
Monitoring report on connection network codes implementation

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Abstract

An ENTSO-E obligation of monitoring the implementation of the European Connection Network Codes has been established in each connection code (NC RfG, NC DC and NC HVDC) in accordance with Article 8(8) of Regulation (EC) No 714/2009. According to the relevant articles of these Regulations (i.e. the connection codes) the monitoring shall cover, in particular, an identification of any divergences in the national implementation and assessment of whether the choice of values and ranges in the requirements applicable to the facilities under these Regulations continues to be valid. For this purpose, ENTSO-E has been collecting the proposals for the national specifications of relevant non-exhaustive requirements since the beginning of the implementation process. After these national implementations were completed, these have been submitted for approval to the designated entity of each Member State (to the NRA by default). The ENTSO-E implementation monitoring report analyses the non-exhaustive requirements that are mandatory for system users to which the connection codes are applicable. This report provides an overview on the national implementation of NC RfG, NC DC and NC HVDC and provides identification of any divergences between the implementation of Network Codes and Network Codes themselves.

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1 Objective and scope

Pursuant to Commission Regulation (EU) No 2016/631 establishing a network code on requirements for grid connection of generators (NC RfG), Commission Regulation (EU) 2016/1388 establishing a network code on demand connection (NC DC) and Commission Regulation (EU) 2016/1447 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (NC HVDC) – later on referred to as the Connection Network Codes (CNCs) – ENTSO-E is obliged to monitor the implementation of CNCs in accordance with Article 8(8) of Regulation (EC) No 714/2009.

The objective of this monitoring report is to provide an overview of CNCs implementation, in particular by identification of any divergences in the national implementation of these CNCs and assessment of whether the choice of values and ranges in the requirements applicable to the facilities under these CNCs continues to be valid. The report represents the national implementations. It does not address any derogations that may have been granted in Member States, nor does outline

Implementation of the Connection Network Codes (CNCs) is currently in progress in some EU Member States. The national implementations of CNCs have been submitted to the relevant national authority for approval by most countries but have not been approved yet in all Member States. Therefore, the assessment of whether the choice of values and ranges in the requirements applicable to power-generating modules, transmission-connected demand facilities, transmission-connected distribution facilities, distribution systems, demand units, HVDC systems and DC-connected power park modules under these EU Regulations continues to be valid has been suspended until approval of the national implementations in all Member States. After that, this assessment can be performed considering the final and valid national specifications of the non-exhaustive requirements.

This report is segmented in 6 chapters. Chapter 1 provides the general objective and scope of this document. Chapter 2 provides information about the input data used for this monitoring report. Chapters 3, 4 and 5 provides an overview of the CNC implementation of these non-exhaustive requirements that have been identified as relevant for this first edition of the monitoring report. Chapter 6 provides a summary of the implementation data and points out national implementations and non-exhaustive requirements that are not fully aligned with the relevant CNC.

2 Input data for the monitoring report

ENTSO-E has tracked the national CNC implementations since the beginning of the implementation process. The national proposals are collected in a monitoring data set as follows:

- For each CNC the national specifications of all non-exhaustive requirements are recorded separately.
- With regards to NC RfG, the Type A-D categorization of power generating modules (MW thresholds) is recorded separately.
- For each requirement, the progress of the implementation and approval has been tracked.

The above mentioned input provided during the implementation process is analyzed in this monitoring report. The quality of data provision for the purpose of implementation monitoring varies between Member States. Therefore, the reported analysis focuses on selected requirements of general application that can be compared between Member States. The analysis is based on confirmation of the national implementation data by TSO experts from each Member State.

Definitions of terms:

DK-1	National specification of Denmark non-exhaustive requirements for CE SA
DK-2	National specification of Denmark non-exhaustive requirements for Nordic SA
DF	Demand facility
DS	Distribution system
FRT	Fault ride through
NC DC	Network code on Demand connection
NC HVDC	Network code on HVDC systems and DC
NC RfG	Network code on Requirements for generators
PPM	Power park module
SA	Synchronous area
SPGM	Synchronous power generating module
TC-CDS	transmission-connected closed distribution system
TC-DF	transmission-connected demand facility
TC-DS	transmission-connected distribution system
TS	Transmission system

3 NC RfG implementation

3.1 MW threshold values

- Reference: Article 5(2)
- Object(s) of national implementation:
 - Definition of MW thresholds to categorize power-generating modules into 4 categories (A, B C and D).

Country	A/B threshold	B/C threshold	C/D threshold
AT	250 kW	35 MW	50 MW
BE	1 MW	25 MW	75 MW*
BG	1 MW	5 MW	20 MW
CZ	100 kW	30 MW	75 MW
DE	135 kW	36 MW	45 MW
DK	125 kW	3 MW	25 MW
EE	0.5 MW	5 MW	15 MW
ES	100 kW	5 MW	50 MW
FI	1 MW	10 MW	30 MW
FR	1 MW	18 MW	75 MW**
GB	1 MW	10 MW	50 MW
GR	1 MW	20 MW	75 MW
HR	500 kW	5 MW	10 MW
HU	200 kW	5 MW	25 MW
IE&NI	100kW	5MW	10MW
IT	11,08 kW	6 MW	10MW
LT	250 kW	5 MW	15 MW
LU	135 kW	36 MW	45 MW
LV	0,5 MW	5 MW	15 MW
NL	1 MW	50 MW	60 MW
PL	200kW	10MW	75MW
PT	1 MW	10 MW	45 MW
RO	1 MW	5 MW	20 MW
SE	1,5 MW	10 MW	30 MW
SI	10 kW	5 MW	20 MW
SK	100 kW	5 MW	20 MW

*BE: In BE, the TSO has proposed a derogation for power generating modules of Type D with a maximum capacity of less than 25MW and grid connection at a voltage level above 110kV. Requirements applicable to Type A or B power generating modules shall apply to these power generating modules as well, as the case may be. The request for derogations has been submitted for regulatory approval.

**FR: national legislation requires power-generating modules above a defined installed capacity to be connected at the voltage level of 110 kV

3.2 Rate-of-change-of-frequency (RoCoF) withstand capability

- Reference: Article 13(1)(b)
- Object(s) of national implementation:

- Definition of a RoCoF threshold to be withstood by power-generating modules without adverse impact on operation.

RoCoF	SA: Continental Europe	SA: Nordic	SA: GB	SA: IE&NI	SA: Baltic
±0,5 Hz/sec	NL				
±1 Hz/sec	DE*		GB*	IE&NI	
±1,5 Hz/sec	DE*, RO*				
±2 Hz/sec	AT, BE*, BG, CZ, DE, DK-1, ES, GR, HR, LU, PL, PT, RO*, SI*, SK	DK-2, SE, FI		IE&NI*	
±2,5 Hz/sec	HU, IT				EE, LT, LV
Site-specific	FR				

*DE - 2Hz/s, 1.5Hz/s, 1Hz/s measured over 500ms, 1000ms, 2000ms respectively

*BE,- RoCoF requirement are specified in the format of a “frequency ride through” as recommended in the IGD “[Rate of Change of Frequency \(RoCoF\) withstand capability](#)”

*IE&NI – 2Hz/s for PGMs type A

*GB Measured over a rolling 500ms time period.

*SI - 500 ms window based on the moving average with the accuracy of the RoCoF measurement of at least ±10 mHz/s

*DK-1 – based on two moving average over 200 ms window.

*RO - RoCoF - 2Hz/s for 500ms, 1.5Hz/s for 1000 ms, 1.25Hz/s for 2000ms respectively.

In FR the RoCoF withstand capability has been understood as a site-specific requirement, therefore no nationally uniform value has been defined. FR is waiting for more studies at synchronous area level to define the RoCoF value.

3.3 Frequency ranges

- Reference: Article 13(1)(a)
- Object(s) of national implementation:
 - Definition of a minimum time of operation of power-generating modules for defined frequency ranges

A. Synchronous Area: Continental Europe

	Frequency Range 47.5Hz - 48.5Hz	Frequency Range 48.5Hz - 49.0Hz
30 min	BE, BG, CZ, DE, DK-1, ES, FR, GR, HR, HU, LU, NL, PL, RO, SI, SK, PT	BE, BG, DE, DK-1, FR, GR, HR, LU, NL, PL, RO, SI, SK
60 min	AT	HU
90 min	none	AT, CZ
unlimited	IT (PPMs and Type D SPGMs)	ES, IT (PPMs and Type D SPGMs), PT

All Member States of the Continental Europe synchronous area have specified that all power-generating modules shall be able to withstand frequencies outside the frequency range from 49 Hz to 51 Hz, for which operation unlimited in time is exhaustively required, for at least 30 minutes.

Furthermore, peninsular areas (ES, IT for PPMs and Type D SPGMs, PT) and several countries in Continental Europe have specified longer minimum times for operation in case of low frequencies.

B. Other synchronous areas:

Frequency Range	48.5Hz - 49.0Hz	47.5Hz - 49.0Hz
30 min	DK-2, SE, FI	LV, LT, EE
90 min	GB, IE&NI	

The minimum time of operation for the frequency range 48,5 Hz – 49 Hz has been specified in the Nordic synchronous area unanimously as 30 minutes. The minimum times of operation for other frequency ranges are exhaustively determined by NC RfG.

The minimum time of operation for the frequency range 48,5 Hz – 49 Hz has been specified in the Great Britain and Northern Ireland & Ireland synchronous areas as 90 minutes. The minimum times of operation for other frequency ranges are exhaustively determined by NC RfG.

The minimum time of operation for the under-frequency ranges from 47,5 Hz to 49 Hz has been specified in the Baltic synchronous area unanimously as 30 minutes.

3.4 Limited frequency sensitive mode - under-frequency (LFSM-U) and over-frequency (LFSM-O)

- Reference: Article 13(2) and article 15.2(c)
- Object(s) of national implementation:
 - Definition of LFSM frequency thresholds and droops for over-frequency and under-frequency schemes for capability to support the recovery of frequency to the normal operation range by power-generating modules

A. Synchronous Area: Continental Europe

LFSM-O		
Default freq. threshold	50,2 Hz	AT, BE*, BG (PGM type D), CZ, DE, DK-1, ES, FR, GR, HR, HU, IT, LU, NL, PL, PT, RO, SI, SK
	50,3 Hz	BG (PGM type A, B, C)
Selectable freq. threshold	50,2-50,5 Hz	AT, BG, CZ, DE, ES, FR, GR, HR, HU, IT, LU, NL, PL, RO, SI, SK, DK-1
Default droop	2,6 %	IT (PPM)
	4 %	IT (hydro)
	4,5 %	BG
	5 %	AT, BE, CZ, DE, DK-1, ES, FR, GR, HR, HU, IT (other SPGM), LU, NL, PL, RO, SI, SK
Droop range	2-12 %	AT, BE, BG, DE, GR, HR, HU, IT, LU, PL, RO, SI, DK-1
	2-10 %	BG (PGM type D)
	3-12 %	FR
	4-10 %	CZ
	4-6 %	PT
	4-12 %	NL

*BE: 50,2 Hz is to be considered as a fixed threshold, because no range beyond this threshold has been

defined

LFSM-U		
Default freq. threshold	49,8 Hz	AT, BE*, CZ, DE, DK-1, ES, FR, GR, HR, HU, IT, LU, NL, PL, PT, RO, SI, SK
	49,7 Hz	BG
Selectable freq. threshold	49,8-49,5 Hz	AT, BG, CZ, DE, ES, FR, GR, HR, HU, IT, LU, NL, PL, RO, SI, SK
Default droop	2,6 %	IT (PPM)
	4 %	IT (hydro)
	5 %	AT, BE, CZ, DE, DK-1, ES, FR, GR, HR, IT (other SPGM), LU, NL, PL, RO, SI, SK
Droop range	2-12 %	AT, BE, DE, GR, HR, HU, IT, LU, PL, RO, SI, DK-1
	4-10 %	CZ
	3-12 %	FR
	4-6 %	PT
	4-12 %	NL

*BE: 49,8 Hz is to be considered as a fixed threshold, because no range beyond this threshold has been defined

B. Synchronous Area: Nordic

	Default frequency threshold	Default droop	Droop range
LFSM-O	50,5 Hz	4 %	2-12 %
	FI, SE, DK-2	DK-2	FI, SE, DK-2
LFSM-U	49,5 Hz	4%	2-12 %
	FI, DK-2, SE	DK-2	FI, SE, DK-2

C. Synchronous Area: Great Britain

	Default frequency threshold	Selectable frequency threshold	Default droop
LFSM-O	50,4 Hz	50,2-50,5 Hz	10 %
LFSM-U	49,5 Hz	49,8-49,5 Hz	10 %

D. Synchronous Area: Northern Ireland & Ireland

	Default frequency threshold	Selectable frequency threshold	Default droop	Droop range
LFSM-O	50,2 Hz	50,2-50,5 Hz	4 %	2-12 %
LFSM-U	49,5 Hz		4 %	

E. Synchronous Area: Baltic

	Default frequency threshold	Default droop	Droop range
LFSM-O	50,2 Hz	5 %	2-12 %
	EE, LT, LV	EE, LT, LV	EE, LT, LV
LFSM-U	49,8 Hz	5 %	2-12 %
	EE, LT, LV	EE, LT, LV	EE, LT

3.5 Admissible active power reduction from maximum output with falling frequency

- Reference: Article 13(4) and 13(5)
- Object(s) of national implementation:
 - Definition of a frequency threshold and a level of active power reduction where an admissible active power reduction is allowed at low frequencies

A. Synchronous Area: Continental Europe

		SPGM	PPM
Steady-state admissible reduction of active power	≤ 0 % P/Hz		FR
	≤ 2 % P/Hz	CZ, IT*, SI*, SK, PT	AT, BE, CZ, HR, PL*, RO*, SI*, SK, PT
	≤ 4 % P/Hz	PL*	
	≤ 6 % P/Hz	DK-1	DK-1
	$\leq 6,67$ % P/Hz	HR	
	≤ 10 % P/Hz	AT, BE* DE, ES, FR*, GR, LU, NL, PL, RO*	DE, ES, LU, NL
Steady-state frequency threshold	49 Hz	BG, CZ, DK-1, HR, IT*, PL*, PT, SK	AT, BE, BG, CZ, DK-1, HR, PL*, PT, RO*, SI*, SK
	49,5 Hz	AT, BE*, DE, ES, FR*, GR, IT* (gas turbines), LU, NL, PL*, RO*, SI*	DE, ES, LU, NL
Site-specific		HU	HU

*BE FR, RO, SI have specified transient characteristics for admissible active power reduction according to the IGD “[Maximum Admissible active power reduction at low frequencies](#)”.

BG has specified the range of admissible active power reduction from maximum output with falling frequency (2 – 15 % per Hz with default setting 9%/Hz) wider than defined by NC RfG.

*PL has specified steady-state admissible reduction of active power parameter as 2%/Hz for PPMs, 4%/Hz for CCGT (Combined Cycle Gas Turbine) and GT (Gas Turbine) and 10%/Hz for other SPGMs.

During the public consultation in France, the stakeholders have stated that PPM are able to maintain the active power with falling frequency, therefore no admissible active power reduction has been defined in the national implementation.

In previous versions of the Italian Grid Code and technical standards, the admissible active power reduction was not foreseen for PPMs, which was maintained and not contested by stakeholders during the public

consultation. Consequently, the active power reduction is allowed only in case technical proven technical restrictions.

B. Synchronous Area: Nordic

		SPGM	PPM
Admissible reduction of active power	3 % P/Hz	SE	SE
	6 % P/Hz	DK-2	DK-2
	10 % P/Hz	FI	FI
Frequency threshold	49 Hz	DK-2, FI, SE	DK-2, FI, SE

C. Synchronous Area: Great Britain

	PGM
Admissible reduction of active power	2 % P/Hz
Frequency threshold	49,5 Hz

D. Synchronous Area: Northern Ireland & Ireland

	PGM
Admissible reduction of active power	2 % P/Hz
Frequency threshold	49,5 Hz

IE&NI has specified transient characteristic of admissible active power reduction according to IGD

E. Synchronous Area: Baltic

		SPGM	PPM
Admissible reduction of active power	2 % P/Hz	EE, LT	EE, LT
	10 % P/Hz	LV	LV
Frequency threshold	49 Hz	EE, LT, LV	EE, LT, LV

3.6 Frequency sensitive mode

- Reference: Article 15(2)d
- Object(s) of national implementation:
 - Definition of frequency sensitive mode parameters (frequency insensitivity, frequency response dead band, droop and time parameters)

A. Synchronous Area: Continental Europe

Frequency response insensitivity	±10 mHz	AT*, BE, BG, CZ, DE, DK-1, ES, FR, GR, HR, HU, IT, LU, NL, PL, PT, RO, SI, SK
Range of freq, response dead band	20-200 mHz	HR
	0 – ±200 mHz	AT*, CZ, DE, DK-1, FR, LU, NL, RO, SK

	0 – ±500 mHz	BE, NL, PL, SI, IT, GR
Default freq. response dead band	20 mHz	BG
	10 mHz	PL, GR
	0 mHz	BE, FR, RO, PT, ES, SI, DK-1
Selectable Droop	4-12 %	NL
	3-12 %	FR
	2-12 %	AT*, BE, BG, CZ, DE, DK-1, ES, GR, HR, HU, IT, LU, PL, PT, RO, SI, SK
Max. admissible full activation time	≤ 12 s	ES
	≤ 30 s	AT*, BE, BG, CZ, DE, DK-1, FR, GR, HR, HU, IT, LU, NL, PL, PT, RO, SI, SK
Max. admissible initial delay for PGMs without inertia	As short as possible	CZ, DK-1, NL
	≤ 0,5 s	AT*, BE, ES, FR, HR, PL, PT, RO, SI, IT
	≤ 1 s	BG, DE, GR, HU, LU
	≤ 2s	SK
Minimum time period for the provision of full active power frequency response	15 min	BE, BG, CZ (steam PP), DE, DK-1, ES, FR, GR, HR, HU, LU, NL, PT, RO*, SI, SK
	30 min	AT*, CZ, IT, PL, RO*

*RO - SPGM - 30 min, PPM category C and D and Offshore: (15-30) min depending on the availability of the primary source.

*AT – FSM parameters have not been approved at the national level. They have been specified as prequalification criteria.

Frequency response dead band:

- IT - Default values: Synchronous PGM: ±10 mHz (Hydro and steam), ±20 mHz (other thermal PGMs); PPM: ±10 mHz
- HU - artificial deadband is not allowed (minimum value as small as possible)
- FR: frequency response deadband should be selectable within the range 0 - 200mHz, 0 is required if the unit provides FCR.

Droop:

- IT - Default values: Synchronous PGM: 4% (Hydro) 5% (Thermal PGMs); PPM: 4%
- FR – Droop value is selectable, depending on the active power reserve to provide. The droop value shall ensure at least a full activation of the active power range reserve within 200 mHz frequency deviation.

B. Synchronous Area: Nordic

Frequency response insensitivity	±10 mHz	FI, SE, DK-2
Range of freq, response dead band	0 - ±500 mHz	FI, SE, DK-2
Selectable Droop	2-12 %	FI, SE, DK-2
Max. admissible full activation time	30 s	FI, SE, DK-2
Time period for the provision of full active power frequency response	15 min	FI, SE, DK-2

C. Synchronous Area: Great Britain

Frequency response insensitivity	±15 mHz
Frequency response dead band	0 mHz
Selectable Droop	3-5 %
Max. admissible full activation time	≤ 10 s
Time period for the provision of full active power frequency response	30 sec*

*GB Primary Response – Deliverable in 10 seconds and sustainable for a further 30 seconds. Secondary Response deliverable in 30 seconds and sustainable for 30 minutes. High Frequency Response deliverable in 10 seconds and sustainable thereafter.

D. Synchronous Area: Ireland & Northern Ireland

Frequency response insensitivity	15 mHz
Frequency response dead band	15 mHz
Default droop	4 %
Time period for the provision of full active power frequency response	20 min

E. Synchronous Area: Baltic

Frequency response insensitivity	10 mHz	EE, LT, LV
Range of freq, response dead band	0 - ±500 mHz	EE, LT, LV
Selectable Droop	2-12 %	EE, LT, LV
Max. admissible full activation time	≤ 30 s	EE, LT, LV
Time period for the provision of full active power frequency response	15 min	EE, LT
	30 min	LV

3.7 Voltage ranges

- Reference: Article 16(2)
- Object(s) of national implementation:
 - Definition of a minimum time of operation for defined voltage ranges

A. Synchronous Area: Continental Europe

Implementation of voltage ranges for the voltage level from 110 kV to 300 kV:

	voltage range 1.118 - 1.15 p.u.
20 min	BE, BG, FR*, PT, NL, RO
30 min	AT, DE, LU
60 min	CZ, DK-1, ES, GR, HR, HU, PL, SI, SK, IT*

*FR : 1 p.u = 220kV for the 225kV voltage level.

Implementation of voltage ranges for the voltage level from 300 kV to 400 kV:

	voltage range 1.05 - 1.10 p.u.
20 min	BE, BG, FR, NL, RO, PT
30 min	AT, DE, LU,
60 min	CZ, DK-1, ES, GR, HR, HU, PL, SI, SK, IT*

*IT: the connection requirements shall not permit to limit the performance of the power plant; the time requirement is an operational requirement.

B. Synchronous Area: Nordic

Implementation of voltage ranges for the voltage level from 300 kV to 400 kV:

	voltage range 1.05 - 1.10 p.u.
60 s	SE
60 min	DK-2, FI

C. Other synchronous areas:

Minimum time periods of voltage ranges in the Great Britain, Northern Ireland & Ireland and Baltic synchronous areas are exhaustively determined by NC RfG. No more specification during the implementation period has been required.

3.8 Capability of reconnection after an incidental disconnection caused by a network disturbance

- Reference: Article 14(4)
- Object(s) of national implementation:
 - Definition of parameters (frequency range, voltage range, gradient of active power and observation time) of reconnection after an incidental disconnection

A. Synchronous Area: Continental Europe

f range [Hz]						U range [p.u.]		
47,5-50,05	47,5-51	47,5-50,2	47,5-50,1	49,0-50,05	49,9-50,1	0,85-1,1	0,85-1,15	0,9-1,118
CZ, SK	DE (PGM type D), NL, LU, ES*	DK-1, DE (PGM type B, C), IT (type D), RO*	AT, DE (PGM type A)	PL	BE*, HR, HU, IT, SI*	AT, BE, CZ, DE* (PGM type A), IT (PPM), RO, *PL	PL**	DE*, GR*, HR, IT (SPGM), HU, NL, SI**, SK, LU, DK-1, ES*

*RO - frequency range is 47,5-50,5 for PPM

*PL – voltage range for 400 kV nominal voltage

**PL – voltage range for 110 kV and 220 kV nominal voltage

*SI – default value, and shall be adjustable within the range of $47,5 \text{ Hz} \leq f \leq 51,0 \text{ Hz}$

**SI – default voltage value (0.9 - 1.1 p.u), and shall be adjustable within the range of 0.85 - 1.1 p.u.

*NL – voltage range of 0.9 – 1.1 p.u.

*GR - $49,5 \leq f \leq 50,5$ Hz, $0,9 \leq U \leq 1,1$ p.u. Capability of reconnection after an incidental disconnection caused by a network disturbance is not foreseen for PGMs of type D.

*ES – frequency shall be in range according to article 13 of NC RfG and voltage range shall be in range of 0,9 – 1,1 p.u.

Gradient P [%/min]		Minimum observation time [s]			
≤10	≤20	≥30	≥60	≥180	≥300
AT, BE, CZ, GR, HU, SI*, SK	HR, IT, NL, DK-1, RO	IT*	AT*, BE, HR, NL, PL, SI**	GR, DK-1	CZ, HU, SK, RO

*RO: Gradient P is $\leq 20\%$ P_{max}/min, usually 10% P_{max}/min

*BE an additional criterion on the voltage magnitude is used (between 90%-110% of the nominal one)

*IT: the observation time is selectable between 0 and 900 s (default: 30s)

*AT: the observation time is selectable between 0 and 300 s (default: 60s)

*SI – default value (of maximum admissible gradient of increase in active power output) and shall be adjustable within the range of up to $\Delta P_{\text{Ramp-up limit}} \leq 20\%$ P_{max/min}. An automatic re-connection to the network after an unintentional disconnection caused by a network disturbance for:

- type C PGMs is prohibited unless specified otherwise
- type D PGM is prohibited.

**SI - default value ($T_{\text{observation}} = 60$ s), and shall be adjustable within the range of 0 s and 300 s

FR: The parameters of the capability of reconnection are site-specific. Conditions are described in the operation agreement. Automatic reconnection can be allowed (but has to be automatically de-activated after a delay without voltage at the connection point)

*DE: 0.9 – 1.1 –PGM at 110 kV and (0.85 – 1.1) PGM at 220 kV and 400 kV

SK: 47,5 – 50,05 Hz, U 0.95 – 1.1 at or below 110 kV, 0.95 -1.05 above 110 kV

PL - No limitation of the gradient of increase of active power has been specified

PT - The parameters of the capability of reconnection are site specific.

DE, LU – No minimum observation time before reconnection has been specified, nor any limitation of the gradient of increase of active power.

ES – Gradient of active power and minimum observation time have not been specified

BG – Automatic reconnection is not allowed

No detail specifications of capability of reconnection after an incidental disconnection caused by a network disturbance has been provided by Bulgaria.

B. Synchronous Area: Nordic

f range [Hz]			U range [p.u.]	Gradient P [%/min]	observation time [s]	
47,05-50,1	47,5-50,5	49,0-51,0	0,9-1,05	20	180	60-600
SE	DK-2	FI	SE, FI	DK-2	DK-2	FI

C. Synchronous Area: Baltic

f range [Hz]		U range [p.u.]	Gradient P [%/min]	observation time [s]
49-50,2	49-50,1	0,9-1,1	≤10	60
LV	EE, LT	LT, LV	LT, EE	LT, EE

EE: Any voltage range not specified, when reconnection is required voltage should be in unlimited operation range

Ireland and Northern Ireland have considered the capability of reconnection after an incidental disconnection caused by a network disturbance as a site-specific requirement.

In GB, automatic reconnection after an incidental disconnection is not permitted unless an instruction has been given by the System Operator. The only exclusion to this is where frequency has exceeded the limits specified in ECC.6.1.2 and there is a requirement for the Generator to protect plant and personnel as outlines in ECC.6.2.2.1.1, ECC.6.3.13.1 and ECC.6.3.15.10(vi) of the GB Grid Code.

3.9 Operation following tripping to houseload

- Reference: Article 15(5)c(iii)
- Object(s) of national implementation:
 - Definition of minimum time of houseload operation

A. Synchronous Area: Continental Europe

Minimum operation time within the PGM is capable of operating after tripping to houseload							
0 min	1h	2h	3h	4h	6h	12h	site specific
DK-1	NL, RO	AT, BG, CZ, DE, GR, HR, HU, LU, PL, SK	SI*	ES, FR	-	IT	PT, BE

*SI - PGM of types C and D shall be capable of continuing operation following tripping to houseload for at least 3 hours, if they are not capable of starting from shutdown without any external electrical energy supply (black start capability) within a time frame less than 15 minutes.

FR, the value is considered as site-specific and defined in the connection agreement. 4h is typical value for thermal units

GR proposal: 2 hours for steam turbines, 4 hours for gas turbines

B. Other synchronous Areas

Minimum operation time within the PGM is capable of operating after tripping to houseload					
Nordic			Northern Ireland & Ireland		Baltic
0 min	1h	12 h	4h		6h
DK-2	FI	SE	IE&NI		EE, LT, LV

GB has not specified the minimum time for house load operation in the GB Grid Code. Under ECC.6.3.5.6(iii) of the GB Grid Code the minimum operating time shall be specified on a site-specific basis depending upon the prime mover (ie Generator) technology.

3.10 Active power recovery for synchronous PGM

- Reference: Article 17(3)
- Object(s) of national implementation:
 - Definition of magnitude and time of active power recovery capability

A. Synchronous Area: Continental Europe

Parameters of active power recovery of SPGM							
Magnitude of active power [%]				Time for active power recovery [s]			Site specific
85	90	95	pre-fault value	1-3	5	as fast as possible	
HU	FR, GR	*ES, PT	AT, CZ, *DE, NL, *LU, IT, RO, SI, HR, SK	CZ, DE, HU, BG, LU, PT, *ES	FR, GR	AT, IT, NL, PL, RO, SK	BE, HR, IT, PL

*DE, *LU - Magnitude of active power 80% of the pre-fault values, if the pre-fault active power value was between 80% and 100%. Time for active power recovery 3s, if retained voltage during the fault was > 20%; 6s, if retained voltage during the fault was ≤ 20%

DK-1 no additional requirement on top of inherent generator capabilities are requested. Inherent capabilities must not be intentional delayed. In addition, A 14.4.a is applicable.

*ES - depending on retained voltage during the fault: if retained voltage higher than 0,2 pu--> SPGM must recover 95% of previous P in a time lower than 1 sec once voltage has recovered up to 0,85 pu and the rest pf P within next 2 sec; if retained voltage lower than 0,2 pu, SPGM shall recover 95% of its previous P in a time lower than 3 sec once U>0,85 and the rest of P within next 2 sec

PL has not specified magnitude of active power recovery

SI - Time for active power recovery has not been specified

B. Synchronous Area: Nordic

Parameters of active power recovery of SPGM					
Magnitude [%]			Time for active power recovery [s]		
85	90	pre-fault value	1-3	5	as fast as possible
		FI	FI	SE	

DK-2 no additional requirement on top of inherent generator capabilities are requested. Inherent capabilities must not be intentional delayed.

C. Synchronous Area: Baltic

Parameters of active power recovery of SPGM				
Magnitude [%]		Time for active power recovery [s]		
70	90	1	5	10
LT, LV	EE	EE	LT	LV

D. Synchronous Area: Northern Ireland & Ireland

Parameters of active power recovery of SPGM	
Magnitude [%]	Time for active power recovery [s]
90	1 (0,5s after voltage has recovered to 90% of Un)

IE&NI	IE&NI
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E. Synchronous Area: Great Britain

Parameters of active power recovery of SPGM	
Magnitude [%]	Time for active power recovery
90	as fast as possible
GB	In GB within 0.5s of fault clearance for faults up to 140ms

3.11 Active power recovery for PPMs

- Reference: Article 20(3)
- Object(s) of national implementation:
 - Definition of magnitude, accuracy of restoration, restoration time and criteria when the post-fault active power recovery begins for active power recovery capability of power-park modules

A. Synchronous Area: Continental Europe

Magnitude of active power [%]				Accuracy for active power recovery [%]		Site specific
85	90	95	pre-fault value	± 5	± 10	
HU	GR, IT, NL, PL, SK, RO, FR	ES, PT	AT, CZ, BG, DE, HR, LU, SI	CZ, GR, SI, FR	BG, HR, IT, NL, PL, SK, HU, RO	BE, HR

DE, LU – Accuracy has not been specified.

When the post-fault active power recovery begins, based on a voltage criteria [%]		Time for active power recovery [s]					
85	90	0,5-1,5	2	3	5	10	as fast as possible
CZ, *ES, IT, SI, SK, RO, FR, HU	AT, DE, GR, NL, PL, LU	BG, CZ, DE, SK, *PT, *ES	GR, IT	HU	HR, PL, *DK-1	NL, RO	AT, LU, FR

*SI – PPM shall be capable of providing post-fault active power recovery with a rate of active power increase of at least 20 % P_{max}/s .

*DK-1 - The plant shall deliver normal production no later than 5 seconds after the operating conditions at the mains connection point are back in the area of continuous operation. The active power gradient shall be at least 20% of the rated power of the system.

*PT - After the fault has been cleared and the voltage recovery has started at the generator module connection point, the active power output shall recover to reach 95% of the active power before the fault within less than 1 second. The set time to reach active power before the fault should be less than 2 additional seconds.

*ES - depending on residual voltage of the fault: if U residual higher than 0,2 pu--> PPM must recover 95% of previous P in a time lower than 1 sec once voltage has recovered up to 0,85 pu and the rest pf P within next 2 sec; if U residual lower than 0,2 pu, PPM shall recover 95% of its previous P in a time lower than 3 sec once U>0,85 and the rest of P within next 2 sec

B. Synchronous Area: Nordic

Magnitude [%]		Accuracy for active power recovery [%]	When the post-fault active power recovery begins, based on a voltage criteria [%]		Time for active power recovery [s]		
20	90	± 5	85	90	1-3	2	5
DK-2	FI	FI, SE	FI	SE	FI	SE	*DK-2

DK-2 - The plant shall deliver normal production no later than 5 seconds after the operating conditions at the mains connection point are back in the area of continuous operation. The active power gradient shall be at least 20% of the rated power of the system.

C. Synchronous Area: Baltic

Magnitude [%]		Accuracy for active power recovery [%]	When the post-fault active power recovery begins, based on a voltage criteria [%]		Time for active power recovery [s]	
70	90	± 5	85	90	1	10
LT, LV	EE	LT, LV	EE	LT, LV	EE	LT, LV

D. Synchronous Area: Great Britain

Parameters of active power recovery for PPM	
Magnitude [%]	Time for active power recovery
90	as fast as possible
GB	In GB within 90% of the pre-fault active power should be restored within 0.5s of fault clearance for faults up to 140ms in duration

E. Synchronous Area: Northern Ireland & Ireland

Magnitude [%]	When the post-fault active power recovery begins, based on a voltage criteria [%]	Time for active power recovery [s]
90	90	0,5

3.12 Fault ride through “FRT” capability

- Reference: Article 14(3) and article 16(3)
- Object(s) of national implementation:
 - Definition of fault ride through capability of power-generating modules at the connection point by without adverse impact on system operation

A. Synchronous Area: Continental Europe

FRT capability for SPGMs of type B and C

Voltage parameters								
U _{ret} [p.u.]				U _{clear} [p.u.]			U _{rec2} [p.u.]	
0	0,05	0,15	0,30	0,40	0,70	0,75	0,85	0,90
BG	CZ, ES, FR, HR, IT, NL, PL, PT, SI, SK		AT, CZ*, BE, DE, DK-1, GR, RO, FR*, LU	BG	BE, CZ, DE, DK-1, EE, ES, FR, GR, HR, IT, NL, PL, PT, RO, SI, SK, LU	AT	AT, BG, CZ, DE, ES, GR, IT, NL, PL, PT, RO, SI, SK	BE, DK-1, FR, HR

*CZ: for SPGM type B and C ≤ 1 MW

*FR: for SPGM type B < 5 MW,

Recovery time parameters										
t _{clear} [s]			t _{rec2} [s]					t _{rec3} [s]		
0,15	0,2	0,25	0,15	0,25	0,4	0,5	0,7	0,95	1,5	
AT, BG, CZ, DE, ES, FR, GR, HR, IT, NL, PL, PT, LU, SI	BE	DK-1, RO, SK	GR, IT, NL	SK	AT	ES, LU	BE, BG, CZ, DE, DK-1, FR, HR, PL, PT, RO, SI, AT	AT	BE, BG, CZ, DE, DK-1, ES, FR, GR, HR, IT, LU, NL, PL, PT, RO, SI, SK	

FRT capability for PPMs of type B and C

Voltage parameters					
U _{ret} [p.u.]			U _{clear} [p.u.]		
0	0,05	0,15	0	0,05	0,15
HR	AT, CZ, ES, FR, IT, NL, PL, PT, SI, SK	BE, DE, GR, RO, DK-1	HR	AT, CZ, ES, FR, NL, PL, PT, SI, SK	BE, DE, GR, IT, RO, DK-1

Recovery time parameters							
t _{clear} [s]			t _{rec3} [s]				
0,15	0,2	0,25	1,5	1,6	2,5	3	
AT, CZ, DE, FR, GR, HR, PL, SI, LU	BE, ES, IT	DK-1, NL, PT, RO, SK	AT, BE, DK-1, ES, GR, HR, FR, IT	PT	PL, SI	BE, CZ, DE, ES, GR, LU, NL, RO, SK	

FRT capability for SPGMs of type D

Voltage parameters				
U _{rec1} [p.u.]			U _{rec2} [p.u.]	
0,50	0,60	0,70	0,85	0,90
BE, CZ, FR, GR, IE&NI, IT, PL, PT, SI	AT, DK-1	DE, ES, LU, RO	AT, CZ, DE, DK-1, ES, IT, LU, NL, PL, PT, RO, SI, SK	BE, FR, GR, HR

Recovery time parameters									
t _{clear} [s]			t _{rec1} [s]						
0,15	0,20	0,25	0,15	0,20	0,25	0,27	0,30	0,45	0,60
AT, CZ, DE, DK-1, ES, FR, HR, GR, LU, PL, PT, SI	IT, BE, GR	NL, RO, SK	DK-1, FR, HR, SI	GR	SK	ES	DE, LU, NL	BE, CZ, IT, PL, PT, SE, RO	DK-1
t _{rec2} [s]						t _{rec3} [s]			
0,25	0,30	0,50	0,60	0,70	0,85	0,8	1,35	1,5	
SK	NL	DE, ES, LU	AT, BE, SI	CZ, FI, FR, GR, IT, HR, PL, PT, RO	DK-1	BE	FR	AT, CZ, DE, DK-1, ES, GB, GR, HR, IT, LU, NL, PL, PT, RO, SI, SK	

FRT capability for PPMs of type D

All voltage parameters of FRT for PPMs of type D were exhaustively determined by NC RfG. No more specification during the implementation period has been required.

Recovery time parameters								
t _{clear} [s]			t _{rec3} [s]					
0,15	0,20	0,25	1,5	1,6	2,0	2,5	2,8	3,0
AT, CZ, DE, ES, FR, GR, HR, LU, PL, PT, SI, DK-1	BE, IT	DK-1, NL, RO, SK	AT, BE, FR, DK-1	PT	IT (≤150kV)	PL	IT (>150kV)	SK, SI, RO, NL, LU, HR, GR, ES, DK-1, DE, CZ

F. Other synchronous areas

FRT capability for SPGMs of type B and C

Voltage parameters									
U _{ret} [p.u.]					U _{clear} [p.u.]			U _{rec2} [p.u.]	
0,05	0,10	0,15	0,25	0,30	0,70		0,90	0,85	0,90
FI, LT, LV, IE&NI*	GB* Type C only	IE&NI	SE, EE	DK-2	FI, EE, LT, LV, GB, DK-2, IE&NI*		SE	FI, LT, LV, IE&NI	SE, EE, GB, DK-2, IE&NI*

Recovery time parameters												
t _{clear} [s]						t _{rec2} [s]						
0,14	0,15	0,20	0,25			0,14	0,25	0,45	0,50	0,60	0,70	0,90
GB	FI, IE&NI*	SE	IE&NI, EE, LT, LV, DK-2			GB	IE&NI, DK-2	GB, IE&NI*	SE	EE	FI, LT, LV	DK-2
t _{rec3} [s]												
0,50		0,75			1,0		1,50		2,9			
SE		EE			FI		GB, LT, LV, DK-2		IE&NI			

*GB: In GB for Type B SPGM only, U_{ret} is set at 0,3 p.u.

*IE&NI: these values apply only for SPGM connected to the transmissions system (t_{clear}=t_{rec2})

FRT capability for PPMs of type B and C

Voltage parameters						
U _{ret} [p.u.]			U _{clear} [p.u.]			
0,05	0,10	0,15	0,05	0,10	0,15	
FI, LT, LV	GB	IE&NI, SE, EE, DK-2	FI	GB	EE, IE&NI, LT, LU, LV, SE, DK-2	

Recovery time parameters									
t _{clear} [s]					t _{rec3} [s]				
0,14	0,15	0,2	0,25		1,5	2,0	2,2	2,9	3,0
GB	FI	SE	IE&NI, EE, LT, LV, DK-2		FI, EE, DK-2	SE	GB	IE&NI	LT, LV

FRT capability for SPGMs of type D

Voltage parameters						
U _{rec1} [p.u.]					U _{rec2} [p.u.]	
0,5	0,51	0,545	0,6176	0,6	0,85	0,9
GB, LT, LV, IE&NI	EE	SE	FI	DK-2	LT, LV, FI	EE, SE, GB, DK-2, IE&NI

Recovery time parameters							
t _{clear} [s]				t _{rec1} [s]			
0,14	0,15	0,20	0,25	0,15	0,25	0,30	0,45
GB	IE&NI, DK-2	FI, SE	EE, LT, LV	DK-2, IE&NI	EE, FI, GB	LT	LV, SE
t _{rec2} [s]				t _{rec3} [s]			
0,45	0,70	0,75	0,45	0,75	1,0	1,5	
EE, GB, IE&NI, SE	FI, LT, LV	DK-2	IE&NI	EE, SE	FI	GB, LT, LV, DK-2	

FRT capability for PPMs of type D

All voltage parameters of FRT for PPMs of type D were exhaustively determined by NC RfG. No more specification during the implementation period has been required.

Recovery time parameters								
t _{clear} [s]				t _{rec3} [s]				
0,14	0,15	0,20	0,25	1,5	2,0	2,2	2,9	3,0
GB	IE&NI, DK-2	FI	EE, LT, LV	FI, EE, DK-2	LT	GB	IE&NI	LV

A graphical interpretation of the FRT capabilities is attached in the annex of this document.

4 NC DC implementation

4.1 Frequency ranges

Reference: Article 12

- Object(s) of national implementation:
 - Definition of a minimum time of operation of transmission-connected distribution systems (TC-DS), transmission-connected demand facilities (TC-DF) and transmission-connected closed distribution systems (TC-CDS) for defined frequency ranges

A. Synchronous Area: Continental Europe

Frequency Range	47.5Hz - 48.5Hz	48.5Hz - 49.0Hz
30 min	BE, BG, CZ, DE, DK-1, ES, FR, GR, HR, HU, LU, NL, PL, RO, SI, SK, PT	BE, BG, DE, DK-1, FR, GR, HR, LU, NL, PL, RO, SI, SK
60 min	AT	HU
90 min	none	AT, CZ,
unlimited	IT	ES, IT, PT

All Member States of Continental Europe synchronous have specified that new connected facilities shall be able to withstand at least 30 minutes at all frequency ranges outside the frequency range from 49 Hz to 51 Hz, for which unlimited time of operation is exhaustively required.

Furthermore, peninsular areas (ES, IT, PT) and several countries in continental Europe have specified longer minimum times for operation in case of low frequencies.

B. Other synchronous areas

Frequency Range	48.5Hz - 49.0Hz	47.5Hz - 49.0Hz
30 min	DK-2, SE, FI	LV, LT, EE
90 min	GB, IE&NI	

The minimum time of operation in the frequency range 48,5 Hz - 49 Hz has been specified unanimously as 30 minutes in the Nordic synchronous area.

The minimum time of operation in the frequency range 48,5 Hz - 49 Hz has been specified as 90 minutes for the Great Britain and Northern Ireland & Ireland synchronous areas. Time periods of other frequency ranges are exhaustively determined by NC DC.

The minimum time of operation in the frequency ranges from 47,5 - 49 Hz has been specified unanimously as 30 minutes in the Baltic synchronous area.

4.2 Voltage ranges

- Reference: Article 13
- Object(s) of national implementation:
 - Definition of a minimum time of operation of TC-DS, TC-DF and TC-CDS for defined voltage ranges

The implementation of the voltage ranges according to NC RfG has been considered. All Member States have specified the same time periods as for NC RfG.

A. Synchronous Area: Continental Europe

Implementation of voltage ranges for the voltage level from 110 kV to 300 kV:

	Voltage range 1.118 - 1.15 p.u.
20 min	BE, BG, FR, PT
30 min	AT, DE, LU, RO
60 min	CZ, DK-1, ES, GR, HR, HU, NL, PL, SI, SK, IT*

Implementation of voltage ranges for the voltage level from 300 kV to 400 kV:

	Voltage range 1.05 - 1.10 p.u.
20 min	BE, BG, FR, PT
30 min	AT, DE, LU, RO
60 min	CZ, DK-1, ES, GR, HU, PL, SI, SK, IT*, NL, HR

*IT: the connection requirement does not permit to limit the performance of the facility; the time requirement is an operational requirement.

FR : 1 p.u = 220kV for the 225kV voltage level.

All new connected facilities in the Continental Europe synchronous area shall be able to withstand voltages up to 1,118 p.u. at the connection point for an unlimited time and they shall be able to withstand voltages above 1,118 p.u. (up to 1,15 p.u.) between 20 and 60 minutes.

B. Synchronous Area: Nordic

Implementation of voltage ranges for the voltage level from 300 kV to 400 kV:

	Voltage range 1.05 - 1.10 p.u.
60 min	DK-2, FI
60 s	SE

Implementation of voltage ranges is fully aligned among all Member States in the Nordic synchronous area. New connected facilities are required to withstand voltages from 0,9 p.u. up to 1,05 p.u. at the connection point for an unlimited time and they shall be able to withstand voltages above 1,05 p.u. (up to 1,1 p.u.) for at least 60 seconds.

C. Synchronous Area: Baltic

Voltage ranges are exhaustively specified in NC DC for the Baltic synchronous area, and no further specifications are required.

D. Synchronous Area: Great Britain

The voltage ranges are exhaustively specified in NC DC for the Great Britain synchronous area, and no further specification are required.

E. Synchronous Area: Northern Ireland & Ireland

The voltage ranges are exhaustively specified in NC DC for the Northern Ireland & Ireland synchronous area, and no further specifications are required.

4.3 Reactive power capability

- Reference: Article 15(1)
- Object(s) of national implementation:
 - Definition of a reactive power range at TC-DS and TC-DF connection points for exchange of reactive power

All Member States have specified the same ranges for reactive power for TC-DF and TC-DS. Most of the Member States have implemented the default range (i.e. 0,9 power factor) for importing and exporting reactive power.

Synchronous areas	TS-DS connection point		TS-DF connection point	
	Country	Ranges	Country	Ranges
Continental Europe	AT*, BG, CZ, DE, ES, GR, HU, NL, RO, PT	$\cos(\phi) = 0,9$	AT, BG, CZ, DE, ES, GR, HU, NL, RO, PT	$\cos(\phi) = 0,9$
	DK-1	$\cos(\phi) = 0,99/\text{max.} \pm 15\text{MVAr}$	DK-1	$\cos(\phi) = 0,99/\text{max.} \pm 15\text{MVAr}$
	AT*, HR, LU, *SI	$\cos(\phi) = 0,95$	HR, LU, SK*, SI	$\cos(\phi) = 0,95$
	PL*	$\cos(\phi) = <1; 0,928>$ or $\cos(\phi) = <-0,928; 0,928>$	PL	$\cos(\phi) = <1; 0,928>$
	IT	$0,9 < \cos(\phi) < 1$	IT	$0,9 < \cos(\phi) < 1$
Nordic	FI	$\cos(\phi) = 0,987$	FI	$\cos(\phi) = 0,987$
	DK-2	$\cos(\phi) = 0,99$	DK-2	$\cos(\phi) = 0,99$
Baltic	EE, LV, LT	$\cos(\phi) = 0,9$	EE, LV, LT	$\cos(\phi) = 0,9$
GB	GB	$\cos(\phi) = 0,9$	GB	$\cos(\phi) = 0,9$
IE&NI	IE&NI	$\cos(\phi) = 0,9$	IE&NI	$\cos(\phi) = 0,9$

*AT: Austrian implementation of Q at TS/DS-Interface takes into account a definition of a “PQ-funnel”

*PL : During national implementation PL specified: $\cos(\phi) = <0,928; 1>$ for connection point at HV/110 kV transformer bay and $\cos(\phi) = <-0,928; 0,928>$ for connection point at HV/110 kV substation owned by TSO

*SI - The compensation of reactive power shall be implemented in such a manner so that reactive power is balanced within 15 minutes

*SK – For TC-DF the reactive power range has been specified range given by $\cos(\phi) = 0,95$ for reactive power import and $\cos(\phi) = 1$ for export and for TC-DS has been decided that the range is based on joint study and connection point.

BE - MV connection points at TS-DS -> Q/Ppad(power put at disposal)= 21% (inductive), Q/ppad=15% (capacitive) and HV connection point at TS-CDS -> Q/Ppad= 33% (inductive), Q/Ppad=15% (capacitive).
TS-DF connection points -> Q/Ppad= 33% (inductive), Q/Ppad=15% (capacitive)

Furthermore, France has specified that the reactive power range will be contracted at the each connection point individually.

Site-specific (contract)	
Country	Remark
FR	financial incentive: $\tan(\phi) = \text{site specific}$ Technical requirement: $Q_{\max} = 48\% P_{\max}$
SE	

4.4 Capability of connection and reconnection

- Reference: Article 19(4)
- Object(s) of national implementation:
 - Definition of automatic or manual connection and reconnection of TC-DS and TC-DF to the system

All Member States have specified the conditions under which a transmission-connected demand facility or a transmission-connected distribution system is entitled to reconnect to the transmission system.

SA	Automatic reconnection allowed			Manual reconnection	
	Country	Ranges	Remark	Country	Remark
Continental Europe	FR*	site-specific	only during a disturbance or in specific cases	AT, BG, CZ, DK-1, GR, HU, IT, PL, SI, SK, FR, NL	permission/ authorization must be given
	RO	site-specific			
Nordic	FI	normal continuous f (49.00-51.00) and U (0.90-1.05)	only allowed if relevant network operator gives permission to install automatic reconnection capability	DK-2	permission/ authorization must be given
Baltic	LT	Voltage: $0,9 \text{ p.u.} \leq U \leq 1,1 \text{ p.u.}$ Frequency: 47-50 Hz;	Monitoring time: 60 sec; Maximum active power increase: 10% Pmax/min.		

	LV	f and U ranges specified in NC DC art 12 and 13			
	EE	site-specific	Parameters selected from unlimited continuous f and U defined in NC DC art 12 and 13. Need approval first from TSO		
GB				GB	permission/ authorization must be given

*FR: the conditions are described in the operation agreement. Automatic reconnection can be allowed (but has to be automatically de-activated after a delay without voltage at the connection point)

*BE: default is manual reconnection after authorization but in contract automatic reconnection can be allowed
 SE - Connection and reconnection will be according to art. 19, 37 and 39 NC DC

Site-specific	
Country	*BE, DE, EE, ES, HR, IT, LU, IE&NI, RO, PT

5 NC HVDC implementation

5.1 Frequency ranges

- Reference: Article 11
- Object(s) of national implementation:
 - Definition of a minimum time of operation of HVDC systems for defined frequency ranges

Frequency Range	47.5Hz - 48.5Hz	48.5Hz - 49.0Hz	51.0Hz - 51.5Hz	51.5Hz - 52Hz
≥15min				BE, BG, CZ, DE, ES, FR, GB, HR, NL, PT, RO, SK, EE, LT, LV, FI, GR
≥30 min	HU		HU	IT, SE, SI
≥60 min		HU		IE&NI, DK
≥90 min	BG, CZ, DE, FR, GB, HR, NL, RO, SK, EE, LT, LV, FI, IE&NI, GR, DK	BG, CZ, DE, FR, GB, HR, NL, RO, SK, EE, LT, LV, FI, IE&NI, GR, DK	BG, CZ, DE, FR, HR, NL, RO, SK, EE, LT, LV, FI, IE&NI, GB, GR, DK	
unlimited	BE, ES, IT, PL, PT, SI, SE	BE, ES, IT, PL, PT, SI, SE	BE, ES, IT, PL, PT, SI, SE	PL

5.2 Voltage ranges

- Reference: Article 18
- Object(s) of national implementation:
 - Definition of a minimum time of operation of HVDC systems for defined voltage ranges

The implementation of the voltage ranges according to the NC RfG and NC DC have been considered.

A. Synchronous Area: Continental Europe

Implementation of voltage ranges for the voltage level from 110 kV to 300 kV:

	Voltage range 1.118 - 1.15 p.u.
≥20 min	BG, DE, FR, NL, RO
≥60 min	CZ, ES, GR, HR, PT, SI, SK, PL, DK-1
≥10h	BE
unlimited	IT

Implementation of voltage ranges for the voltage level from 300 kV to 400 kV:

	Voltage range 1.05 - 1.0875 p.u
≥60 min	BE (≥10h), BG, CZ, DE, ES, FR, GR, HR, NL, PL, PT, SI, SK, IT ¹⁴ , RO, DK-1

¹⁴IT: For periods of more than 60 minutes, the HVDC connection shall remain connected but reduced capabilities are allowed. The facility owner shall specify the performance of the HVDC link under these conditions.

HU has specified the minimum limited operation time in combination with frequency ranges -> the minimum limited operation time from 20 min to 2 hours.

B. Synchronous Area: Nordic

Implementation of voltage ranges for the voltage level from 300 kV to 400 kV:

	Voltage range 1.05 - 1.10 p.u.
15 min	SE
60 min	DK-2, FI

The voltage ranges are exhaustively specified in NC HVDC for the Northern Ireland & Ireland, Great Britain and Baltic synchronous areas, and no further specifications are required.

5.3 Frequency Sensitive Mode (FSM)

- Reference: Article 15
- Object(s) of national implementation:
 - Definition of a frequency sensitive mode parameters (frequency insensitivity, frequency response dead band, droop and time parameters) of operation of HVDC systems

A. Synchronous Area: Continental Europe

Frequency response insensitivity	10 - 15 mHz	CZ, HR, HU, NL, PL, PT, SI, SK, RO, FR, DK-1
	30 mHz	ES, BG, DE, GR, IT
Frequency response dead band	0 mHz	FR
	0 – 200 mHz	BG, CZ, DE, HR, HU, PL, PT, SK, DK-1
	0 – 500 mHz	ES, GR, IT, NL, SI, RO
Droop	≥ 0,1 %	ES, BG, CZ, DE, GR, IT, SI, SK, NL
	2-12 %	HR, PL, PT, HU, DK-1
	3-12 %	FR, RO
Max. admissible full activation time	≤ 2 s	IT, NL
	≤ 30 s	ES, CZ, GR, HR, HU, PL, PT, SI, SK, RO, FR
Max. admissible initial delay	≤ 0,5 s	CZ, GR, HR, IT, NL, PL, PT, SI, SK, RO, FR
	≤ 1 s	HU

BE - site specific.

DK: specified initial delay ≤ 20 ms and full activation ≤ 100 ms

B. Synchronous Area: Nordic

Frequency response insensitivity	10 mHz	FI, SE, DK-2
Frequency response dead band	0-500 mHz	FI, SE, DK-2
Droop	2-12 %	FI, SE, DK-2

C. Synchronous Area: Great Britain

Frequency response insensitivity	±15 mHz	GB
Frequency response dead band	0 mHz	GB
Droop	3-5 %	GB
Max. admissible full activation time	≤ 10 s	GB
Max. admissible initial delay	≤ 0,5 s	GB

D. Synchronous Area: Ireland & Northern Ireland

Frequency response insensitivity	15 mHz	IE&NI
Frequency response dead band	15 mHz	IE&NI
Default droop	4 %	IE&NI
Droop	0,1 - 12 %	IE&NI

E. Synchronous Area: Baltic

Frequency response insensitivity	10 mHz	EE, LT, LV
Frequency response dead band	0 - 200 mHz	LT
	0 - 500 mHz	EE, LV
Droop	0,1-12 %	EE, LT, LV
Max. admissible full activation time	≤ 30 s	EE, LT, LV
Max. admissible initial delay	≤ 0,5 s	EE, LT, LV

5.4 Post fault active power recovery

- Reference: Article 26
- Object(s) of national implementation:
 - Definition of magnitude and time for active power recovery capability of HVDC systems

Magnitude [p.u.]			Recovery time [s]							
0,85	0,9	The prefault set points	immediately	0,2	0,25	0,30	0,5	1,0	1,5	10
HU, SE, GR	IE&NI, NL, PL, RO, SK, GB, EE, DK,	BE, CZ, FI, FR, IT, SI	PL	BE, FR, IT, NL, SI,	FI	LT	GB, GR	CZ, IE&NI, SK, EE	HU	RO*, SE

	IE&NI, LT, ES			DK, ES					
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RO* - Recovery time is (1÷10 s)

DE – not specified

EE, HR – align with RfG (as for PPM)

PT – site-specific

No information on national specifications of post fault active power recovery has been provided by Bulgaria and Latvia.

5.5 Reactive power capability

- Reference: Article 20
- Object(s) of national implementation:
 - Definition of a reactive power range at HVDC systems connection points

Site-specific	Same as NC RfG
BE, CZ, IT, PL, GR, HU, SK	ES, FR, GB ¹⁵ , SI, RO, HR, DK

	NL		LT		IE&NI	
	U-range [p.u.]	Q/P _{max} range [p.u.]	U-range [p.u.]	Q/P _{max} range [p.u.]	U-range [p.u.]	Q/P _{max} range [p.u.]
> 300 kV			0,197	0,95	0,15	0,66
≤ 300 kV	0,20	0,28	0,218	0,95	0,218	0,66

FI, SE		SK		BG, DE		EE		PT	
U-range [p.u.]	Q/P _{max} range [p.u.]	U-range [p.u.]	Q/P _{max} range [p.u.]	U-range [p.u.]	Q/P _{max} range [p.u.]	U-range [p.u.]	Q/P _{max} range [p.u.]	U-range [p.u.]	Q/P _{max} range [p.u.]
0,15	0,95	0,225	0,95	0,225	0,74	0,22	1,0	0,22	0,9

¹⁵GB: the reactive capability for HVDC Systems is the same as Type C and Type D Power Park Modules.

No information on national specifications of reactive power capability has been provided by Latvia.

5.6 Limited frequency sensitive mode (LFSM-O/U)

- Reference: Article 15
- Object(s) of national implementation:
 - Definition of LFSM frequency thresholds and droops for over-frequency and under-frequency schemes for capability to support the recovery of frequency to the normal operation range by HVDC systems

LFSM-O											
Frequency threshold [Hz]				Droop s3 [%]							
range	default value			range				default value			Site specific
50,2 - 50,5	50,2	50,4	50,5	≥ 0,1	2 - 10	2 - 12	4 - 6	4	5	0,8	
GR, PL, CZ, FI, GB, DK, ES	EE, DE, FR, IT, RO, CZ, PT, SI, LT, HR, NL, LV, DK, IE&NI	GB	FI	FR, GR, CZ, LT, IT, RO, NL, ES	GB	PL, DK, FI, HR, LV, IE&NI	PT	IE&NI	EE, RO, CZ, LT, DE, HR, NL, LV, DK, SK	IT	BE, SI

No information on national specifications of LFSM-O has been provided by Hungary.

LFSM-U											
Frequency threshold [Hz]				Droop s4 [%]							
range	default value			range				default value			Site specific
49,8 - 49,5	49,8	49,5	≥ 0,1	2 - 10	2 - 12	4 - 6	4	5	0,8		
GR, PL, CZ, FI, GB, DK, HU, ES	EE, FR, IT, RO, CZ, PT, SI, LT, DE, HR, NL, LV, DK	FI, IE&NI	FR, GR, CZ, LT, IT, FI, RO, NL, ES	GB	PL, DK, HR, LV, HU, IE&NI	PT	IE&NI	EE, RO, CZ, LT, DE, HR, NL, LV, DK, SK	IT	BE, SI	

BE – site-specific
 SE – align with NC RfG
 SI – site-specific droop
 BG – not specified

6 Summary

Identification of deviations in national implementations from CNC provisions

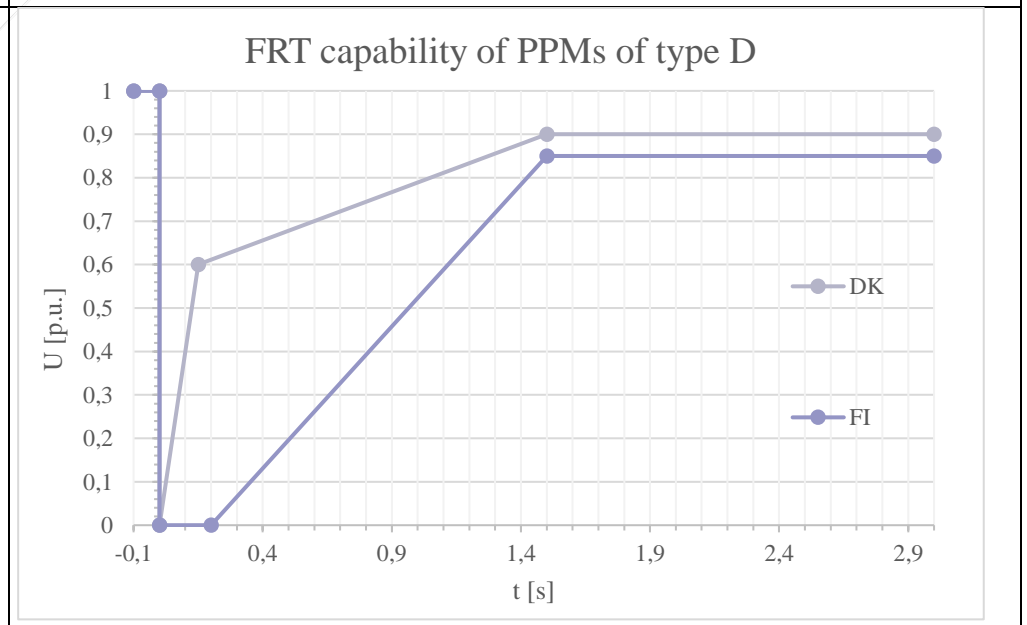
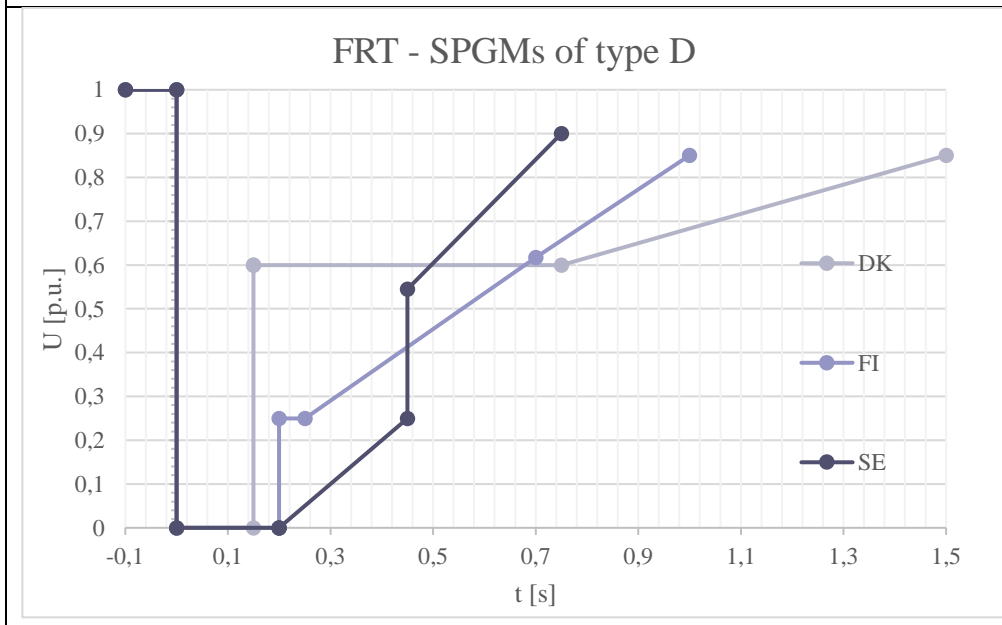
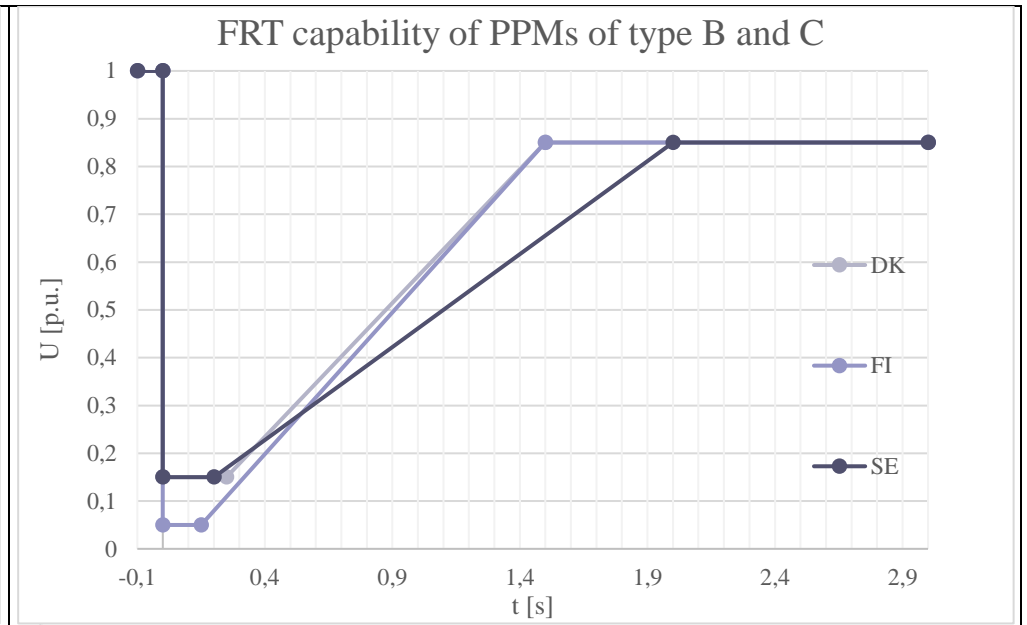
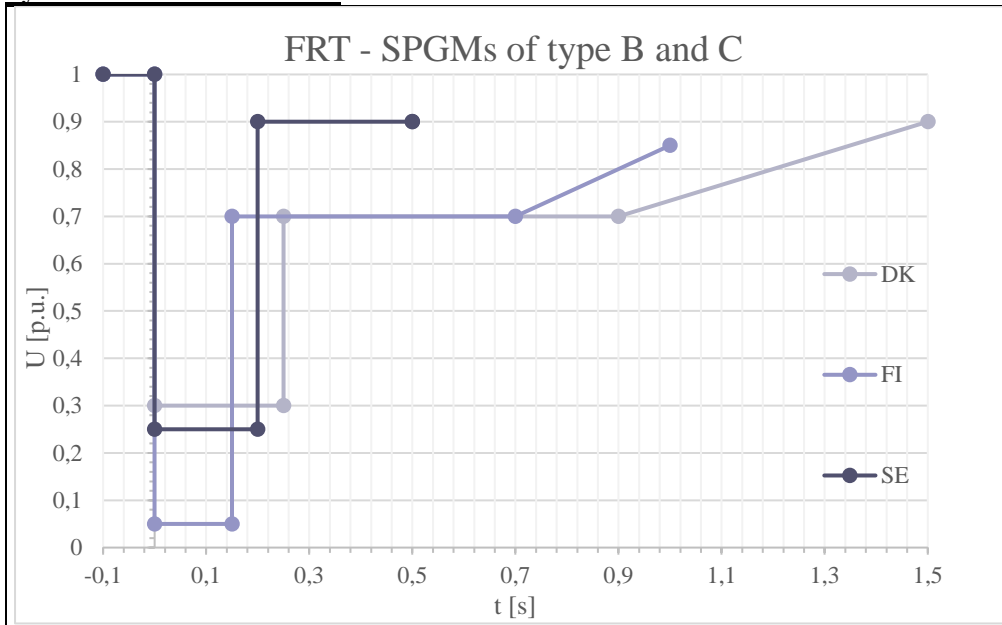
Requirement	CNC provision	National implementation
Admissible active power reduction from maximum output with falling frequency	The range of admissible active power reduction from maximum output with falling frequency is between 2 and 10 % P _{max} /Hz at frequency threshold in range from 49,5 Hz to 49 Hz.	Bulgaria specified the range of admissible active power reduction from maximum output with falling frequency as 2 – 15 % P _{max} /Hz with a default of 9 % P _{max} /Hz. The range is wider than defined by NC RfG.
		In France, no active power reduction from maximum output with falling frequency is admitted for PPMs. This is the result of discussion with the relevant stakeholders in France.
FRT	Retained voltage to be withstood during a fault shall be in range of 0.05 – 0.3 pu for Type B and C PGMs.	Bulgaria specified the retained voltage to be withstood during a fault for Type B and C PGMs as 0.0 pu.
Implementation of NC HVDC	The Austrian TSOs and DSOs agreed with the relevant NRA to not propose national specifications for the non-exhaustive requirements of NC HVDC, because there are no mid- or long-term HVDC projects foreseen.	Luxembourg does not propose national specifications for the non-exhaustive requirements of NC HVDC, because they are not needed now and in future.

A detailed overview about the current status of the CNC implementation including all the data specified by the TSO's and approved by the NRA's is available from the Active Library on CNC implementation on the ENTSO-E website¹. A high level overview of the CNC implementation is included in the Annex of this report.

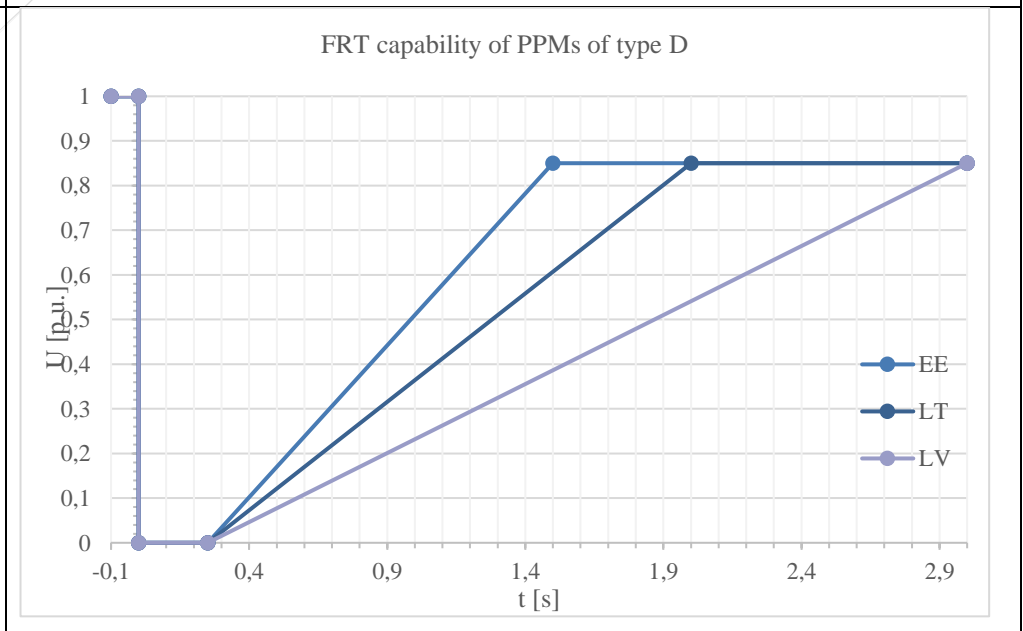
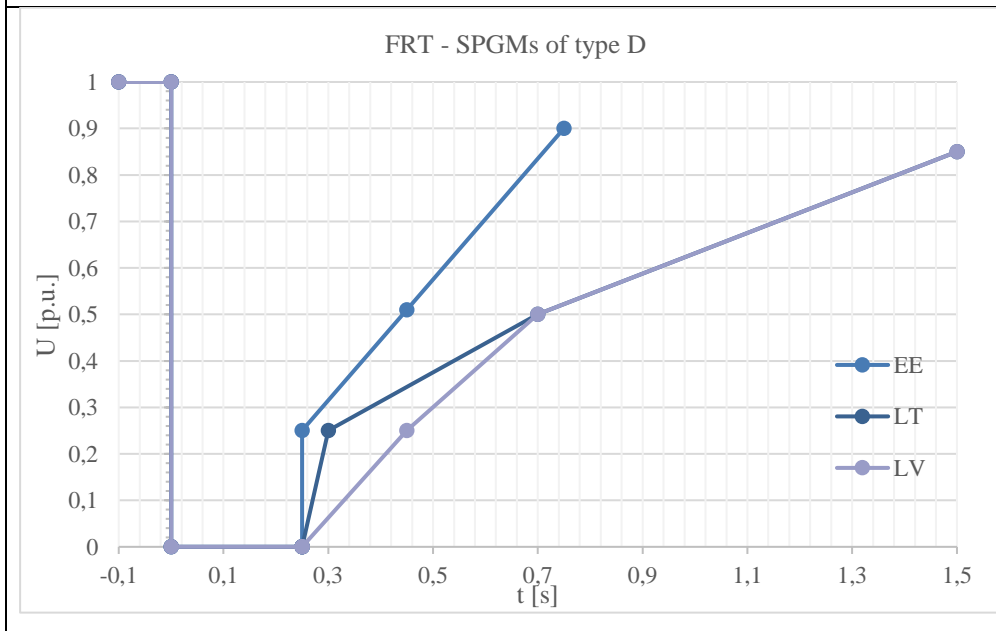
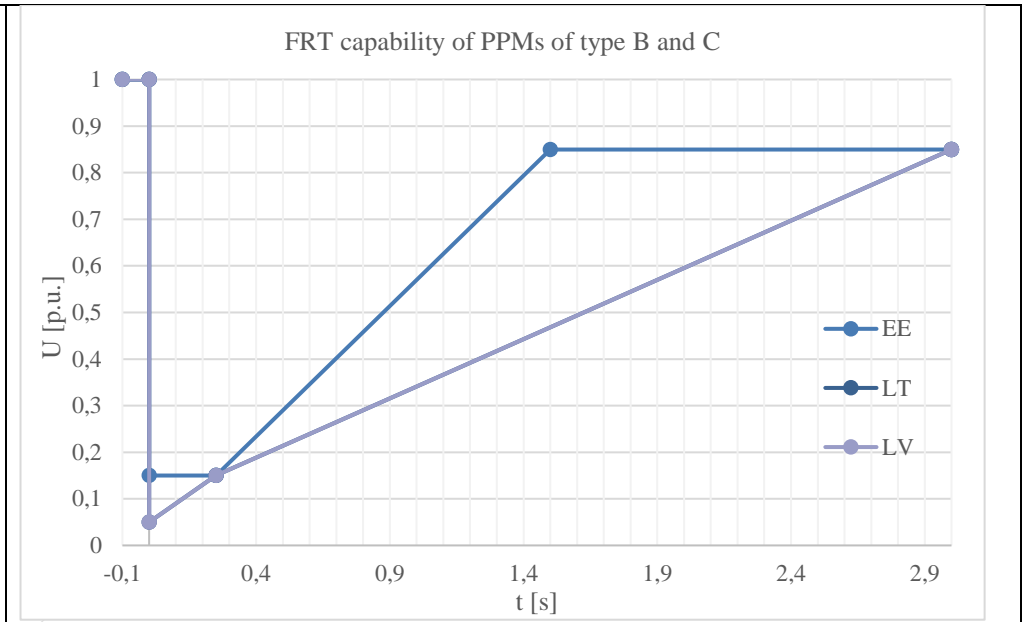
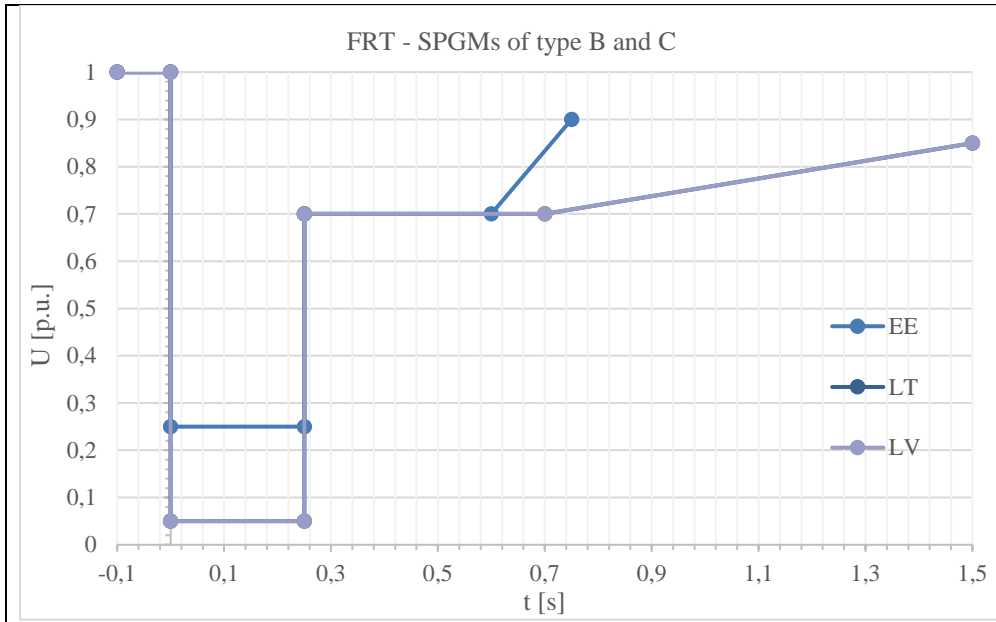
¹ https://docstore.entsoe.eu/layouts/download.aspx?SourceUrl=https://docstore.entsoe.eu/Documents/Network%20codes%20documents/CNC/CNC_Non_exhaustive_requirements.xlsx

Annex – FRT characteristics

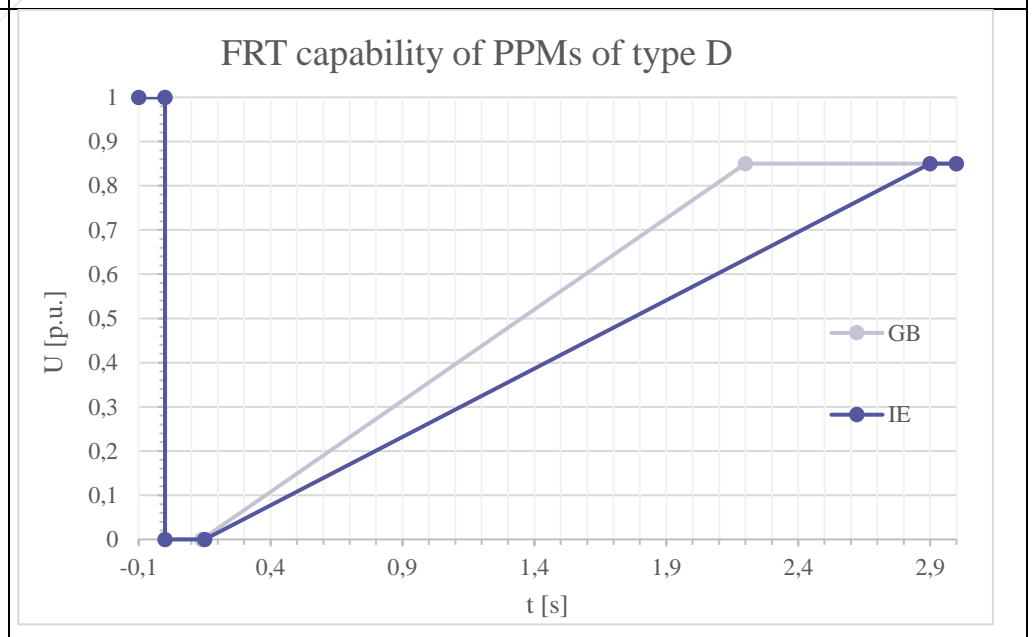
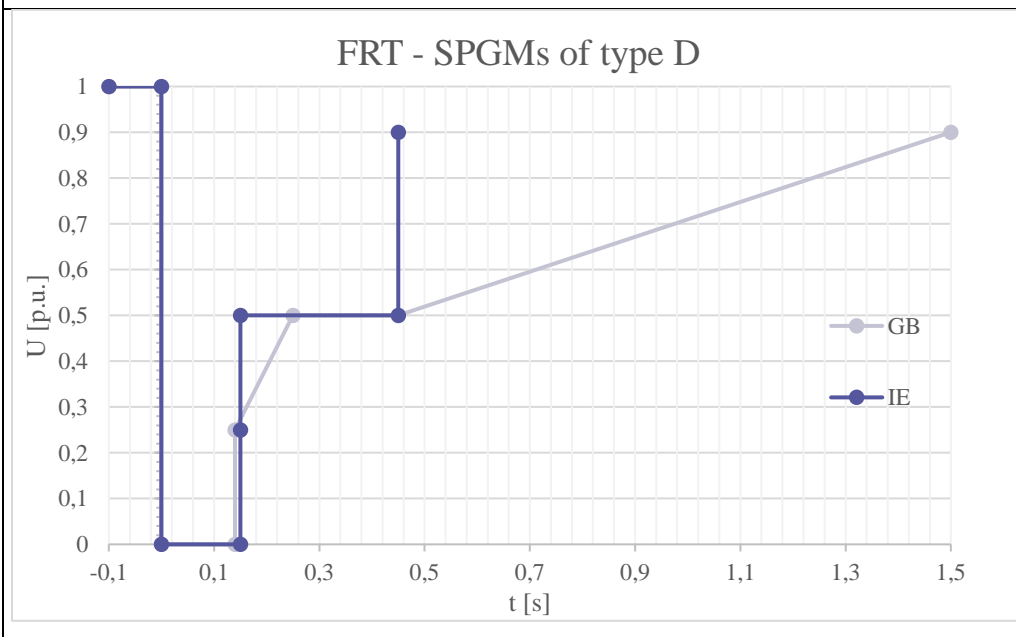
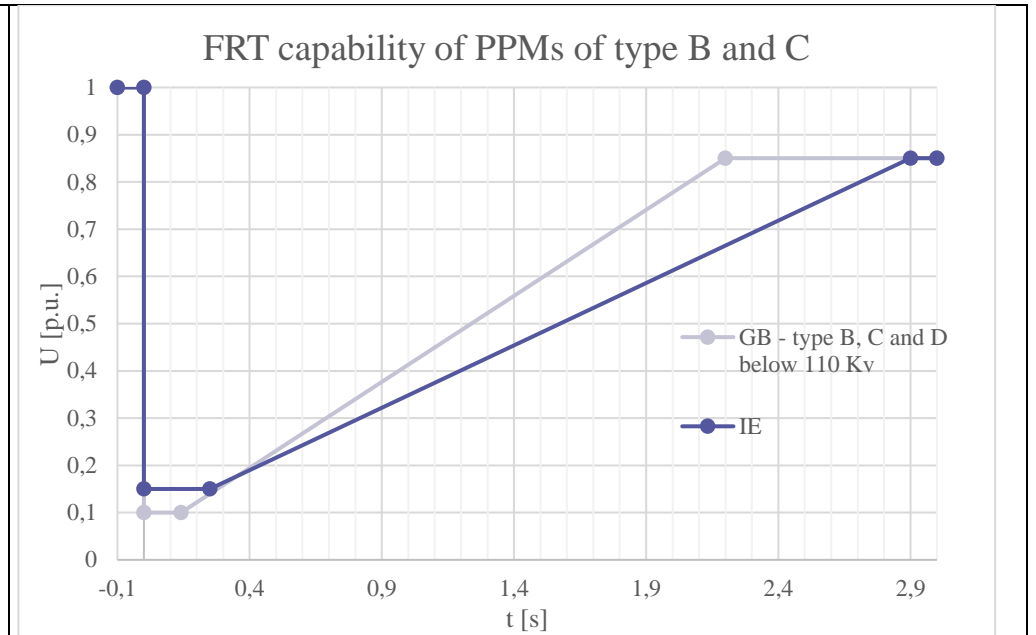
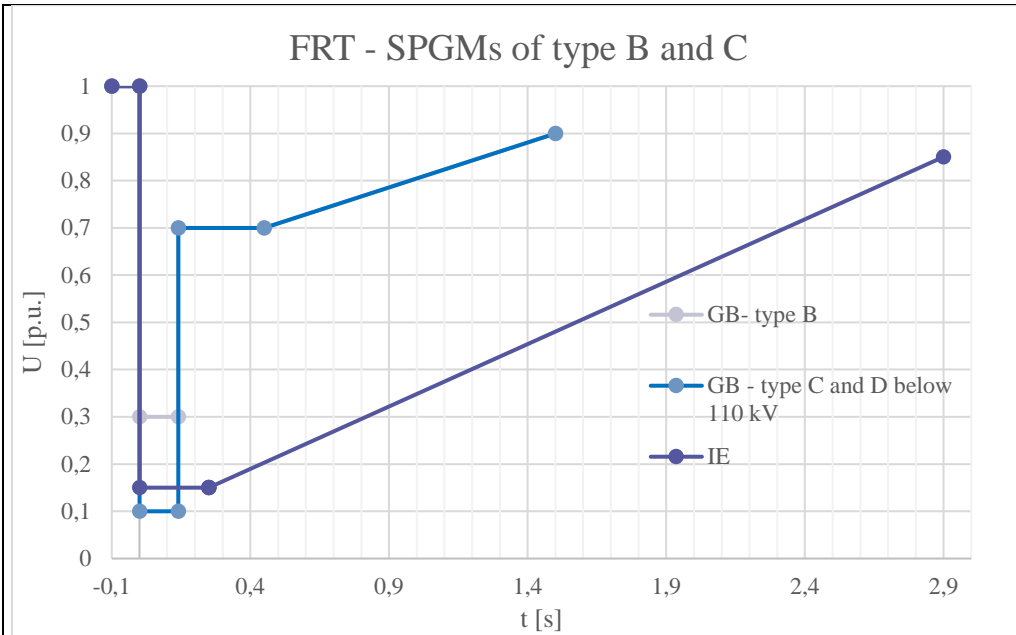
Synchronous Area: Nordic



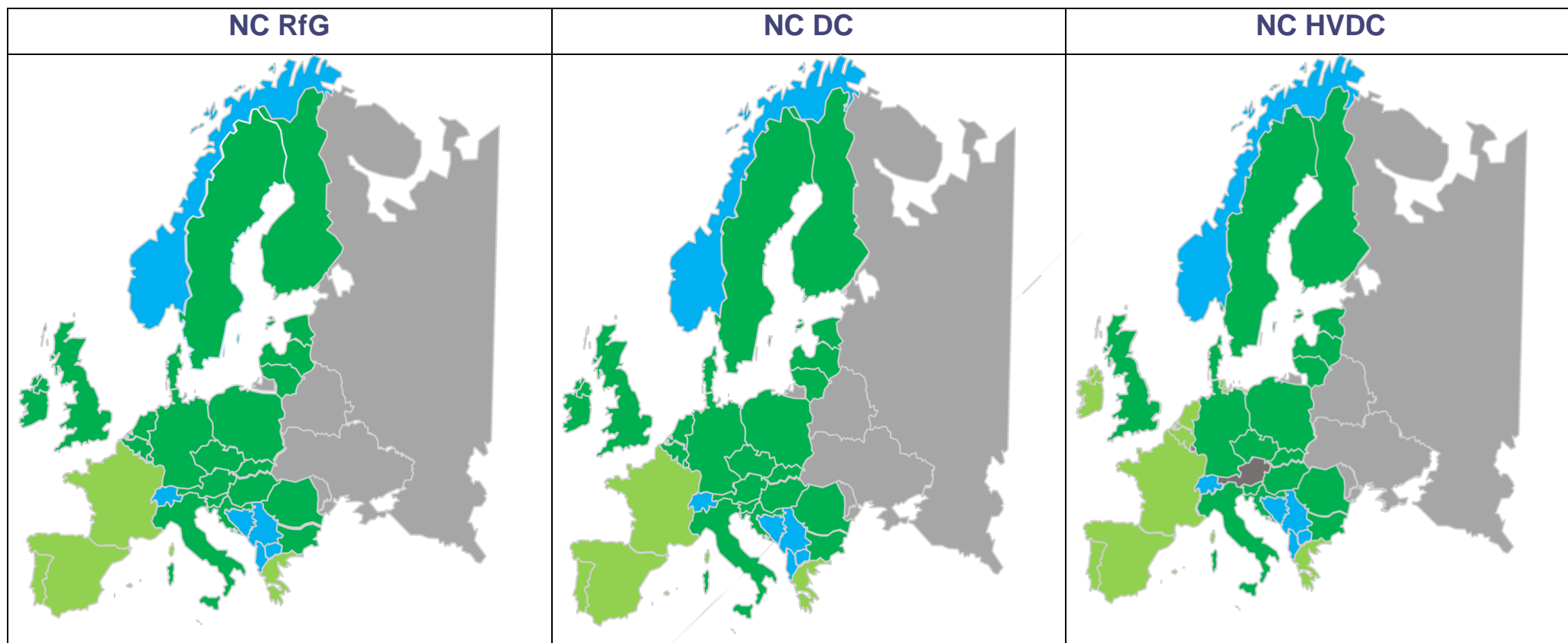
Synchronous Area: Baltic



Synchronous Area: Great Britain and Northern Ireland & Ireland



Annex – Implementation overview at EU member states



Approved/binding

Submitted for approval

Non-EU MS - implementation under different framework

No proposals