Fault Ride Through Implementation of RfG and Scope of Study Work

nationalgrid

Antony Johnson
National Grid – TNS Technical Policy

Overview

- High level Fault Ride Through Requirements
- Review of the current ENTSO-E RfG Fault Ride Through Requirements for Type D Power Generating Modules
- Implementation
- Selection of Voltage against time curves
- Scope of Study work
- Summary
- References
- Discussion

nationalgrid

High Level Fault Ride Through Requirements

- Required to:-
  - Ensure Generation remains connected and stable during main protection operating times for Transmission System faults.
  - Prevent voltage collapse during Transmission System Faults
  - Ensure appropriate recovery of active power following fault clearance to prevent frequency collapse
  - Ensure sufficient generation robustness and network resilience to transmission faults cleared in backup protection operating times.
  - Ensure requirements are consistent with the credible operating and design criteria covered in the SQSS
  - Be achievable by manufacturers

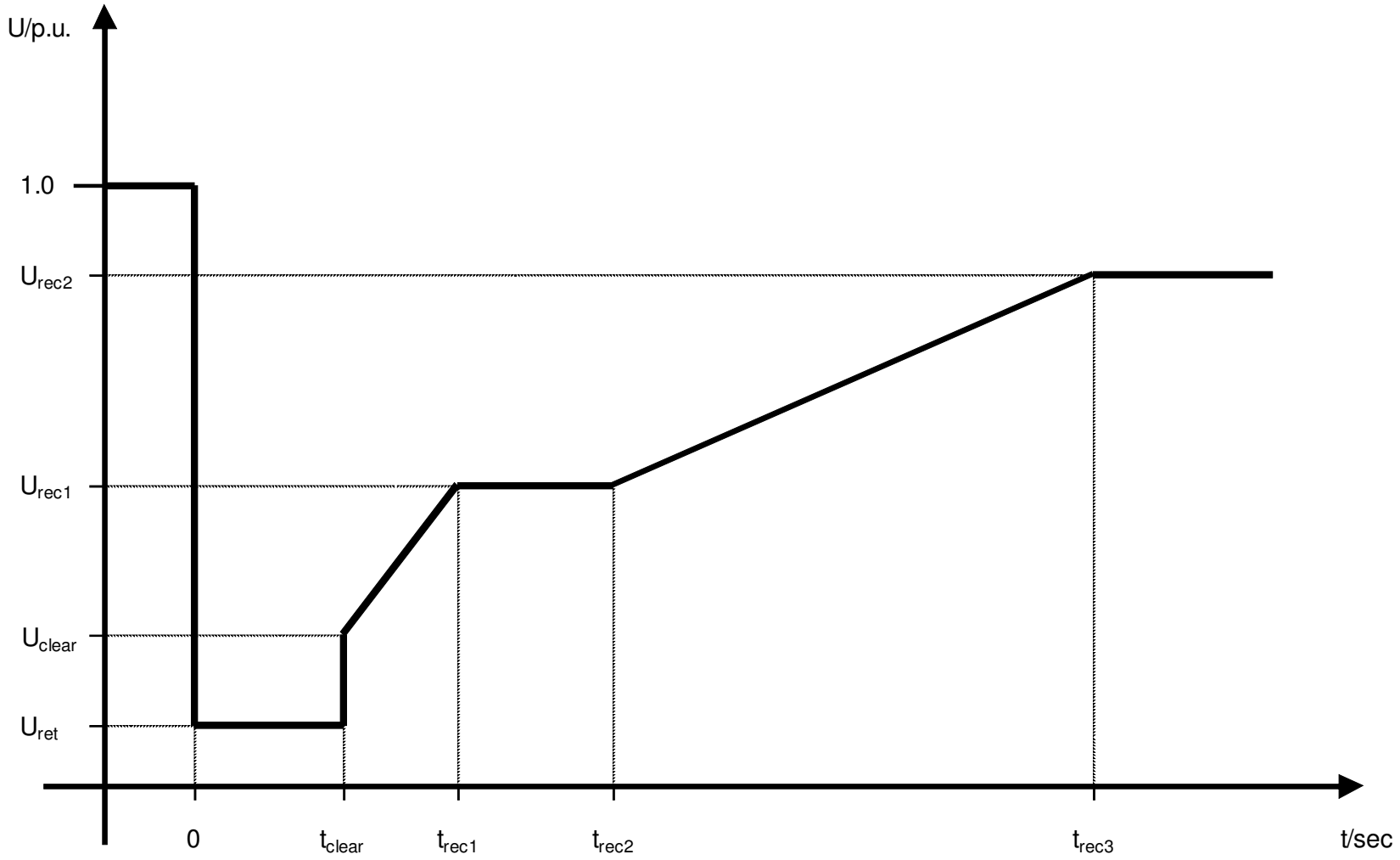
* See Section 5 Appendix 2 of Grid Code Consultation H/04

ENTSO-E Requirements for Large Directly Connected Synchronous Generating Units

nationalgrid

- Article 9 (3), Article 11 (3) and Article 12 (3)(a)
  - 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 Table 7.1.

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



Interpretation of Voltage against time profile

nationalgrid

- 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 7.1 – Type D Synchronous Power Generating Modules

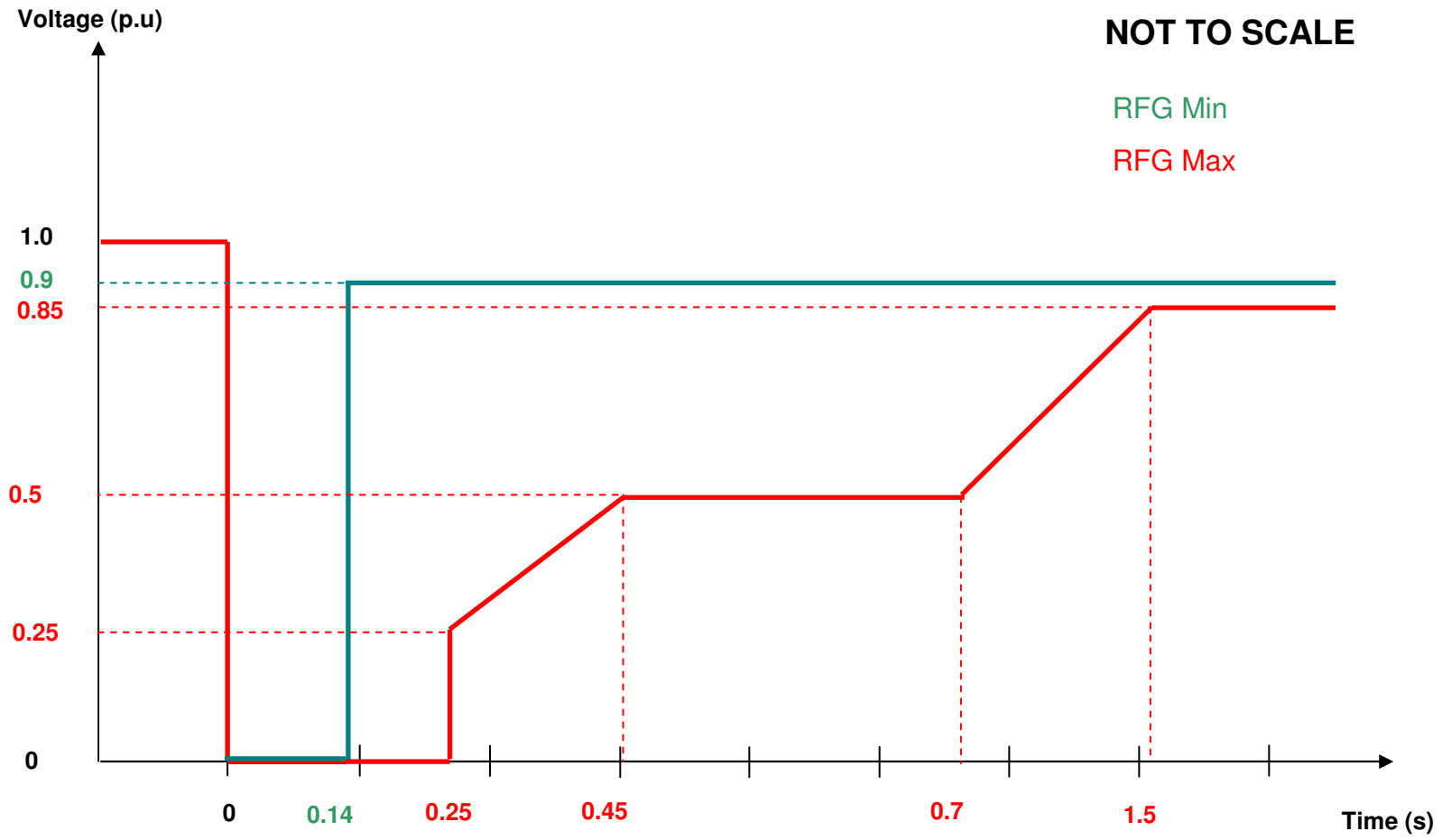
nationalgrid

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

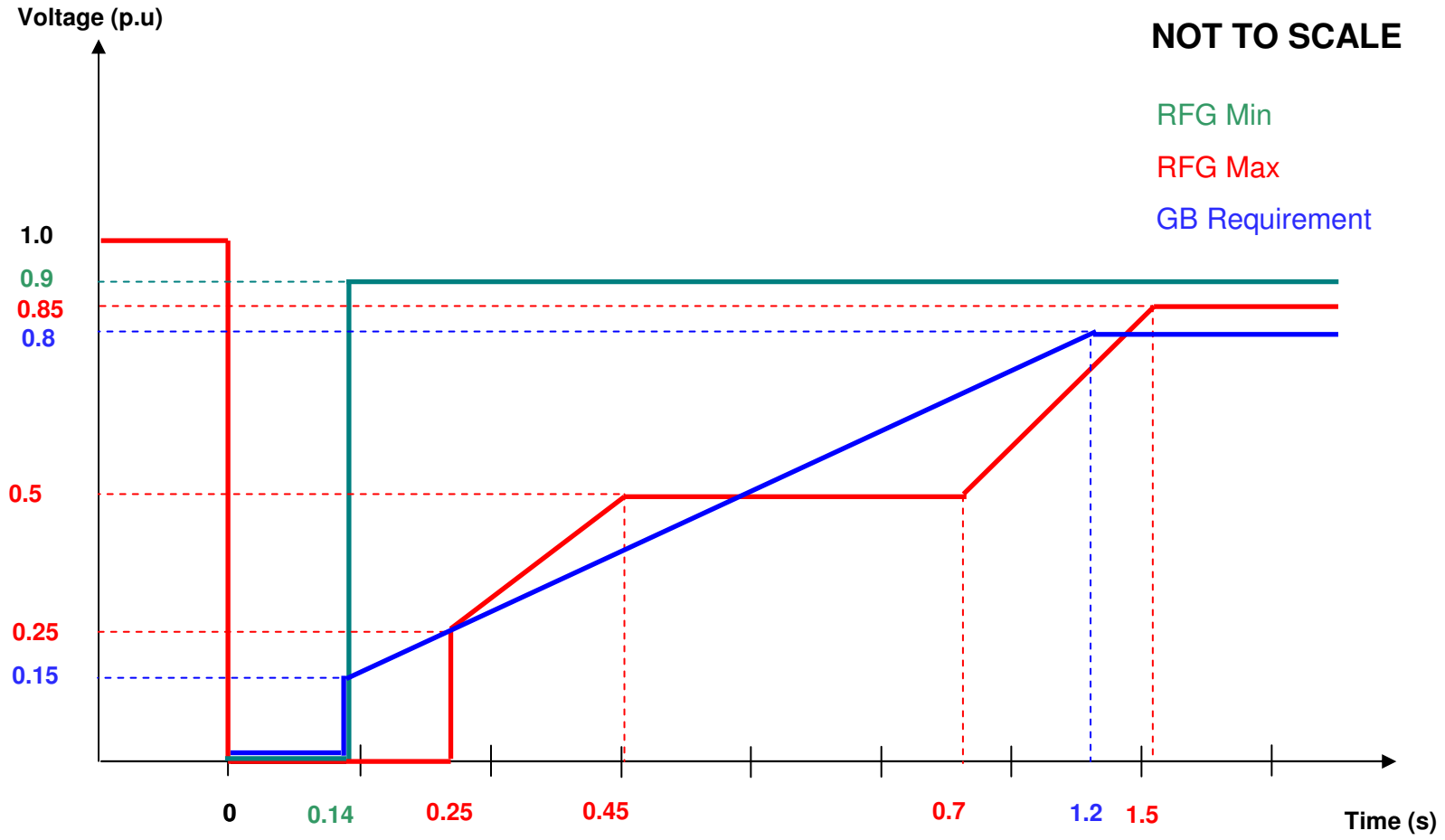
Table 7.1 – Fault Ride Through Capability of Synchronous Power Generating Modules

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



Additional Requirements (1)

- 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

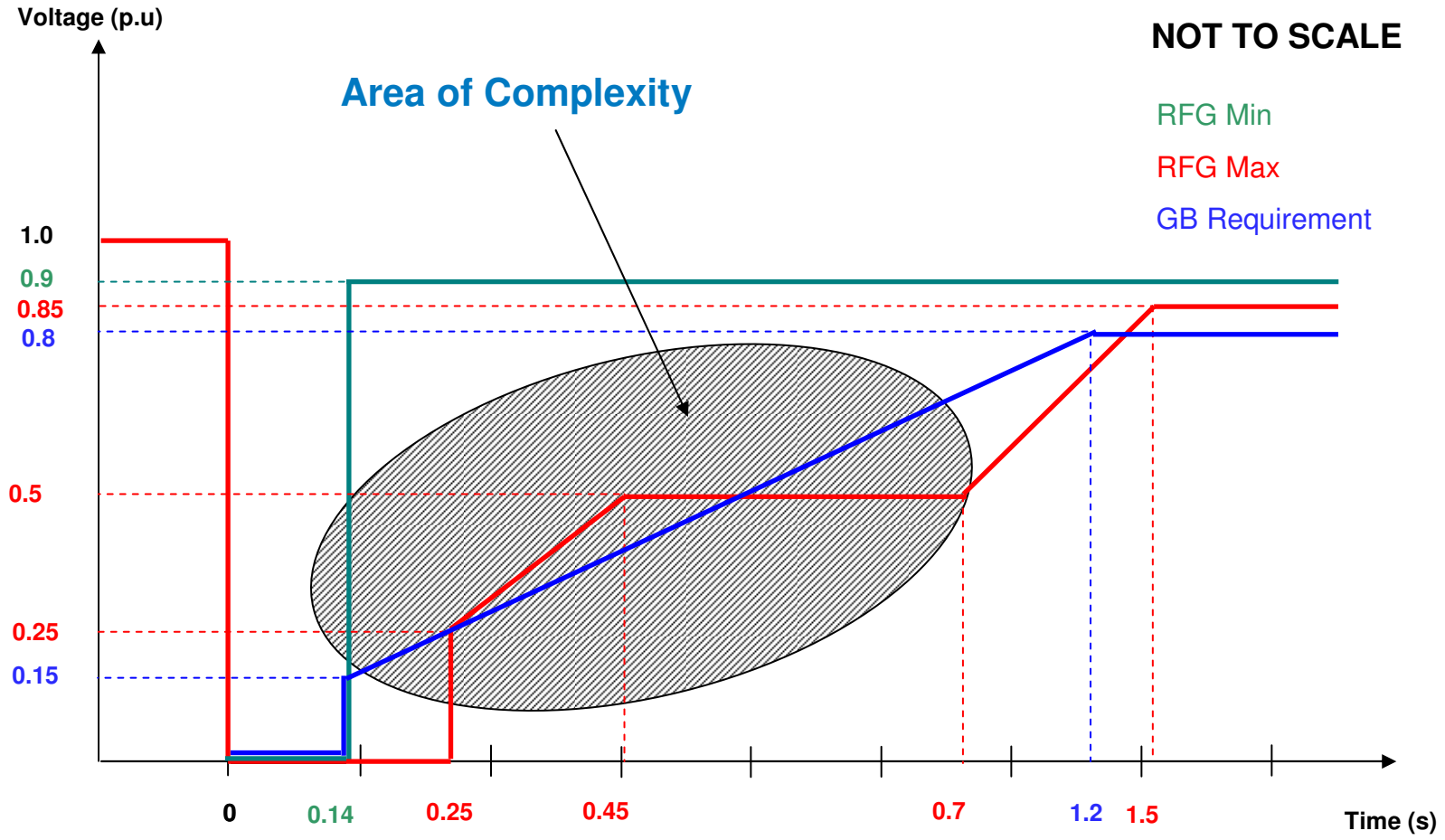
Additional Requirements (2)

- 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) (3) regarding.
  - 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.
  - The Fault Ride Through capabilities in the case of asymmetrical faults shall be defined by each TSO while respecting the provisions of Article 4(3)
  - The TSO shall define (subject to Article 4(3)) the magnitude and time for Active Power recovery of the Generating Unit

Implementation

- For the purposes of this section of work – consider the requirements only in respect of Large directly connection Synchronous Plant
- Determine Voltage against curve within range permitted by ENTSO-E Drafting – study work dependant
- Active Power Recovery as per current GB requirements There should be no reason to change this unless there is good reason not to do so.
- Asymmetrical faults – as per current GB requirement – applicable only for faults cleared in main protection operating times?
- Pre and post fault conditions – specified in the Bilateral Agreement
- Additional guidance – Question 24 of the Frequently asked Questions document and Implementation Guideline – sections 3.9 and 3.10
- Reactive Power injection for Synchronous Generators not specified in the ENTSO-E Requirements for Generators and would remain at National level.

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



Determination of Voltage against time curve and other characteristics

nationalgrid

- For Directly Connected Synchronous Generation the area of complexity is in the zone shown in slide 13.
- System studies required to determine voltage against time curve.
- The voltage against time curve should cater for the list of events defined in the SQSS and be representative of worst case but credible conditions based on the minimum needs of the Transmission System.
- Other factors such as active power recovery and reactive current injection to remain unchanged (at this stage) from the current GB Grid Code provisions (ie Active Power recovery within 0.5 seconds of fault clearance for faults lasting no more than 140ms and 1 second for faults lasting in excess of 140ms.
- There are still some potential issues over the length of the voltage depression for longer duration faults eg 85% volts for 1.5 seconds where as GB is 85% for 3 minutes
- Need to understand the impact on station auxiliaries .

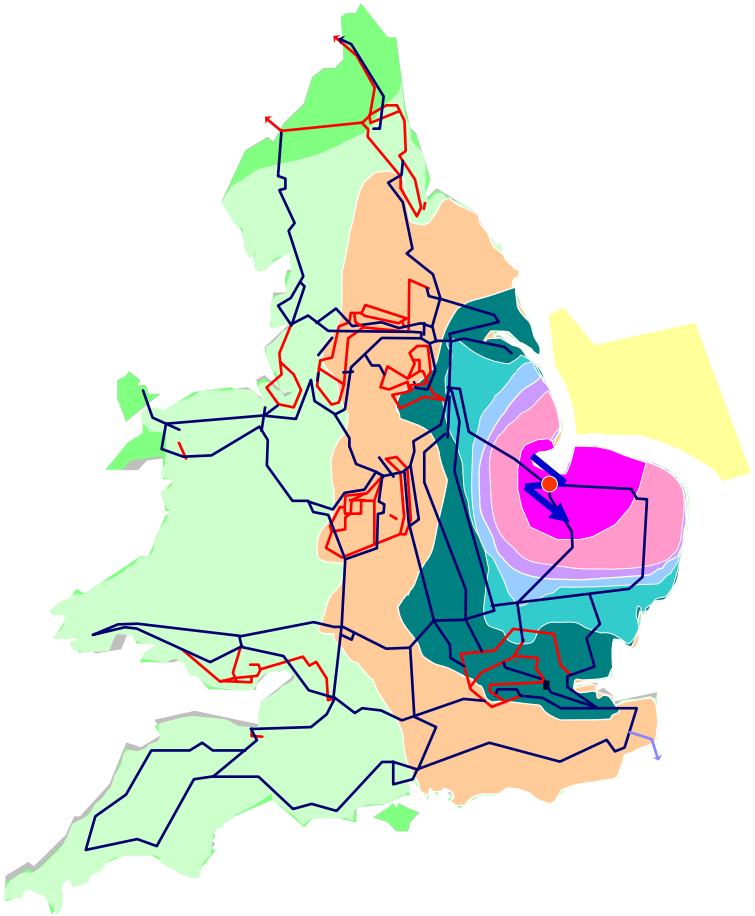
Study Cases

nationalgrid

- The worst case voltage recovery will be at a remote generation site under minimum demand conditions with a potentially high volume of wind generation.
- A few minor sensitivities will need to be run to check the impact of a fault adjacent to high concentrations of generation and that the active power recovery assumptions are still appropriate
- It is proposed to use the full England and Wales multi machine study in Digsilent Power Factory for this purpose.

Fault Ride Through Capability
Voltage Dip Propagation - The Wash

nationalgrid



3 phase fault a Walpole 400 kV substation

- Fault Location 0 % Volts
- 0 - 15 % Volts
- 15 - 30 % Volts
- 30 - 40 % Volts
- 40 - 50 % Volts
- 50 - 60 % Volts
- 60 - 70 % Volts
- 70 - 80 % Volts
- 80 - 90 % Volts

Summary

- Determine the voltage against time curve for a directly connected synchronous generator through system studies to be consistent with the ENTSO-E requirements.
- Notwithstanding the developments of the voltage against time curve, adopt the same parameters (eg Active Power Recovery / Reactive current injection) as currently in GB unless there is good reason not to do so.
- Ensure that there is no impact on station auxiliaries as a result of the proposed new voltage against time curve.
- Time scales – Next meeting circa April 2014 – purpose to summarise the current progress of the modelling work and any sensitivities
- Develop a high level view of the legal text in lieu of the final voltage against time curve – ie future text would need to segregate the requirements of synchronous and asynchronous plant

References

- ENTSO-E Requirements for Generators
  - https://www.entsoe.eu/major-projects/network-code-development/requirements-for-generators/
- ENTSO-E Requirements for Generators – Frequently asked Questions document
  - https://www.entsoe.eu/major-projects/network-code-development/requirements-for-generators/
- ENTSO-E Implementation Guidelines
  - https://www.entsoe.eu/major-projects/network-code-development/requirements-for-generators/
- GB Grid Code Consultation H/04
  - http://www.nationalgrid.com/NR/rdonlyres/3DD7D7C7-6460-4257-BF99-E168D794C13E/7027/aacp_h04.pdf
- GB Security and Quality of Supply Standards
  - http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/SQSS/The-SQSS/

Discussion