Unit shall be capable of restoring active power output to within 90% of the level immediately before the fault and within 0.5 seconds of restoration of the voltage to the nominal levels defined in CC.6.1.4 of the Grid Code.

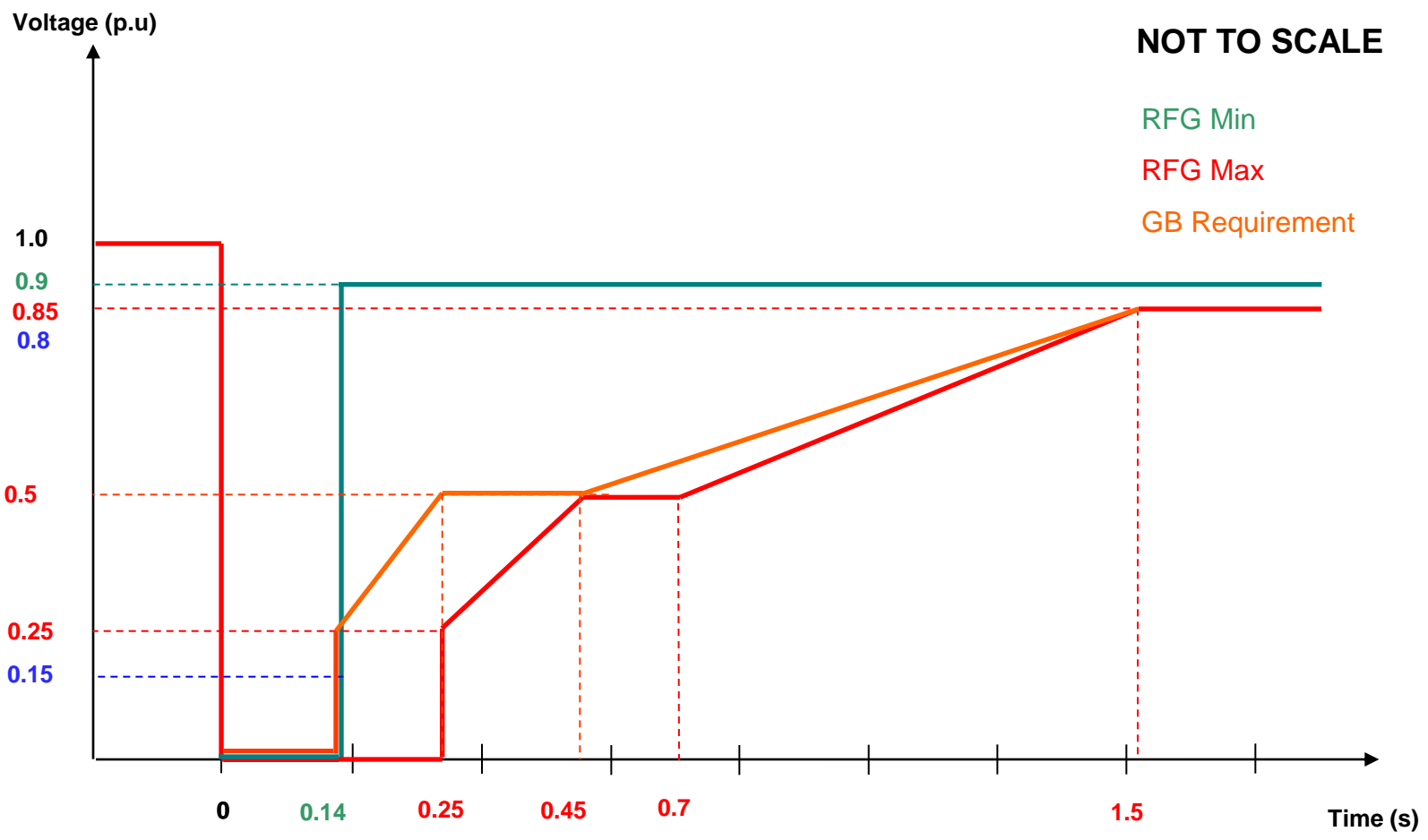
# GB Mode A Requirements (2)

## Short Circuit Faults applicable to Synchronous Generating Units

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- Once the Active Power output has been restored to the required level, Active Power Oscillations shall be acceptable provided :
  - - 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.

# GB Mode A Requirements Voltage Against Time Curve



# GB Parameters – Consistent with Table 7.1

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

Table 7.1 – Parameters for Figure 3 for fault ride through capability of synchronous power generating modules.

# GB Mode A Requirements

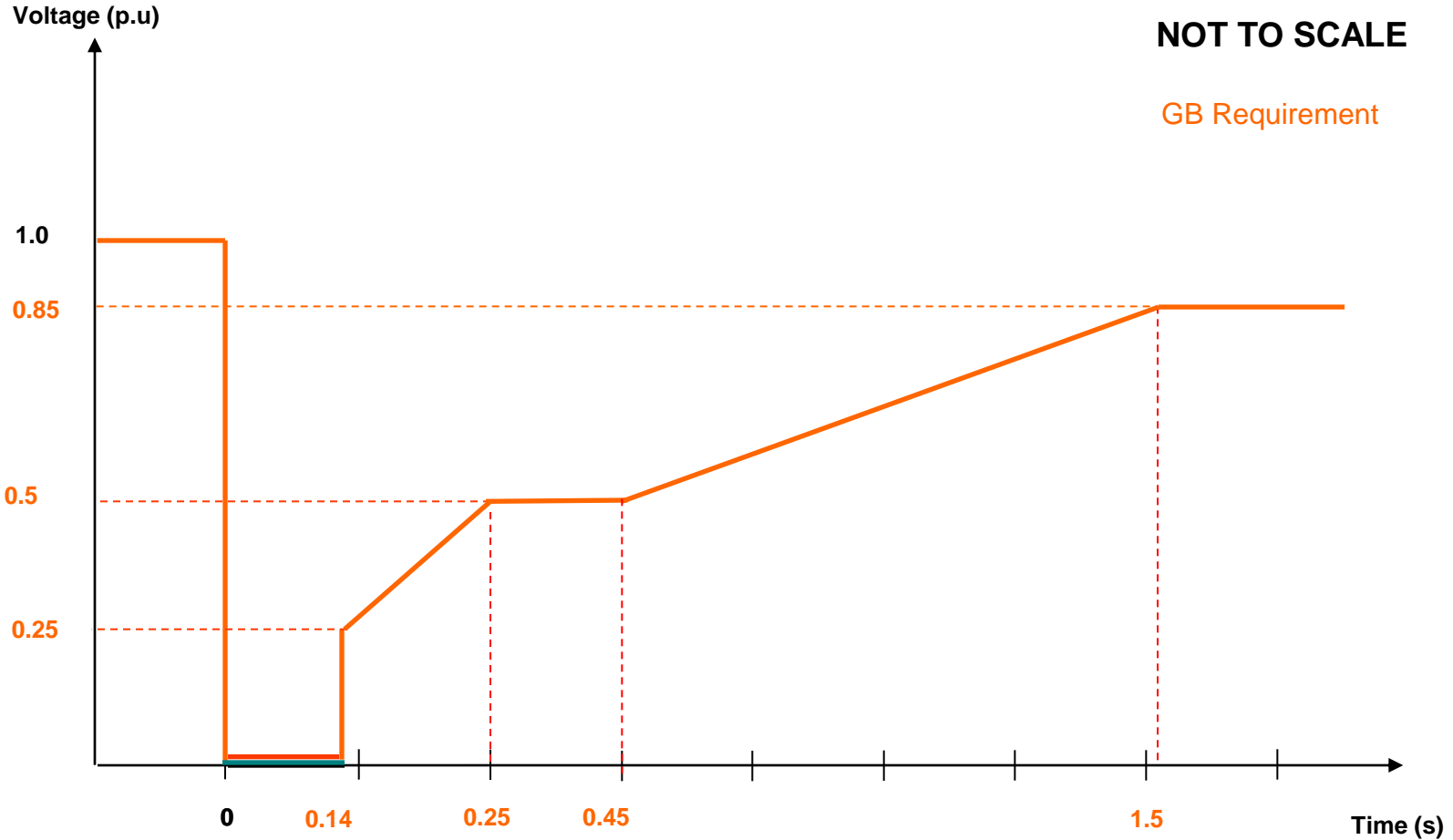
## Assessment Criteria

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- National Grid will specify the Maximum and Minimum fault level (both pre and post fault) at the connection point in the Bilateral Agreement
- Study work should demonstrate compliance with the Generating Unit at full output at maximum leading and maximum lagging power factor and under maximum and minimum fault levels.

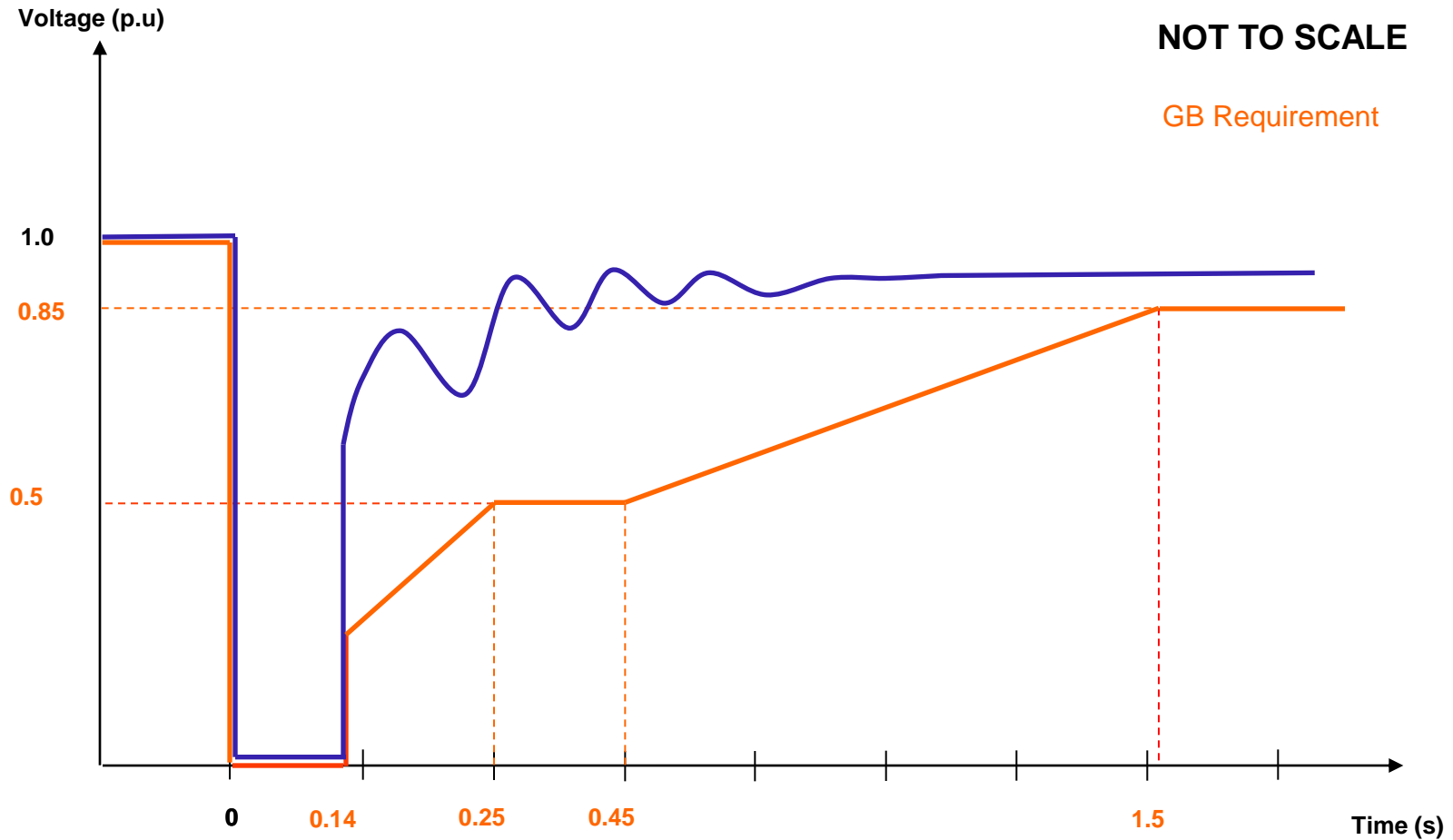


# GB Mode A Requirements Voltage Against Time Curve



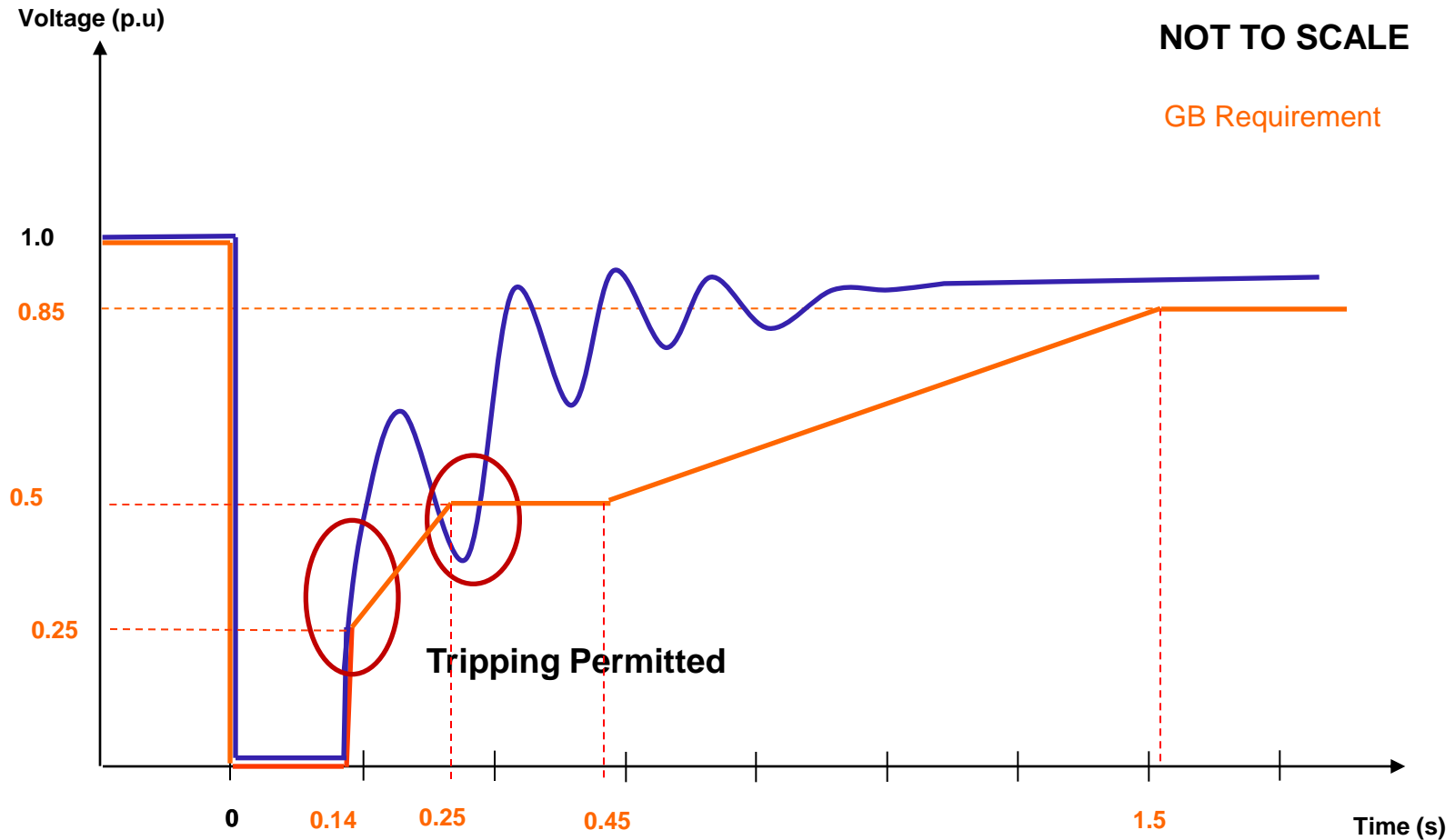
# GB Mode A Requirements

## Voltage Against Time Curve – Generator to remain Connected



# GB Mode A Requirements

## Voltage Against Time Curve – Generator Permitted to Trip

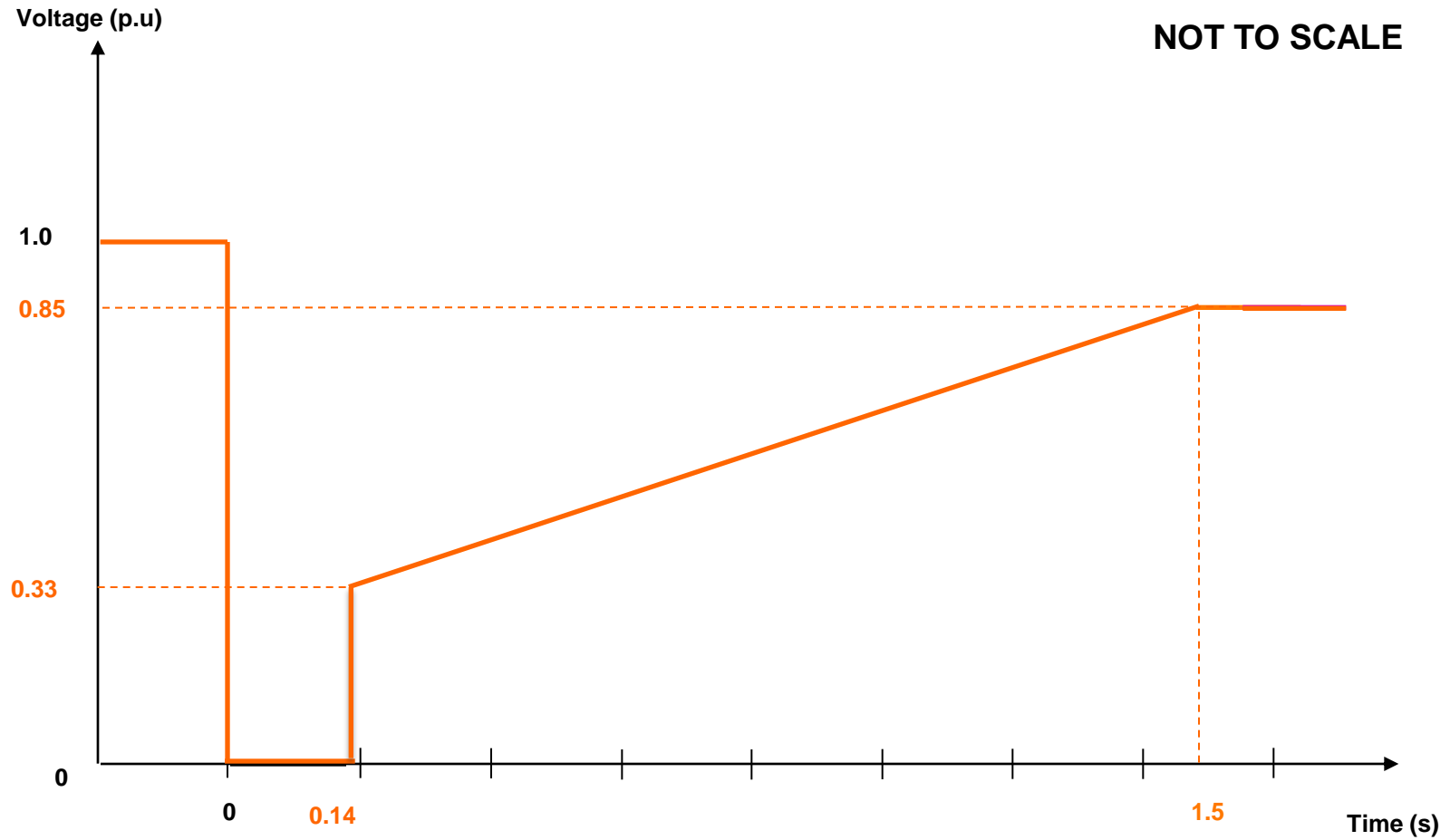


# Mode B Faults

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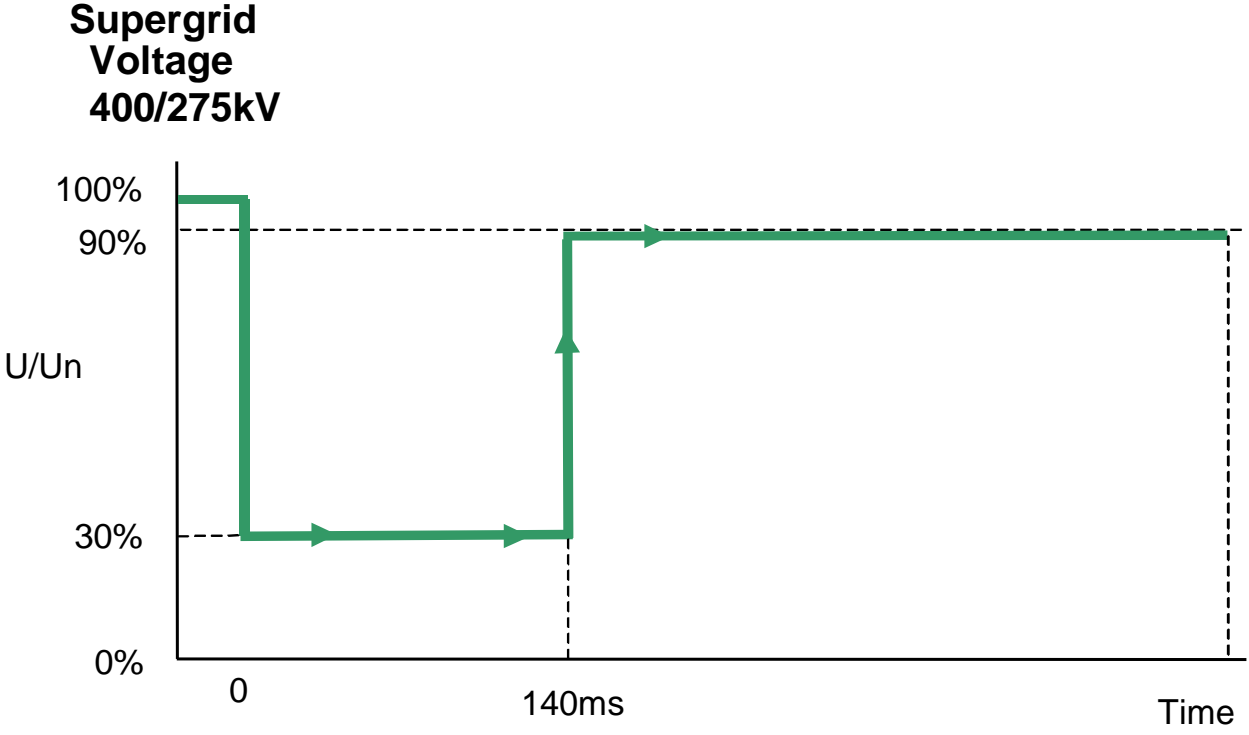
- As per current GB fault ride through requirements defined in CC.6.3.15.1(b) with a revised voltage duration curve – see next slide.
- Would apply specifically to Synchronous Generating Units only
- The existing Figure 5 would be changed to reflect the latest study work completed as part of this working group.
- Note – this requirement would remain as a voltage duration curve – (ie each point on the profile represents a voltage level and an associated time duration).

# Mode B Voltage Duration Curve



# Voltage dips in excess of 140ms

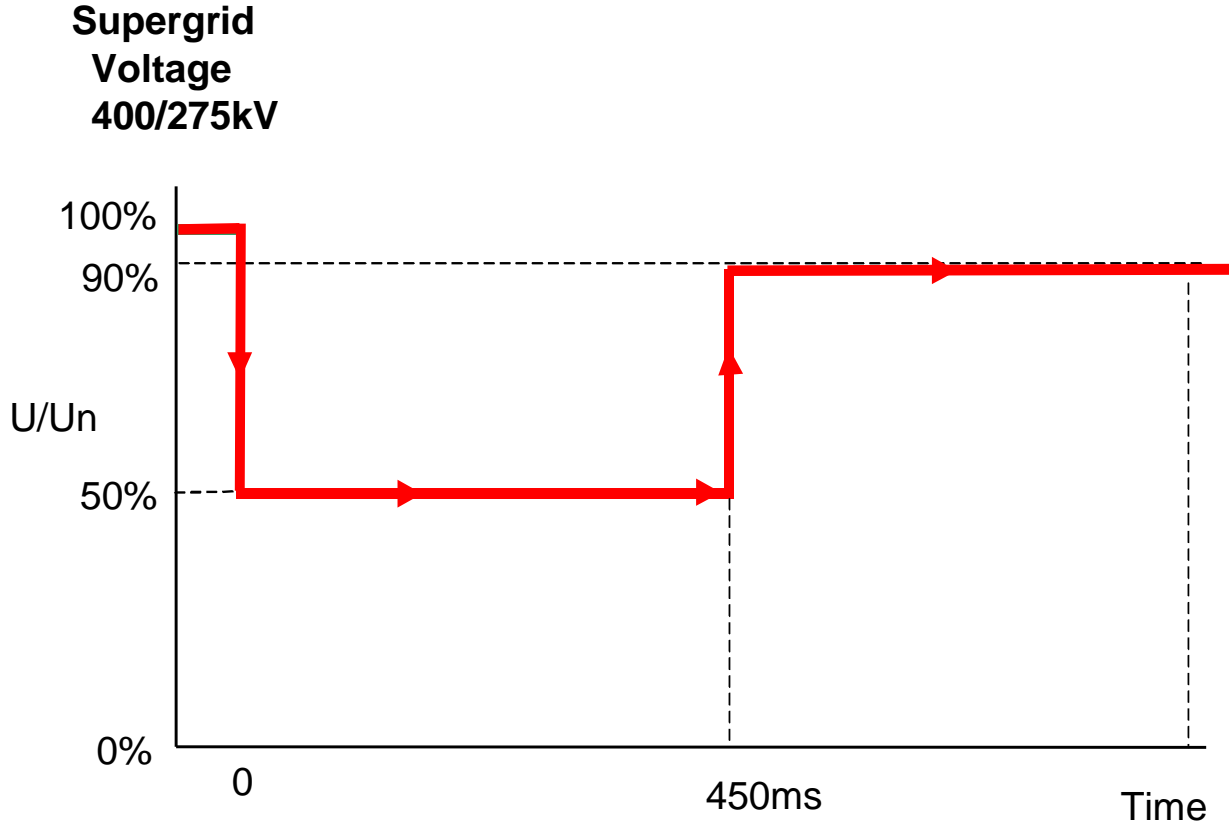
## 30% Retained Voltage (CC – Appendix 4A)



30% retained voltage, 140ms duration

# Voltage dips in excess of 140ms

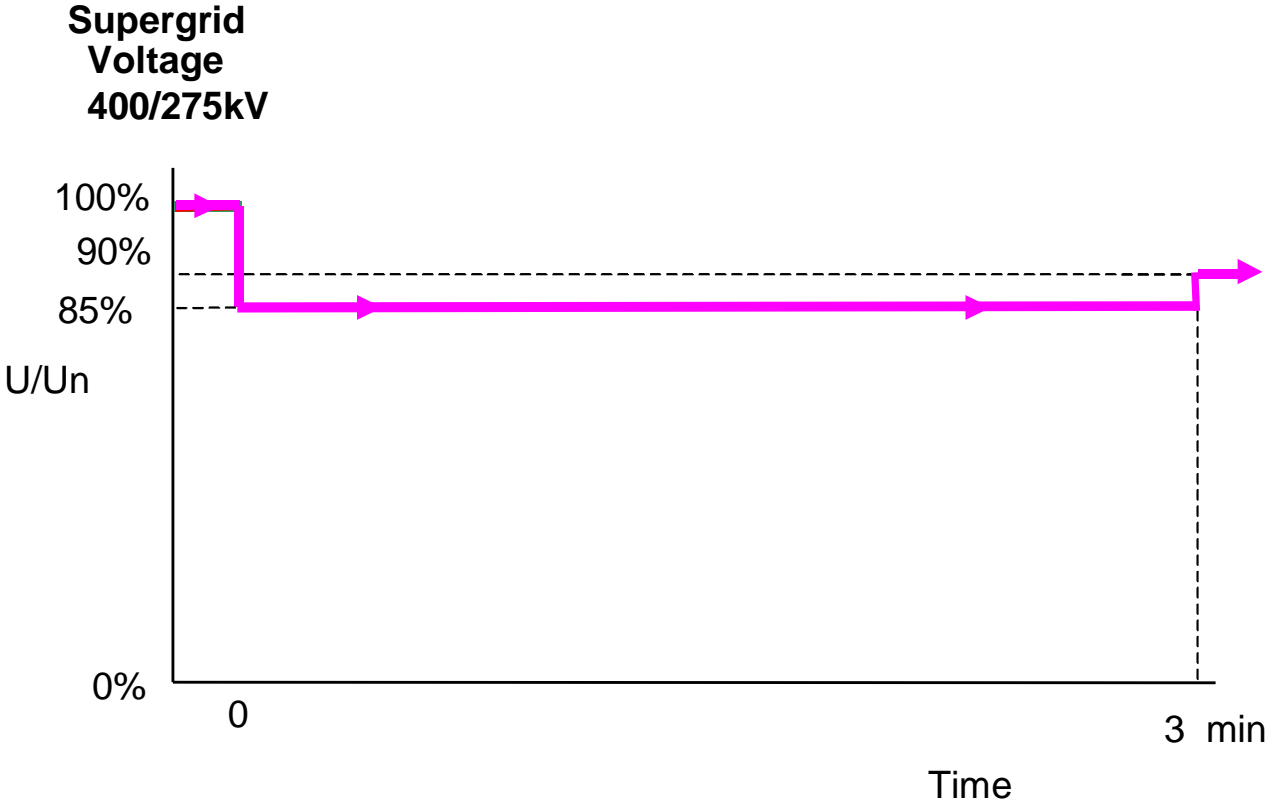
## 50% Retained Voltage (CC – Appendix 4A)



50% retained voltage, 450ms duration

# Voltage dips in excess of 140ms

85% Retained Voltage (CC – Appendix 4A)



85% retained voltage, 3 minutes duration



# Next Steps

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- Work Group Members to consider the fault ride through proposals for directly connected Synchronous Generators.
- Develop Grid Code Legal Text
- Consider changes on other documents – eg Guidance Notes for Synchronous Generators?
- Further work