

---

# Parameters of Non-exhaustive requirements

ENTSO-E Guidance document for national implementation for network codes on grid connection

---

Draft for consultation 1 July -15 August 2016

22 June 2016

---

## DESCRIPTION

**Codes & Articles** Network Codes (NCs) Requirements for Generators (RfG), Demand Connection Code (DCC) and High Voltage Direct Current (HVDC)  
All articles with non exhaustive requirements for which a national choice is requested (see tables per code below)

**Objective** This general guidance should help to determine the main criteria/motivation for the definition at national level of these non-exhaustive requirements

In order to provide more specific guidance on major issues, some of the requirements have been clustered in separate IGDs:

- Voltage issues
- Frequency parameters
- Restoration issues
- Active and reactive power control
- Instrumentation, simulation and protections parameters

On those clusters, general guidance in order to help the Transmission System Operators (TSOs) to define their own parameters has been provided.

**NC frame** These non-exhaustive topics are those for which the European level CNCs do not contain all the information or parameters necessary to apply the requirements immediately. These requirements are typically described in the CNC as “TSO / relevant system operator shall define” or “defined by / determined by / in coordination with the TSO / relevant TSO”.

Some of them need a choice at national level, but wider sharing and in some cases collaboration on the criteria can be necessary.

Non-exhaustive parameters for any requirement may be varied across different types of significant grid users. Similarly non-exhaustive parameter requirements may be applied regionally. In both cases of varying applications, these need to be justified, comply with the network codes and do not lead to more stringent or detailed rules that would be incompatible with the network codes.

See tables below.

**Further info** IGD Parameters related to frequency stability  
IGD Instrumentation simulation models and protection  
IGD Voltage-related parameters  
IGD System Restoration

## INTERDEPENDENCIES

**Between the NCs** Several requirements exist in all three CNCs, RfG, DCC and HVDC. Consistency in the national choices shall be ensured.

## In other NCs

There are many links nationally to the implementation of the codes applying the connection capabilities in both system and market operation (System Operation Committee and Market Committee topics). In some cases these topics will be at a national level be contained in combined documents (e.g. broader content Grid Codes). Consistency needs to be maintained in these cases, i.e. it needs to be ensured that national connection code frequency capabilities are actually defined so that the settings that need to be applied can be developed through system and market operation codes.

## System characteristics

System characteristics and its likely evolution have to be taken into consideration for the definition at national level of non-exhaustive requirements

The choice of most of the non-exhaustive parameters shall be linked to the level of RES penetration in each country at the entry into force of the NC, but account for the future as system characteristics are expected to change continuously and differently in each country. In this context, it is recommended to consider at national level the expected changes in network needs over the next 15-20 years, in order to define these parameters.

Some choices will be also influenced by the proportion of the different types of generators within the country (type A/B versus C/D).

In general, determining factors to be considered for the definition at national level of the non-exhaustive requirements, could be:

- Maintaining existing requirements and performance, that are already foreseen from previous national regulations where their need and benefit is demonstrated by operational experience
- Taking into consideration national generation portfolio characteristics and their evolution (e.g. level of penetration of renewable energy sources)
- Taking into consideration national system characteristics and its evolution (e.g. rural/urban conditions, density of load and generation)
- Ensuring that requirements needed for guaranteeing security of supply will be fulfilled at any time even considering the peculiarity of each electricity system (such as negative balance of each country)

## Technology characteristics

Specification of non-exhaustive parameters for the functional requirements will typically be unaffected by the use of technology.

### COLLABORATION

## TSO – TSO

Many parameters for non-exhaustive requirements should require coordination between TSOs. in terms of criteria to be considered for the national implementation

Some requirements could require collaboration at synchronous area level, other requirements require collaboration between adjacent TSO, to ensure an efficient behaviour of the facilities connected near the border of these TSOs.

TSO – DSO

Many parameters for non-exhaustive requirements should require coordination between the TSO and Distribution System Operator (DSO) to ensure their function to meet the functional requirements in the CNCs. These will be identified in the associated tables.

REGIONAL SYSTEM  
OPERATOR (RSO) –  
Grid User

Many parameters for non-exhaustive requirements should require coordination between the RNO and end user to ensure their function to meet the functional requirements in the CNCs. These will be identified in the associated tables.

Table 1 – RfG Non-Exhaustive Requirements

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
FREQUENCY ISSUES	FREQUENCY RANGES		13.1.a.(i)	A, B, C, D	Time period for operation in the frequency ranges <b>Continental Europe</b> 47.5 - 48.5 Hz and 48.5 - 49 Hz <b>Nordic</b> :48.5 - 49 Hz <b>GB</b> :48.5 - 49 Hz <b>Ireland</b> :48.5 - 49 Hz <b>Baltic</b> : 47.5 - 48.5 Hz and 48.5 - 49 Hz and 51 - 51,5 Hz	TSO
		X	13.1.a.(ii)	A, B, C, D	Agreement on wider frequency ranges, longer minimum times for operation or specific requirements for combined frequency and voltage deviations	agreement between the RSO (DSO or TSO), in coordination with the TSO, and the Power Generating Facility Owner (PGFO)
	RATE OF CHANGE OF FREQUENCY (ROCOF) WITHSTAND CAPABILITY		13.1.(b)	A, B, C, D	- Maximum ROCOF for which the Power Generating Module (PGM) shall stay connected	TSO
					specify ROCOF of the loss of main protection	RSO in coordination with the TSO
	Limited Frequency Sensitive Mode (LFSM)-O		13.2.(a)	A, B, C, D	Frequency threshold and droop settings	TSO
		X			Requirements in case of expected compliance on an aggregate level	TSO
		X	13.2.(b)	A	Use of automatic disconnection and reconnection	TSO
		X	13.2.e	A, B, C, D	Expected behaviour of the PGM once the minimum regulating level is reached	TSO
	ADMISSIBLE ACTIVE POWER REDUCTION FROM MAXIMUM OUTPUT WITH FALLING FREQUENCY		13.4	A, B, C, D	Admissible active power reduction from maximum output with falling frequency	TSO
			13.5	A, B, C, D	definition of the ambient conditions applicable when defining the admissible active power reduction	TSO
	LOGIC INTERFACE	X	13.6	A, B, C, D	Requirements for the additional equipment necessary to allow active power output to be remotely operable	RSO
	AUTOMATIC CONNECTION TO THE NETWORK		13.7	A, B, C, D	Conditions for automatic connection to the network, including: - frequency ranges and corresponding delay time - Maximum admissible gradient of increase in active power output	TSO
	LOGIC INTERFACE	X	14.2.b	B, C, D	Requirements for the equipment necessary to make the logic interface (to cease active power output) remotely operable	RSO
FREQUENCY STABILITY		15.2.(a)	B, C, D	Time period for frequency stability to be reached	TSO	

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
	LFSM-U		15.2.c	C, D	Definition of the frequency threshold and droop	TSO
				C, D	Definition of Pref	TSO
	FREQUENCY SENSITIVE MODE		15.2.d.(i)	C, D	Parameters of the Frequency Sensitive Mode (FSM): - Active power range related to maximum capacity - Frequency response insensitivity - Frequency response dead band - Droop	TSO
			15.2.d.(iii)	C, D	Maximum admissible full activation time	TSO
			15.2.d.(iv)	C, D	Maximum admissible initial delay for power generating modules with inertia	TSO
		X	15.2.d.(iv)	C, D	Maximum admissible initial delay for power generating modules without inertia	TSO
			15.2.d.(v)	C, D	time period for the provision of full active power frequency response	TSO
	FREQUENCY RESTORATION CONTROL		15.2.e	C, D	Specifications of the Frequency Restoration Control	TSO
	REAL-TIME MONITORING OF FSM		15.2.g	C, D	List of the necessary data which will be sent in real time	RSO (DSO or TSO) or TSO
		X			definition of additional signals	RSO (DSO or TSO) or TSO
RATES OF CHANGE OF ACTIVE POWER OUTPUT		15.6.e	C, D	Definition of the minimum and maximum limits on rates of change of active power output (ramping limits) in both an up and down direction, taking into consideration the specific characteristics of the prime mover technology	RSO in coordination with the TSO	
SYNTHETIC INERTIA CAPABILITY FOR POWER PARK MODULE (PPM)	X	21.2	PPM: C, D	- Definition of the operating principle of control systems to provide synthetic inertia and the related performance parameters	TSO	
VOLTAGE ISSUES	FAULT RIDE THROUGH CAPABILITY		14.3.a	B, C, D	Voltage-against-time profile	TSO
			14.3.a	B, C, D	pre-fault and post-fault conditions	TSO
			14.3.b	B, C, D	Voltage-against-time profile for asymmetric faults	TSO
			16.3.a.(i)	D	voltage-against-time profile	TSO
		X	16.3.a.(ii)	D	pre-fault and post-fault conditions	TSO
			16.3.c	D	Voltage-against-time profile for asymmetric faults	TSO
	ACTIVE POWER CONTROLLABILITY AND CONTROL RANGE		15.2.a	C, D	Time period to reach the adjusted active power set point Tolerance applying to the new set point and the time to reach it.	RSO (DSO or TSO) or TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition	
	<b>AUTOMATIC DISCONNECTION DUE TO VOLTAGE LEVEL</b>		15.3	C, D	Voltage criteria and technical parameters at the connection point for automatic disconnection	RSO (DSO or TSO), in coordination with the TSO	
	<b>VOLTAGE RANGES</b>		16.2.a.(i)	D	<b>For Continental Europe</b> time period for operation in the voltage range 1,118 pu-1,15 pu for PGM connected between <b>110kV and 300 kV</b>	TSO	
		X	16.2.a.(ii)	D	Determination of shorter time periods in the event of simultaneous overvoltage and under frequency or simultaneous under voltage and over frequency	relevant TSO	
		X	16.2.a.(iii)	D	<b>For Spain</b> time period for operation in the voltage range 1,05 pu-1,0875 pu for PGMs connected between <b>300kV and 400 kV may be specified as unlimited</b>	TSO	
		X	16.2.a.(v)	D	<b>For Baltic</b> voltage ranges and time period for operation may be specified in line with continental Europe for facilities connected for <b>400 kV</b>	TSO	
				16.2.b	D	Wider voltage ranges or longer minimum time periods for operation may be agreed.	agreement between the RSO and the PGFO, in coordination with the TSO
		<b>REACTIVE POWER CAPABILITY FOR SYNCHRONOUS PGM</b>	X	17.2.a	Synchronous B, C, D	Capability to supply or absorb reactive power	RSO
	<b>SUPPLEMENTARY REACTIVE POWER FOR SYNCHRONOUS PGM</b>	X	18.2.a	Synchronous C, D	Definition of supplementary reactive power to compensate for the reactive power demand of the high-voltage line or cable when the connection point is not located at the HV side of the step-up transformer	RSO	
	<b>REACTIVE POWER CAPABILITY AT</b>		18.2.b.(i)	Synchronous C, D	Definition of a U-Q/Pmax-profile at maximum capacity	RSO in coordination with the TSO	

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
	<b>MAXIMUM CAPACITY FOR SYNCHRONOUS PGM</b>		18.2.b.(iv)	Synchronous C, D	appropriate timescale to reach the target value	RSO
	<b>VOLTAGE STABILITY FOR SYNCHRONOUS PGM</b>		19.2.b.(v)	Synchronous D	Power threshold above which a PSS function is to be specified	TSO
	<b>REACTIVE POWER CAPABILITY FOR PPM</b>	X	20.2.a	PPM: B, C, D	Capability to supply or absorb reactive power	RSO
	<b>FAST FAULT CURRENT INJECTION FOR PPM</b>	X	20.2.b	PPM: B, C, D	Specifications of: - how and when a voltage deviation is to be determined as well as the end of the voltage deviation - Fast fault current characteristics - Timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance	RSO in coordination with the TSO
		X	20.2.c	PPM: B, C, D	Specifications for asymmetrical current injection, in case of asymmetric faults (1-phase or 2-phase)	RSO in coordination with the TSO
	<b>SUPPLEMENTARY REACTIVE POWER FOR PPM</b>	X	21.3.a	PPM: C, D	Definition of supplementary reactive power for a PPM whose connection point is not located at the high-voltage terminals of its step-up transformer nor at the terminals of the high-voltage line or cable to the connection point at the PPM, if no step-up transformer exists	RSO
	<b>REACTIVE POWER CAPABILITY AT MAXIMUM CAPACITY FOR PPM</b>		21.3.b	PPM: C, D	Definition of a U-Q/Pmax-profile at maximum capacity	RSO in coordination with the TSO
	<b>REACTIVE POWER CAPABILITY BELOW MAXIMUM CAPACITY FOR PPM</b>		21.3.c.(i) 21.3.c.(ii)	PPM: C, D	definition of a P-Q/Pmax-profile below maximum capacity	RSO in coordination with the TSO
			21.3.c.(iv)	PPM: C, D	appropriate timescale to reach the target values	RSO
	<b>REACTIVE POWER CONTROL MODES FOR PPM</b>		21.3.d.(iv)	PPM: C, D	In voltage control mode: t1 = time within which 90% of the change in reactive power is reached t2 = time within which 100% of the change in reactive power is reached	RSO
			21.3.d.(vi)	PPM: C, D	In power factor control mode: - Target power factor - Time period to reach the set point - Tolerance	RSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
			21.3.d.(vii)	PPM: C, D	Specifications of which of the above three reactive power control mode options and associated set points is to apply, and what further equipment is needed to make the adjustment of the relevant set point operable remotely;	RSO, in coordination with the TSO and the PGFO
	<b>PRIORITY TO ACTIVE OR REACTIVE POWER CONTRIBUTION FOR PPM</b>		21.3.e	PPM: C, D	Specification of whether active power contribution or reactive power contribution has priority during faults for which fault-ride-through capability is required.	relevant TSO
	<b>VOLTAGE RANGES FOR OFFSHORE PPM</b>		25.1	Offshore	<b>For Continental Europe</b> time period for operation in the voltage range 1,118 pu-1,15 pu for PGM connected between <b>110kV and 300 kV</b>	TSO
	<b>VOLTAGE CONTROL SYSTEM FOR SYNCHRONOUS PGM</b>		19.2.a	Synchronous D	- Parameters and settings of the components of the voltage control system - Specifications of the AVR	agreement between the PGFO and the RSO, in coordination with the TSO
	<b>VOLTAGE RANGES</b>		25.1	Offshore	<b>For Continental Europe</b> time period for operation in the voltage range 1,118 pu-1,15 pu, 1,05pu-1,10pu for PGM For Nordic time period for operation in the voltage range 1,05pu-1,10pu for PGM	TSO
		X	16.2.a.(iii)	Offshore	<b>For Spain</b> time period for operation in the voltage range 1,05 pu-1,0875 pu for PGMs connected between <b>300kV and 400 kV may be specified as unlimited</b>	TSO
		X	16.2.a.(v)	Offshore	<b>For Baltic</b> voltage ranges and time period for operation may be specified in line with continental Europe for facilities connected for <b>400 kV</b>	TSO
	<b>REACTIVE POWER CAPABILITY AT MAXIMUM CAPACITY FOR OFFSHORE PPM</b>		25.5	Offshore	Definition of the U-Q/Pmax-profile at Pmax	TSO
<b>RESTORAT SYSTEM</b>	<b>CAPABILITY OF RECONNECTION AFTER AN INCIDENTAL DISCONNECTION</b>		14.4.a	B, C, D	Conditions for reconnection to the network after an incidental disconnection caused by network disturbance	TSO
			14.4.b	B, C, D	Conditions for automatic reconnection	TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
	<b>CAUSED BY A NETWORK DISTURBANCE</b>					
	<b>BLACK START CAPABILITY</b>	X	15.5.a.(ii)	C, D	Technical specifications for a quotation for Black Start Capability	TSO
		X	15.5.a.(iii)	C, D	Timeframe within which the PGM is capable of starting from shutdown without any external electrical energy supply	RSO (DSO or TSO) in coordination with the TSO
		X	15.5.a.(iv)	C, D	voltage limits for synchronisation when art.16.2 non applicable	RSO (DSO or TSO)
	<b>CAPABILITY TO TAKE PART IN ISLAND OPERATION</b>	X	15.5.b.(iii)	C, D	Methods and criteria for detecting island operation	agreement between the PGFO and the RSO (DSO or TSO), in coordination with the TSO
	<b>OPERATION FOLLOWING TRIPPING TO HOUSELOAD</b>		15.5.c.(iii)	C, D	Minimum operation time within which the PGM is capable of operating after tripping to house load	RSO (DSO or TSO), in coordination with the TSO
	<b>ACTIVE POWER RECOVERY FOR SYNCHRONOUS PGM</b>		17.3	Synchronous B, C, D	Definition of the magnitude and time for active power recovery	TSO
<b>POST FAULT ACTIVE POWER RECOVERY FOR PPM</b>		20.3.a	PPM: B, C, D	Specifications of the post-fault active power recovery  Following specifications: - when the post-fault active power recovery begins, based on a voltage criteria - a maximum allowed time for active power recovery - a magnitude and accuracy for active power recovery	TSO	
<b>MODELS AND PROTECTION INSTRUMENTATION SIMULATION</b>	<b>CONTROL SCHEME AND SETTINGS</b>		14.5.a	B, C, D	control schemes and settings of the control devices	agreement and coordination between the TSO, the RSO (TSO and DSO) and the PGFO
	<b>ELECTRICAL PROTECTION SCHEMES AND SETTINGS</b>		14.5.b	B, C, D	protection schemes and settings	agreement and coordination between the RSO and the PGFO
	<b>INFORMATION EXCHANGES</b>		14.5.d	B, C, D	Content of information exchanges and precise list and time of data to be facilitated.	RSO (DSO or TSO) or TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
	<b>MANUAL, LOCAL MEASURES WHERE THE AUTOMATIC REMOTE DEVICES ARE OUT OF SERVICE</b>		15.2.b	C, D	Time period and tolerance requested to reach the set point in cases where the automatic remote control devices are out of service	RSO (DSO or TSO) or TSO
	<b>LOSS OF ANGULAR STABILITY OR LOSS OF CONTROL</b>		15.6.a	C, D	criteria to detect loss of angular stability or loss of control	Agreement between the PGFO and the RSO (DSO or TSO), in coordination with the TSO.
	<b>INSTRUMENTATION</b>	X	15.6.b.(i)	C, D	Definition of the quality of supply parameters	RSO
			15.6.b.(ii)	C, D	Settings of the fault recording equipment, including triggering criteria and the sampling rates	Agreement between the PGFO and the RSO (DSO or TSO), in coordination with the TSO.
			15.6.b.(iii)	C, D	Specifications of the oscillation trigger detecting poorly damped power oscillations	RSO in coordination with the TSO
			15.6.b.(iv)	C, D	Protocols for recorded data.	agreement between the PGFO, the RSO and the relevant TSO
	<b>SIMULATION MODELS</b>	X	15.6.c.(iii)		Specifications of the simulation models	RSO in coordination with the TSO
	<b>INSTALLATION OF DEVICES FOR SYSTEM OPERATIONS AND SYSTEM SECURITY</b>	X	15.6.d	C, D	Definition of the devices needed for system operation and system security	RSO or TSO and PGFO
	<b>NEUTRAL-POINT AT THE NETWORK SIDE OF STEP-UP TRANSFORMERS</b>		15.6.f	C, D	Specifications of the earthing arrangement of the neutral-point at the network side of step-up transformers	RSO
	<b>AUTOMATIC DISCONNECTION</b>	X	16.2.c	D	Definition of the threshold for automatic disconnection	RSO in coordination with the TSO
					Definition of the parameters	agreement between le RSO and the PGFO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
	<b>SYNCHRONISATION</b>		16.4	D	Settings of the synchronisation devices	agreement between le RSO et the PGFO
	<b>ANGULAR STABILITY UNDER FAULT CONDITIONS</b>		19.3	Synchronous	Agreement for technical capabilities of the PGM to aid angular stability.	agreement between the TSO and the PGFO
	<b>SYNTHETIC INERTIA CAPABILITY FOR PPM</b>	X	21.2	PPM: C, D	- Definition of the operating principle of control systems to provide synthetic inertia and the related performance parameters	TSO

Table 2 – DCC Non-Exhaustive Requirements

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition	
FREQUENCY ISSUES	FREQUENCY RANGES		12.1	Transmission Connected Demand Facility (DF) and DSO	Time period for operation in the frequency ranges <b>Continental Europe</b> 47.5 - 48.5 Hz and 48.5 - 49 Hz <b>Nordic</b> :48.5 - 49 Hz <b>GB</b> :48.5 - 49 Hz <b>Ireland</b> :48.5 - 49 Hz <b>Baltic</b> : 47.5 - 48.5 Hz and 48.5 - 49 Hz and 51 - 51,5 Hz	TSO	
		X	12.2	Transmission Connected DF and DSO	Agreement on wider frequency ranges, longer minimum times for operation	agreement between the DSO, Transmission Connected Demand Facility (TCDF) and the TSO	
		X	29.2 (a)	DF and Closed Distribution System (CDS) offering Demand Response (DR)	definition of a extended frequency range	agreement between TSO and TC DSO or TC DF	
	DEMAND RESPONSE SFC		X	29.2 (c)	Demand Unit (DU) offering DR	for DU connected below 110 kV: definition of the normal operating range	RSO
			X	29.2 (c)	DU offering DR	definition of the allowed frequency dead band	TSO, in consultation with the TSO of the synchronous area
			X	29.2 (e)	DU offering DR	definition of the frequency range for DR System Frequency Control (SFC) and definition of the maximum frequency deviation to respond	TSO, in consultation with the TSO of the synchronous area
			X	21.2 (g)	DU offering DR	definition of the rapid detection and response to frequency system changes	TSO, in consultation with the TSO of the synchronous area
	VOLTAGE ISSUES	VOLTAGE RANGES		13.1 and ANNEX II	Transmission Connected DF and Transmission connected DSO above 110kV	<b>For Continental Europe</b> time period for operation in the voltage range 1,118 pu-1,15 pu for facilities connected between <b>110kV and 300 kV</b>	TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
		X	13.4	Transmission Connected DF and Transmission connected DSO above 110kV	<b>For Spain</b> time period for operation in the voltage range 1,05 pu-1,0875 pu for facilities connected between <b>300kV and 400 kV may be specified as unlimited</b>	TSO
		X	13.5	Transmission Connected DF and Transmission connected DSO above 110kV	<b>For Baltic</b> voltage ranges and time period for operation may be specified in line with continental Europe for facilities connected for <b>400 kV</b>	TSO
	<b>AUTOMATIC DISCONNECT ON DUE TO VOLTAGE LEVEL</b>		13.6	Transmission Connected DF and Transmission connected DSO	Voltage criteria and technical parameters at the connection point for automatic disconnection	agreement between TCDF or TCDSO and the TSO
	<b>REACTIVE POWER CAPABILITY FOR TRANSMISSION CONNECTED DEMAND FACILITY AND TRANSMISSION CONNECTED DISTRIBUTION SYSTEM</b>		15.1 (a)	Transmission Connected DF	definition of the actual reactive power range for DF without onsite generation	TSO
			15.1 (b)	Transmission Connected DSO	definition of the actual reactive power range for DF with onsite generation	TSO
	<b>REACTIVE POWER CAPABILITY FOR TRANSMISSION CONNECTED DISTRIBUTION SYSTEM</b>		15.1 (c)	Transmission Connected DSO	Definition of the scope of the analysis to find the optimal solution for reactive power	agreement between TSO and TC DSO
		X	15.1 (d)	Transmission Connected DF and DSO	Define other metrics than power factor	TSO
		X	15.1 (e)	Transmission connected DF and Transmission connected DSO	use of other metrics	TSO
	<b>DEMAND RESPONSE APC, RPC and TRANSMISSION CONSTRAINT MANAGEMENT (TCM)</b>	X	28.2 (a)	DF and CDS offering DR	definition of a extended frequency range	agreement between TSO and TC DSO or TC DF
		X	28.2 (c)	DF and CDS offering DR	for DF or CDS connected below 110 kV: definition of the normal operating range	RSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
		X	20.2 € , (l)	DF and CDS offering DR	technical specifications to enable the transfer of information for DR LFDD and Low Voltage Demand Disconnection (LVDD), for DR Active Power Control (APC) and DR Reactive Power Control	RSO
		X	20.2 (f), (j)	DF and CDS offering DR	definition of the time period to adjust the power consumption	TSO
		X	20.2 (i)	DF and CDS offering DR	definition of the modalities of notification in case of a modification of the DR capability	RSO or TSO
		X	20.2 (o)	DF and CDS offering DR	definition of the ROCOF maximum value	TSO
	<b>POWER QUALITY</b>		20	Transmission connected DF and Transmission connected DSO	allocated level of voltage distortion	TSO
<b>SYSTEM RESTORATION</b>	<b>SHORT CIRCUIT REQUIREMENTS</b>		14.1	Transmission Connected DF and Transmission connected DSO	maximum short-circuit current at the connection point to be withstood	TSO
			14.3		unplanned events: threshold of the maximum short circuit current inducing an information from the TSO in case of a change above this threshold	TCDF or TCDSO
			14.5		planned events: threshold of the maximum short circuit current inducing an information from the TSO in case of a change above this threshold	TCDF or TCDSO
			14.8		unplanned events: threshold of the maximum short circuit current inducing an information from the TC DF or TC DSO in case of a change above this threshold	TSO
			14.9		planned events: threshold of the maximum short circuit current inducing an information from the TC DF or TC DSO in case of a change above this threshold	TSO
	<b>DEMAND DISCONNECTION FOR SYSTEM DEFENSE</b>		19.1	Transmission connected DF and Transmission connected DSO	Definition the capabilities of Low Frequency Demand Disconnection (LFDD) scheme	TSO
			19.2 (a)	Transmission connected DSO	Definition of the LVDD scheme	TSO, in coordination with the TC DSO
			19.2 (b)	Transmission connected DF	Definition of the LVDD scheme	TSO, in coordination with the TC DFO
		X	19.3(b)	Transmission connected DSO	Definition of the automatic on load tap changer blocking scheme	TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
			19.4 (a)	Transmission connected DF and Transmission connected DSO	Definition of the conditions for reconnection after a disconnection	TSO
			19.4 (b)	Transmission connected DF and Transmission connected DSO	Settings of the synchronisation devices (including frequency, voltage, phase angle range and deviation of voltage and frequency)	agreement between TSO and TC DSO or TC DF
		X	19.4 (c)	Transmission connected DF and Transmission connected DSO	definition of the automated disconnection equipment time for remote disconnection	TSO
INSTRUMENTATION SIMULATION MODELS AND PROTECTION	<b>ELECTRICAL PROTECTION SCHEMES AND SETTINGS</b>		16.1	Transmission connected DF and Transmission connected DSO	protection schemes and settings	agreement between TSO and TC DSO or TC DF
	<b>CONTROL REQUIREMENTS</b>		17.1	Transmission connected DF and Transmission connected DSO	schemes and settings of the control devices	agreement between TSO and TC DSO or TC DF
	<b>INFORMATION EXCHANGES</b>		18.1	Transmission connected DF and Transmission connected DSO	definition of the standards to exchange information and time stamping	TSO
			18.2	Transmission connected DF and Transmission connected DSO	definition of the standards to exchange information and time stamping	TSO
			18.3	Transmission connected DF and Transmission connected DSO	Make information exchange standards publically available	TSO
	<b>SIMULATION MODELS</b>	X	21.3	Transmission connected DF, distribution systems and DF above 1000V providing DR	Content and format of the simulation models or equivalent information	TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
		X	21.5	Transmission connected DF, distribution systems and DF above 1000V providing DR	Definition of the requirements for the recordings it to be compared with the response of the model.	RSO or TSO

Table 3 – HVDC Non-Exhaustive Requirements

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
FREQUENCY ISSUES	FREQUENCY RANGES		11.1	HVDC System	Time period for operation in the frequency ranges <b>Continental Europe</b> 47.5 - 48.5 Hz and 48.5 - 49 Hz <b>Nordic</b> :48.5 - 49 Hz <b>GB</b> :48.5 - 49 Hz <b>Ireland</b> :48.5 - 49 Hz <b>Baltic</b> : 47.5 - 48.5 Hz and 48.5 - 49 Hz and 51 - 51,5 Hz	RSO
	WIDER FREQUENCY RANGES	X	11.2	HVDC System	Agreement on wider frequency ranges, longer minimum times for operation	Agreement between TSO and HVDC System Operator
	AUTOMATIC DISCONNECTION		11.3	HVDC System	Frequencies to disconnect	TSO
	MAXIMUM ADMISSABLE POWER OUTPUT	X	11.4	HVDC System	Maximum admissible power output below 49Hz	TSO
	ACTIVE POWER CONTROLLABILITY	X	13.1.(a)i	HVDC system	Maximum and minimum power step	TSO
	ACTIVE POWER CONTROLLABILITY	X	13.1.(a)ii	HVDC System	Minimum active power transmission capacity	TSO
		X	13.1.(a)ii	HVDC System	Maximum delay	TSO
			13.1.(b)	HVDC System	Modification of transmitted active power	TSO
	FAST ACTIVE POWER REVERSAL	X	13.1.(c)	HVDC System	Capability or not	TSO
	AUTOMATIC REMEDIAL ACTIONS	X	13.3	HVDC system	If required, and triggering and blocking criteria	TSO
	SYNTHETIC INERTIA	X	14.1	HVDC System	If required, and functionality	TSO
		X	14.2	HVDC System	Principle of control and performance parameters	Agreement between TSO and HVDC System Operator
	FREQUENCY SENSITIVE MODE		Annex II. 3.(e)	HVDC System	Frequency threshold and droop settings	TSO
			Annex II. 3.(h)(ii)	HVDC System	Active power response capability	TSO
	LFSM-O		Annex II. 4.(m)	HVDC System	Time for full activation	TSO
			Annex II. 5.	HVDC System	Frequency threshold and droop settings	TSO
	LFSM-U		Annex II. 6.(q)	HVDC System	Time for full activation	TSO
		Annex II. 7.	HVDC System	Frequency threshold and droop settings	TSO	
FREQUENCY CONTROL MODE	X	16.1	HVDC System	Need for independent control mode to modulate active power output	TSO	

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
		X	16.1	HVDC System	Specify operating principle	TSO
	<b>MAX. LOSS OF ACTIVE POWER</b>		17.1	HVDC System	specify limit for loss of active power injection	TSO
			17.2	HVDC System	Coordinate specified limit of active power injection	TSOs
	<b>FREQUENCY STABILITY REQUIREMENTS</b>		39.1	HVDC System	Specify coordinated frequency control capabilities	TSO
	<b>FREQUENCY RANGES</b>		39.2.(a)	DC-Connected Power Park Module	Nominal frequencies other than 50Hz will be provided	TSO
	<b>WIDER FREQUENCY RANGES</b>	X	39.2(b)	DC-Connected Power Park Module	Agreement on wider frequency ranges, longer minimum times for operation	Agreement between TSO and HVDC System Operator
	<b>AUTOMATIC DISCONNECTION</b>		39.2(C)	DC-Connected Power Park Module	Frequencies to disconnect	TSO
	<b>LFSM-O</b>		39.4	DC connected Power Park Modules	Frequency threshold and droop settings	TSO
					For PPM: Definition of Pref	TSO
		X			Requirements in case of expected compliance on an aggregate level	TSO
		X			Expected behaviour of the PGM once the minimum regulating level is reached	TSO
	<b>CONSTANT POWER</b>		39.5	DC-Connected Power Park Module	Specify parameters in accordance with Network Code RfG Article 13(3)	See RfG
	<b>ACTIVE POWER CONTROLLABILITY</b>		39.6	DC-Connected Power Park Module	Specify parameters in accordance with Network Code RfG Article 15(2)(a)	See RfG
	<b>LFSM-U</b>		39.7	DC-Connected Power Park Module	Specify parameters in accordance with Network Code RfG Article 15(2)(c)	See RfG
	<b>FSM WITH SUBJECT TO A FAST SIGNAL RESPONSE</b>		39.8	DC-Connected Power Park Module	Specify parameters in accordance with Network Code RfG Article 15(2)(d)	See RfG
	<b>FREQUENCY RESTORATION</b>		39.9	DC-Connected Power Park Module	Specify parameters in accordance with Network Code RfG Article 15(2)(e)	See RfG
	<b>3-9 FOR FREQUENCIES OTHER THAN 50HZ</b>		39.10	DC connected Power Park Modules	Define the parameters capabilities in Article 39.3-39.9 for frequencies other than 50Hz	TSO
	<b>FREQUENCY RANGES</b>		47.1	Remote-end HVDC converter stations	Nominal frequencies other than 50Hz will be provided accounting for Annex I requirements	TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
VOLTAGE ISSUES	VOLTAGE RANGES		Annex III. Table 4	HVDC System	For Continental Europe time period for operation in the voltage range 1,118 pu-1,15 pu for PGM connected between 110kV and 300 kV	TSO
	VOLTAGE RANGES		Annex III. Table 5	HVDC System	For Continental Europe time period for operation in the voltage range 1,05 pu-1,0875 pu and Nordic time period for operation in the voltage range 1,05 pu-1,10pu both for PGM connected between 300kV and 400 kV	TSO
	AGREEMENT ON WIDER VOLTAGE RANGES OR LONGER MIN. TIMES		18.3	HVDC System	Wider voltage ranges or longer minimum time periods for operation may be agreed.	Agreement between TSO and HVDC System Operator
	AUTOMATIC DISCONNECTION		18.3	HVDC System	Voltage criteria and technical parameters at the connection point for automatic disconnection	Agreement between TSO and HVDC System Operator
	VOLTAGE RANGES		18.4	HVDC System	Specify IPU applicable requirements at connection points	RSO with TSOs
		X	18.5	HVDC System	Decision on use continental Europe voltage ranges	Baltic TSOs
	SHORT CIRCUIT CONTRIBUTION DURING FAULTS	X	19.2.(a)	HVDC System	Specifications on voltage deviation	TSO
		X	19.2.(b)	HVDC System	Characteristics of fast fault current	TSO
		X	19.2.(c)	HVDC System	timing and accuracy of fast fault current	TSO
		X	19.3	HVDC System	Specify asymmetrical current injection for such faults	RSO with TSO
	REACTIVE POWER CAPABILITY		20.1	HVDC Converter station	U-Q/Pmax profile at maximum capacity	RSO with TSO
			20.3	HVDC Converter station	Provide timescale to move within U-Q/Pmax profile	RSO with TSO
	REACTIVE POWER EXCHANGED WITH THE NETWORK		21.2	HVDC Converter station	Specify maximum tolerable voltage step value	TSO
	REACTIVE POWER CONTROL MODE		22.1	HVDC Converter station	Define which of the control modes are required	TSO
			22.2	HVDC Converter station	Define of any other control modes are required and if so what are they	TSO
			22.3.(b)	HVDC Converter station	For voltage control mode definition of adjustment steps required for dead band	RSO with TSO
			22.3.(c)	HVDC Converter station	In voltage control mode time within which 90% of the change in reactive power is reached within 01-10secs	RSO with TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
			22.3.(c)	HVDC Converter station	In voltage control mode t <sub>2</sub> = time within which 100% of the change in reactive power is reached within 1-60secs	RSO with TSO
			22.3.(d)	HVDC Converter station	Voltage control slope specified by range and step	RSO with TSO
			22.4	HVDC System	Reactive power range in Mvar or %	RSO
			22.5	HVDC System	Maximum allowable step size of set point	RSO
			22.6	HVDC System	Equipment specification to enable remote control of control modes and set points	RSO with TSO
	<b>PRIORITY TO ACTIVE OR REACTIVE POWER CONTRIBUTION</b>		23	HVDC System	TSO decide active or reactive power has priority	TSO
	<b>FAULT RIDE THROUGH CAPABILITY (FRT)</b>		25.1	HVDC System	Specify voltage against time profile and conditions in which it applies	TSO
		X	25.2	HVDC System	On request provide pre and post fault conditions	RSO
		X	25.4	HVDC System	Voltages where HVDC system can block	Agreement between TSO and HVDC System Operator
			25.5	HVDC System	Acceptance of and narrower settings on under voltage protection	Agreement between TSO and HVDC System Operator
			25.6	HVDC System	Specify FRT capabilities for asymmetrical faults	TSO
	<b>POWER QUALITY</b>		24	HVDC System	Specify fluctuation limits to be respected	TSO
			44	DC connected Power Park Modules	Specify voltage and distortion limits	RSO in coordination with TSO
			50	Remote-end HVDC converter stations	Specify voltage and distortion limits	RSO in coordination with TSO
	<b>POST FAULT ACTIVE POWER RECOVERY</b>		26	HVDC System	Active power recovery magnitude and time profile	TSO
	<b>VOLTAGE RANGES</b>		Annex VII. Table 9 and 10	DC connected Power Park Modules	Time period for operation in the voltage range 1.1-1.118pu and 1,118 pu-1,15 pu for DC connected PPM connected between 110kV and 300 kV and 1.05-1.15pu for DC connected PPM connected from 300kV to 400kV	RSO in coordination with TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
	<b>AGREEMENT ON WIDER VOLTAGE RANGES OR LONGER MIN. TIMES</b>		40.1.(b)	DC connected Power Park Modules	Wider voltage ranges or longer minimum time periods for operation may be agreed.	Agreement between TSO and DC connected PPM owner
	<b>AUTOMATIC DISCONNECTION</b>		40.1.(c)	DC connected Power Park Modules	Voltage criteria and technical parameters at the connection point for automatic disconnection	Agreement between TSO and DC connected PPM owner
	<b>VOLTAGE RANGES FOR OTHER AC VOLTAGES</b>		40.1.(d)	DC connected Power Park Modules	Time period for operation in the voltage range for DC connected PPM	TSO
	<b>AGREEMENT HOW TO MEET REACTIVE POWER REQUIREMENTS (TODAY, FUTURE)</b>		40.1.(i)	DC connected Power Park Modules	Reactive power capabilities	RSO in coordination with TSO
	<b>REACTIVE POWER CAPABILITY</b>		40.2.(b)(i)	DC connected Power Park Modules	Reactive power range within profile in table 11 of Annex VII and if applicable Reactive power range from Article 25(4) of the RfG	RSO in coordination with TSO
	<b>REACTIVE POWER CONSUMPTION OF EXTRA HIGH VOLTAGE LINE</b>		40.2.(b)(ii)	DC connected Power Park Modules	Supplementary reactive power requirements at connection point	RSO in coordination with TSO
	<b>PRIORITY TO ACTIVE AND REACTIVE POWER CONTRIBUTION</b>		40.3	DC connected Power Park Modules	RSO decide active or reactive power has priority	RSO in coordination with TSO
	<b>REACTIVE POWER AND VOLTAGE RANGES</b>		Annex VIII. Table 12 and 13	Remote-end HVDC converter stations	Time period for operation in the voltage range 1.1-1.12pu and 1.2 pu-1.15 pu for remote end converters connected between 110kV and 300 kV and 1.05-1.15pu for remote end converters connected from 300kV to 400kV	TSO
	<b>AGREEMENT ON WIDER VOLTAGE RANGES OR LONGER MIN. TIMES</b>		48.1(b)	Remote-end HVDC converter stations	Wider voltage ranges or longer minimum time periods for operation may be agreed.	Agreement between RSO, TSO and remote end converter owner
	<b>VOLTAGE RANGES FOR OTHER AC VOLTAGES</b>		48.1(c)	Remote-end HVDC converter stations	Time period for operation in the voltage range for DC connected PPM	RSO in coordination with TSO
	<b>REACTIVE POWER PROVISION</b>		48.2.(a)	Remote-end HVDC converter stations	Reactive power capabilities for various voltage levels	RSO in coordination with TSO

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition	
	<b>U-Q/PMAX-PROFILE</b>		48.2.(a)	Remote-end HVDC converter stations	Reactive power capabilities within the boundaries in Annex VIII, table 14	RSO in coordination with TSO	
<b>SYSTEM RESTORATION</b>	<b>ENERGISATION AND SYNCHRONISATION OF HVDC CONVERTER STATIONS</b>	X	28	HVDC Converter Station	If RSO specified, provide limits (including transient max. magnitude, duration and measurement window) of any voltage change to a steady-state level (>5% pre-synchronisation voltage)	RSO with TSO	
	<b>POWER OSCILLATION DAMPING CAPABILITY</b>		30	HVDC System	Specify frequency range to test capability. Agree control parameter settings	TSO, Agreement between TSO and HVDC System Operator	
			30.2	HVDC System	Specifications of extent of SSSI and parameters	TSO	
			30.3	HVDC System	Identify all parties relevant at a connection point	TSO	
	<b>BLACK START</b>	X	37.1	HVDC System Owner	Obtain quote for black start	TSO	
		X	37.2	HVDC System	Timeframe and voltage limits to energise AC busbar with black start, with wider frequency and voltage ranges than Article 11/18 as required	TSO	
		X	37.3	HVDC System Owner	Capacity and availability of black start	Agreement with TSO and HVDC System Owner	
	<b>STABLE OPERATION WITHIN MIN &amp; MAX SC POWER</b>		42.(b)	DC connected Power Park Modules	Specify minimum to maximum short circuit range	RSO in coordination with TSO	
	<b>AND PROTECTION INSTRUMENTATION SIMULATION MODELS</b>	<b>INTERACTION BETWEEN HVDC SYSTEMS AND OTHER PLANTS/EQUIPMENTS</b>		29.2	HVDC Converter Station	Specify study required to examine interaction with adjacent equipment	TSO
				29.3	HVDC Converter Station	Specify all other relevant parties to the study	TSO
			29.4	TSO	Models/information for use in studies	Interacting 3rd Parties	
			29.6	HVDC System	Specify transient levels of performance	TSO	
<b>NETWORK CHARACTERISTICS</b>			32.1	HVDC System	Method and pre-fault and post fault conditions for minimum and maximum short circuit power	TSO	
<b>HVDC SYSTEM ROBUSTNESS</b>			33.1	HVDC System	Specify changes in system conditions for HVDC system to remain stable	TSO	
<b>ELECTRICAL PROTECTION SCHEMES AND SETTINGS</b>			34.1	HVDC System	Specify schemes and settings	TSO with RSO	
			34.3	HVDC System	Acceptance of changes by owner to protection	TSO	

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Definition
			35.1	HVDC System	Control modes and parameters for a control scheme	Agreement with RSO, TSO and HVDC System Owner
		X	35.2	HVDC System	Change to priority order of protection and control	TSO
	<b>CHANGES TO PROTECTION AND CONTROL SCHEMES AND SETTINGS</b>	X	36.1	HVDC System	Changes to control modes or protections settings	TSO
		X	36.2	HVDC System	Coordination of changes and agreement	Agreement with RSO, TSO and HVDC System Owner
	<b>CHANGES TO PROTECTION AND CONTROL SCHEMES AND SETTINGS</b>	X	36.3	HVDC System	Equipment specification to enable remote control of control modes and set points	TSO
	<b>SYNCHRONIZATION</b>		41.1	DC connected Power Park Modules	Provide limits (including transient max. magnitude, duration and measurement window) of any voltage change to a steady-state level (>5% pre-synchronisation voltage)	RSO in coordination with TSO
	<b>OUTPUT SIGNALS</b>		41.2	DC connected Power Park Modules	Specify required output signals	RSO in coordination with TSO
	<b>METHOD OF PRE-FAULT AND POST-FAULT CONDITIONS</b>		42.(a)	DC connected Power Park Modules	Method and pre-fault and post fault conditions for minimum and maximum short circuit power	RSO in coordination with TSO
	<b>EQUIVALENTS REPRESENTING THE COLLECTION GRID</b>		42.(c)	DC connected Power Park Modules	Provide network equivalent for harmonic studies	RSO in coordination with TSO
	<b>ELECTRICAL PROTECTION SCHEMES</b>		43.1	DC connected Power Park Modules	Provide protection requirements	RSO in coordination with TSO
<b>ISSUES GENERAL</b>	<b>SCOPE</b>		38	DC connected Power Park Modules	Non-exhaustive requirements of Articles 11 to 22 of the Network Code RfG will apply	-
	<b>SCOPE</b>		46	Remote-end HVDC converter stations	Non-exhaustive requirements of Articles 11 to 39 will apply	-