European Network of
Transmission System Operators
for Electricity

Parameters related to voltage issues

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

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Description	
Code(s) and Article(s)	Common requirements in Requirements for Generators (RfG), Demand Connection Code (DCC) and High Voltage Direct Current (HVDC): Time period for operation within the defined voltage ranges:

RfG	HVDC	DCC
Art 16.2.a	Art 18	Art 12.1

Automatic Disconnection:

RfG	HVDC	DCC
Art 15.3 and 16.2.c	Art 18.3	Art 12.5

Common requirements in RfG/HVDC:

Wider voltage ranges:

RfG	HVDC
Art 16.2.b	Art 18.2

Fast fault current injection for PPM / Short circuit contribution during faults:

RfG	HVDC
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RfG	HVDC
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Introduction	Voltage requirements are critical to secure planning and operation of a power system within a synchronous area. Voltage issues have a cross border impact as disturbances can propagate widely and, in the worst case, can cause significant disconnection of Power Generating Modules (PGMs), either directly or because of the consequence of a large disturbance on the system frequency. The objective of this guidance document is provide general but more detailed guidance on a cluster of parameters related to voltage issues and to give a framework to define the related non-exhaustive technical requirements . This guidance also seeks to ensure consistency between the

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	requirements for generators, HVDC links and demand facilities in order to ensure voltage stability or recovery. As such this guidance document should be viewed in conjunction with the general guidance on non-exhaustive requirements and more specific IGDs on these issues. This guidance document will also address the elements to be considered in deciding whether a non-mandatory requirement shall be required by a Transmission System Operator (TSO).
NC Frame	**Time period for operation within the defined voltage ranges**

Voltage ranges are defined for grid users connected above 110 kV. For the Continental Europe, Spain and Nordic synchronous areas, the time period for operation in the high-voltage ranges dependant on the connection code has a non-exhaustive parameter that is to be defined at a national level is the time period for operation in the high-voltage ranges. The limits of these time periods for operation are defined in all three Connection Network Codes (Article 16.2.a for the RfG, Article 12.1 for the DCC and Article 18 for the HVDC).

The time period chosen shall be sufficient for the voltage to return to the unlimited range. It has to be long enough for the TSO to take the necessary mitigating actions and short enough to limit the constraints on the grid users' equipment.

The time necessary to return to the unlimited voltage range will depend on the type of actions available to the TSO. If mitigating actions rely on automated compensation devices or controls, this time shall be shorter than if the mitigating actions are manual.

This time shall be short enough in order to meet the need to operate securely the system in high voltage situations according the technical/design limitations of components.

One example of the impact of a technical limitation is when selecting the appropriate operational time period parameter to apply to voltage ranges[1].

400kV (or alternatively commonly referred to as 380kV) voltages are commonly used in Europe. Some differences exist between the three connection codes. NCs RfG and DCC define the reference 1pu value as 400kV for the 400kV grid voltage level. NC HVDC however states "The establishment of the reference 1 pu voltage shall be subject to coordination between the adjacent relevant system operators".

For consistency 400kV should be used in all cases as the 1 pu voltage.

For Continental Europe and Nordic synchronous areas NCs RfG (Table

[1] See also FAQs 20 and 21 for the RfG at: https://www.entsoe.eu/fileadmin/user_upload/_library/consultations/Network_Code_RfG/120626_-_NC_RfG_-_Frequently_Asked_Questions.pdf

6.2) and DCC (Table 3) specify a time period of 20 to 60 minutes to be selected by each TSO for operation from 1.05-1.1pu for 400kV. NC HVDC for HVDC links above 300kV for operation from 1.05-1.0875pu defines the time period for Continental Europe as “To be specified by each TSO, but not less than 60 minutes” (Table 5). The longer period for HVDC reflects the importance placed on keeping the major components of the system operational.

International standards for equipment (i.e. International Electro-technical Committee (IEC) standards) apply a maximum continuous operating voltage (typically Umax) and for 400kV networks this is 420kV. Consequently up to 1.05 pu for 400kV networks a continuous range can be accommodated by equipment designed with a maximum voltage range of 420kV.

However for voltage ranges above 1.05 pu, the adequacy of the equipment capability is defined by the equipment temporary overvoltage capability2. For 420kV switchgear equipment, international standards and experience would permit the use of equipment up to 440kV for a limited time within the ranges defined by the connection network codes. To align to the NC HVDC requiring a minimum of 60 minutes, it is necessary to go beyond the existing standard. This reflects the importance attached to high resilience expected of HVDC links as part of the backbone of the future electrical power system.

Wider voltage ranges

Wider voltage ranges or longer minimum time periods within those voltage ranges can be defined for power generating modules type D and HVDC links, if needed to preserve or restore system security. The technical and economic impact of this requirement for the PGM owner or the HVDC owner shall be assessed to ensure that it is a cost effective solution compared to any other.

This requirement shall be defined in specific cases. One of the aims of the Connection Network Codes is to try to harmonize the connection technical requirements within Europe.

Automatic disconnection

Automatic disconnection is required from HVDC links, Power generating modules type C and D (but not mandatory for type D) and transmission connected demand facilities, transmission connected distribution facility, transmission connected distribution systems at specified voltage levels. During national implementation, the voltage level for disconnection and the technical parameters shall be defined.

For transmission connected demand facilities, transmission connected distribution facility, transmission connected distribution systems, HVDC circuits and power generating modules type D, this requirement is not

[2] See also: CIGRE WG 33.10, Temporary Overvoltages: Withstand Characteristics of Extra High Voltage Equipment, Electra No.179 August 1998, pp. 39-45

mandatory. However in the event that there is a risk to voltage stability (notably collapse) system operators may require additional protection to disconnect demand or generation necessary to permit the timely connection of new facilities or generators and maintain security of supply.

For power generating modules, the voltage criteria will depend on whether the PGM contributes actively to voltage regulation. In this case, the PGM shall stay connected within the whole voltage range defined at national level (or in the code for type D) in order to contribute to voltage restoration for as long as possible. On the contrary, if the reactive power contribution of the PGM isn’t linked to the voltage at the connection point, the PGM shall disconnect when its contribution increases the voltage disturbance.

For HVDC circuits, transmission-connected demand facilities, or transmission-connected distribution facilities/systems the same principle shall apply as with PGMs.

The other parameter to define is the delay between the time the voltage reaches the voltage criteria and the actual disconnection. Several issues shall be considered when defining this time. First, the time shall be long enough to avoid automatic disconnections in case of a transient voltage deviation. On the other hand, it must be short enough to avoid any equipment damage. The time for resynchronization after disconnection shall also be taken into account.

Fast fault current injection for PPM and short-circuit contribution of HVDC converter stations during faults

This technical detail of this requirement is covered in IGD Fault current contribution from PPMs & HVDC converters fault level contribution from PPMs and HVDC systems.

As part of the consideration of the non-exhaustive requirements for this requirement, consideration must also be given to the impact and decisions made for other voltage related non-exhaustive requirements.

The level of fault current injection from PPMs and/or HVDC systems will influence the length and depth of a voltage depression during a fault and consequently the recovery period thereafter.

Another contributing factor to the length of a voltage depression is adequacy of both active and reactive power both during and after the fault is cleared. The priority of either from sources in the area is also a consideration in defining the parameters for fast fault current injection.

As a result of the potential for voltage depression and recovery time both the operational time period within normal voltage ranges and the need for wider voltage ranges may be impacted. Similarly additional protection, for example automatic disconnection, may also be required to provide voltage restoration actions.

This requirement also has a link Fault Ride Through (FRT) capability. It shall be activated at a voltage level outside the normal voltage operation ranges defined by the RSO.

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E.g.: In case of short circuit, the fast fault current injection shall last as long as the FRT profile.

Priority to active or reactive power contribution

This requirement applies to PPM type C and D and HVDC links. During faults for which fault-ride-through capability is required or, for HVDC links, during high or low voltage situations, it is necessary to determine whether active or reactive power has the priority during the voltage disturbance.

For PPM or HVDC links with fast fault current injection, priority is given to reactive power contribution.

In other cases, active power priority can be useful to ensure a more efficient active power recovery of the system after the disturbance, but reactive power priority is an efficient voltage support during faults.

In the two cases, fast active power recovery shall be ensured.

If faults are quickly cleared by the protections, then priority can be given to active power contribution. When faults are not quickly cleared, then priority can be given to reactive power contribution in order to ensure voltage support by supplying or consuming reactive power to the network.

For HVDC links, the time within which the whole active power will be provided is to be determined from the fault inception. The specification of this time period depends on the settings of the high or low voltage protections of the system.

Further Info	IGD Need for synthetic inertia (SI) for frequency regulation IGD Reactive power control modes for PPM & HVDC IGD Reactive power requirement for PPMS & HVDC at low / zero power IGD Reative power mangement at T – D interface IGD Special issues associated with type 'A' generators

INTERDEPENDENCIES

Within CNCs	Several requirements exist in all three Connection Network Codes: RfG, DCC and HVDC: • operating time within voltage ranges • Automatic disconnection Other requirements exist in only two Connection Network Codes: RfG and HVDC: • Wider Voltage Ranges

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	• Fast Fault Current Injection / Short Circuit Contribution during faults • Priority to active or reactive power contribution Consistency in the national choices shall be ensured, taking into account the inherent capabilities of each grid user to support the system during voltage disturbances.
In other NCs	Guideline for system operation sets out how to measure the adequacy of the settings provided to ensure voltage ranges and regulation are met.
System Characteristics	The range of voltage that is required for generators, demand facilities, HVDC systems, etc in the connection codes and the time period that are applicable will depend on the voltage regulation on the network. Automatic voltage control and automated compensation devices will allow shorter time periods. The technical parameters related to automatic disconnection will depend on the contribution of power generating modules and HVDC links to the network voltage regulation. In the North west of Northern Ireland such a situation arises. The loss of the single high capacity double circuit 275kV circuit into the area, at a time of high output from the large scale generation in area, requires generation reduction. This reduction is backed up with automatic disconnection protection to avoid system voltage exceeding system voltage ranges. Inertia is a key issue when defining this requirement. For systems with low inertia, priority shall be given to active power, in order to avoid a lack of active power on the system. If the inertia is sufficient, priority can be given to reactive power.
Technology characteristics	The inherent voltage range related technical capabilities requirements of plant and equipment will vary between technologies. However many of the non-exhaustive requirements in the code have been constrained to ranges which are already in use by TSOs within the EU and are therefore already technically possible for the full range of existing technologies (e.g. PPMs and synchronous generators). Manufacturers have responded in consultation that their plant and equipment is being challenged by some of the requirements or their combined effect in the codes including frequency response capabilities. There are real and costly changes that can occur following parameter selection that must be considered but experience has also shown that often real and manageable concerns from users can be overcome. Early involvement of stakeholders around non-exhaustive parameter selection is therefore essential Therefore careful attention must be taken to ensure that in combination that the non-exhaustive parameters for a variety of voltage related

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	parameters work collectively and are reasonable. For example when specifying a voltage range capability of users plant and equipment the ability to use this range if enduring automatic disconnection is required within this range should be considered.
COLLABORATION	
TSO – TSO	For voltage ranges collaboration between TSO – TSO is needed when several TSOs operate in the same country, and also where material interaction is possible with neighbouring transmission systems voltage ranges. For example higher normal operating ranges in one country may create similarly higher voltages that could be beyond the specified range in another adjacent network.
TSO – DSO	For both defining of the normal voltage ranges and the time period they are capable for operating for coordination between the TSO – Distribution System Operator (DSO) may be necessary. A collaboration between the TSOs and the DSOs concerned, if necessary, is related to define the time periods (>100kV) within the determined voltage ranges and for both voltage level and time (<100kV). Similarly for wider voltage ranges and automatic disconnection an agreement with the DSO will be required. For automatic disconnection collaboration between the DSO and the TSO is needed for HVDC links and power generating modules.
RSO – Grid User	For either wider voltage ranges or automatic disconnection of demand facilities an agreement shall be required with the TSO. For automatic disconnection collaboration between the RSO and the grid user is needed for HVDC links and power generating modules.

Table 1 – RfG Non-Exhaustive Requirements

Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
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
		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 CONTROLLABILTY 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
AUTOMATIC DISCONNECTION DUE TO VOLTAGE LEVEL		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
VOLTAGE RANGES		16.2.a.(i)	D	**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
	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	**For Spain** time period for operation in the voltage range 1,05 pu-1,0875 pu for PGMs connected between **300kV and 400 kV may be specified as unlimited**	TSO

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Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
	X	16.2.a.(v)	D	**For Baltic** voltage ranges and time period for operation may be specified in line with continental Europe for facilities connected for **400 kV**	TSO
		16.2.b	D	Wider voltage ranges or longer minimum time periods for operation may be agreed.	agreement between the RSO and the Power Generating Facility Owner (PGFO), in coordination with the TSO
REACTIVE POWER CAPABILITY FOR SYNCHRONOUS PGM	X	17.2.a	Synchronous B, C, D	Capability to supply or absorb reactive power	RSO
SUPPLEMENTARY REACTIVE POWER FOR SYNCHRONOUS PGM	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
REACTIVE POWER CAPABILITY AT MAXIMUM CAPACITY FOR SYNCHRONOUS PGM		18.2.b.(i)	Synchronous C, D	Definition of a U-Q/Pmax-profile at maximum capacity	RSO in coordination with the TSO
		18.2.b.(iv)	Synchronous C, D	appropriate timescale to reach the target value	RSO
VOLTAGE STABILITY FOR SYNCHRONOUS PGM		19.2.b.(v)	Synchronous D	Power threshold above which a PSS function is to be specified	TSO
REACTIVE POWER CAPABILITY FOR POWER PARK MODULE (PPM)	X	20.2.a	PPM: B, C, D	Capability to supply or absorb reactive power	RSO
FAST FAULT CURRENT INJECTION FOR PPM	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

Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
	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
SUPPLEMENTARY REACTIVE POWER FOR PPM	**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
REACTIVE POWER CAPABILITY AT MAXIMUM CAPACITY FOR PPM		21.3.b	PPM: C, D	Definition of a U-Q/Pmax-profile at maximum capacity	RSO in coordination with the TSO
REACTIVE POWER CAPABILITY BELOW MAXIMUM CAPACITY FOR PPM		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
REACTIVE POWER CONTROL MODES FOR PPM		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
		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
PRIORITY TO ACTIVE OR REACTIVE POWER CONTRIBUTION FOR PPM		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
VOLTAGE RANGES FOR OFFSHORE PPM		25.1	Offshore	**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 CONTROL SYSTEM FOR SYNCHRONOUS PGM		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

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Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
VOLTAGE RANGES		25.1	Offshore	**For Continental Europe** 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	**For Spain** time period for operation in the voltage range 1,05 pu-1,0875 pu for PGMs connected between **300kV and 400 kV may be specified as unlimited**	TSO
	X	16.2.a.(v)	Offshore	**For Baltic** voltage ranges and time period for operation may be specified in line with continental Europe for facilities connected for **400 kV**	TSO
REACTIVE POWER CAPABILITY AT MAXIMUM CAPACITY FOR OFFSHORE PPM		25.5	Offshore	Definition of the U-Q/Pmax-profile at Pmax	TSO

Table 2 – DCC Non-Exhaustive Requirements

Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
VOLTAGE RANGES		13.1 and ANNEX II	Transmission Connected Demand Facility (DF) and Transmission connected DSO **above 110kV**	**For Continental Europe** time period for operation in the voltage range 1,118 pu-1,15 pu for facilities connected between **110kV and 300 kV**	TSO
	X	13.4	Transmission Connected DF and Transmission connected DSO **above 110kV**	**For Spain** time period for operation in the voltage range 1,05 pu-1,0875 pu for facilities connected between **300kV and 400 kV may be specified as unlimited**	TSO
	X	13.5	Transmission Connected DF and Transmission connected DSO **above 110kV**	**For Baltic** voltage ranges and time period for operation may be specified in line with continental Europe for facilities connected for **400 kV**	TSO
AUTOMATIC DISCONNECTION DUE TO VOLTAGE LEVEL		13.6	Transmission Connected DF and Transmission connected DSO	Voltage criteria and technical parameters at the connection point for automatic disconnection	agreement between Transmission Connected Demand Facility (TCDF) or Transmission Connected Distribution System Operator (TCDSO) and the TSO
REACTIVE POWER CAPABILITY FOR TRANSMISSION CONNECTED DEMAND FACILITY AND TRANSMISSION CONNECTED DISTRIBUTION SYSTEM		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
REACTIVE POWER CAPABILITY FOR TRANSMISSION CONNECTED		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

DISTRIBUTION SYSTEM	**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
DEMAND RESPONSE ACTIVE POWER CONTROL (APC), REACTIVE POWER CONTROL (RPC) AND TRANSMISSION CONSTRAINT MANAGEMENT (TCM)	**X**	28.2 (a)	DF and Closed Distribution System (CDS) offering Demand Response (DR)	definition of a extended frequency range	agreement between RSO, in coordination with TSO and DF or CDSO
	X	28.2 (c)	DF and CDS offering DR	for DF or CDS connected below 110 kV: definition of the normal operating range	RSO
	X	20.2 (e), (l)	DF and CDS offering DR	technical specifications to enable the transfer of information for DR Low Frequency Demand Disconnection (LFDD) and Low Voltage Demand Disconnection (LVDD), for DR APC and DR RPC	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 Rate of Change of Frequency maximum value	TSO
POWER QUALITY		20	Transmission connected DF and Transmission connected DSO	allocated level of voltage distortion	TSO

Table 3 – HVDC Non-Exhaustive Requirements

Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
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 1PU 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

Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
		22.3.(c)	HVDC Converter station	In voltage control mode t2 = 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 setpoint	RSO
		22.6	HVDC System	Equipment specification to enable remote control of control modes and setpoints	RSO with TSO
PRIORITY TO ACTIVE OR REACTIVE POWER CONTRIBUTION		23	HVDC System	TSO decide active or reactive power has priority	TSO
FAULT RIDE THROUGH CAPABILITY (FRT)		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
POWER QUALITY		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
POST FAULT ACTIVE POWER RECOVERY		26	HVDC System	Active power recovery magnitude and time profile	TSO
VOLTAGE RANGES		Annex VII. Table 9 and 10	Direct Current (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
AGREEMENT ON WIDER VOLTAGE RANGES OR LONGER MIN. TIMES		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

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Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
AUTOMATIC DISCONNECTION		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
VOLTAGE RANGES FOR OTHER AC VOLTAGES		40.1.(d)	DC connected Power Park Modules	Time period for operation in the voltage range for DC connected PPM	TSO
AGREEMENT HOW TO MEET REACTIVE POWER REQUIREMENTS (TODAY, FUTURE)		40.1.(i)	DC connected Power Park Modules	Reactive power capabilities	RSO in coordination with TSO
REACTIVE POWER CAPABILITY		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
REACTIVE POWER CONSUMPTION OF EXTRA HIGH VOLTAGE LINE		40.2.(b)(ii)	DC connected Power Park Modules	Supplementary reactive power requirements at connection point	RSO in coordination with TSO
PRIORITY TO ACTIVE AND REACTIVE POWER CONTRIBUTION		40.3	DC connected Power Park Modules	RSO decide active or reactive power has priority	RSO in coordination with TSO
REACTIVE POWER AND VOLTAGE RANGES		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
AGREEMENT ON WIDER VOLTAGE RANGES OR LONGER MIN. TIMES		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
VOLTAGE RANGES FOR OTHER AC VOLTAGES		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
REACTIVE POWER PROVISION		48.2.(a)	Remote-end HVDC converter stations	Reactive power capabilities for various voltage levels	RSO in coordination with TSO
U-Q/PMAX-PROFILE		48.2.(a)	Remote-end HVDC converter stations	Reactive power capabilities within the boundaries in Annex VIII, table 14	RSO in coordination with TSO
SCOPE		38	DC connected Power Park Modules	Non-exhaustive requirements of Articles 11 to 22 of the Network Code RfG will apply	-
SCOPE		46	Remote-end HVDC	Non-exhaustive requirements of Articles 11 to 39 will apply	-

Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Proposer
			converter stations		