

European Network of Transmission System Operators for Electricity

NETWORK CODE FOR REQUIREMENTS FOR GRID CONNECTION APPLICABLE TO ALL GENERATORS

JUSTIFICATION OUTLINES

26 JUNE 2012

Disclaimer: This document is not legally binding. It only aims at clarifying the content of the network code for requirements for grid connection applicable to all generators. This document is not supplementing the final network code nor can be used as a substitute to it.



Requirement:	Frequenc	y Rang	jes					
Reference to NC RfG:	Article 8(1) (a)						
Cross-border impact:	Frequence transmise quency is tions of fr everywhe in a comr	Frequency without any doubt is the parameter of an interconnected electricity ransmission and distribution system, which has the largest cross-border impact. Fre- quency is the same across a synchronous area and across all voltage levels. Devia- ions of frequency from its nominal value due to load imbalances therefore occur everywhere at the same time and affect all Power Generating Modules immediately n a common way regardless of their size and voltage level of connection.						
Exhaustive requirement	:	х	Non-exhaustive requirement:					
Justification:	 Due harm parti burd The i Mod chara these resto Inhei nous viatio 	 Due to their immediate cross-border impact, frequency requirements need to be harmonised as much as possible at least on the level of a synchronous area. In particular, the range for unlimited operation needs to be identical to share the burdens of deviations equally. The ranges and time periods where time-limited operation of Power Generating Modules is requested however may vary and shall take into account regional characteristics and the network operators' operational requirements, because these ranges are primarily needed for management of system disturbances and restoration. Inherent inertia of the electricity supply system will decrease due to less synchronous generators connected in future, consequently larger sudden frequency deviations occur in case of load imbalances. 						
Principle/Methodology	only:		(Ranges of) values/parameters given:	х				
Justification:	 Freq Devia affect their 	uency i ations t all Pc size ar	is the same across a synchronous area and ac of frequency from its nominal occur everywhe ower Generating Modules immediately in a co nd voltage level of connection.	cross all ere at th ommon v	voltage levels. e same time and way regardless of			
Alternative solutions:	• Limit	ations will jeo	on penetration of (RES) generation without ir pardize achieving EU energy policy targets.	nherent	inertia, however			
Link to FWGL:	 para men tribu ters; para (e.g. 	graph 2 ts on si ting to " graph 2 voltag	2.1: " Furthermore, the network code(s)sha gnificant grid users in relation to the relevant secure system operation, including Frequer 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	ll define system ncy and significat stand	the require- parameters con- voltage parame- nt parameters "			



Requirement:	Rate of C	hange	of Frequency Withstand Capability				
Reference to NC RfG:	Article 8(Article 8(1) (b)					
Cross-border impact:	Frequence transmiss Frequence Deviation occur eve immedia The rate supply sy future; co imbalance	Frequency without any doubt is the parameter of an interconnected electricity ransmission and distribution system, which has the largest cross-border impact. Frequency is the same across a synchronous area and across all voltage levels. Deviations of frequency from its nominal value due to load imbalances therefore occur everywhere at the same time and affect all Power Generating Modules mmediately in a common way regardless of their size and voltage level of connection. The rate of change of frequency depends on the inherent inertia of the electricity supply system which decreases due to less synchronous generators connected in future; consequently larger sudden frequency deviations occur in case of load mbalances.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	 Due harn How distu is re- cons case Inhe sync freq 	 Due to their immediate cross-border impact, frequency requirements need to be harmonised as much as possible at least on the level of a synchronous area. However, currently the rate of change of frequency in case of a major disturbance can be hardly assessed and depends on the system inertia. Hence it is reasonable to define this parameter on a national level to be able to take into consideration the consequences of system splits and the expected behaviour in case of national islanding and system restoration. Inherent inertia of the electricity supply system decreases due to less synchronous generators connected in future; consequently larger sudden frequency deviations occur in case of load imbalances. 					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	 Low distu Rate Assu defin appr 	 Low experience so far on rate of change of frequency in case of major disturbances of the system. Rate of change of frequency depends on the inherent system inertia. Assuming national islanding and system restoration is the critical case, a definition of the rate of change of frequency parameters on national level is appropriate. 					
Alternative solutions:	Limitatio will jeopa	Limitations on penetration of (RES) generation without inherent inertia, however this will jeopardize achieving EU energy policy targets.					
Link to FWGL:	 para requipara volta para (e.g. 	graph : iremen imeters age par graph : voltag	2.1: " Furthermore, the network code(s)sha ats on significant grid users in relation to the re contributing to secure system operation, incl cameters;" 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	II define elevant uding significa stand	the system Frequency and nt parameters ″		



Requirement:	Limited F	requer	ncy Sensitive Mode - Overfrequency				
Reference to NC RfG:	Article 8	rticle 8(1) (c)					
Cross-border impact:	Frequency transmis quency is tions of f everywh in a com imbaland Generati their des security, Power G	requency without any doubt is the parameter of an interconnected electricity ransmission and distribution system, which has the largest cross-border impact. Fre- juency is the same across a synchronous area and across all voltage levels. Devia- ions of frequency from its nominal value due to load imbalances therefore occur everywhere at the same time and affect all Power Generating Modules immediately in a common way regardless of their size and voltage level of connection. If load mbalances are not removed and frequency deviations increase, masses of Power Generating Modules will disconnect due to frequency, which is out of the range of heir design for operation. This will result in a deterioration of system stability and ecurity, which can be overcome by a smooth reduction of active power output of power Generating Modules at high frequencies, avoiding its tripping.					
Exhaustive requirement	:	х	Non-exhaustive requirement:				
Justification:	 Due harn ties freq Inhe nous viati Smo need 	 Due to their immediate cross-border impact, frequency requirements need to be harmonised as much as possible. In order to consider appropriately the capabilities of generation technologies some flexibility still has to remain for setting the frequency threshold of activation, the droop and the initial delay of activation. Inherent inertia of the electricity supply system decreases due to less synchronous generators connected in future; consequently larger sudden frequency deviations occur in case of load imbalances. Smooth reduction of active power output of Power Generating Modules is needed at high frequencies to maintain system stability. 					
Principle/Methodology	only:		(Ranges of) values/parameters given:	х			
Justification:	 Freq Deviaffee As fa Mocoutpoint 	juency lations ct all Pc r size ar ar as te dules sh but of P pontract	is the same across a synchronous area and ac of frequency from its nominal occur everywho ower Generating Modules immediately in a co nd voltage level of connection. chnically feasible, a common behaviour of all all be endeavoured to achieve a smooth redu ower Generating Modules at high frequencie ed active power frequency response reserves	cross all ere at th ommon v Power G uction of s beyond	voltage levels. e same time and way regardless of Generating active power d full activation		
Alternative solutions:	 Exce adve Limi this 	 Excessive active power frequency response reserves to be contracted, which has adverse impact on cost-effectiveness. Limitations on penetration of (RES) generation without inherent inertia, however this will jeopardize achieving EU energy policy targets. 					
Link to FWGL:	 para men tribu ters; para (e.g. 	ngraph 2 Its on si Iting to Iting to Iting to Iting to Iting Itin Iting Iting Iting Iting Iting Iting Iting Iting Iting Iting	2.1: " Furthermore, the network code(s)sha ignificant grid users in relation to the relevant secure system operation, including Frequen d-Frequency control related issues" 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	III define system ncy and significa stand	the require- parameters con- voltage parame- nt parameters "		



Requirement:	Constant	Outpu	t at Target Active Power			
Reference to NC RfG:	Article 8((1) (d)				
Cross-border impact:	Changes inevitabl maintain nominal	Changes in active power output, other than scheduled or which are technically nevitable, result in load imbalances in the system, which shall be avoided in order to naintain system stability and security by minimizing deviations of frequency from its nominal value.				
Exhaustive requirement	:	х	Non-exhaustive requirement:			
Justification:	 The desc All P system nom 	 The principle of maintaining active power output at its target value already describes this requirement exhaustively. All Power Generating Modules shall follow this principle in order to maintain system stability and security by minimizing deviations of frequency from its nominal value. 				
Principle/Methodology	only:	х	(Ranges of) values/parameters given:			
Justification:	The prind this requ	ciple of iremen	maintaining active power output at its target t exhaustively. There are no parameters to be	: value a e specifi	lready describes ed.	
Alternative solutions:	Leave thi However system.	Leave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.				
Link to FWGL:	 para tech volto 	graph 2 nical re age and	2.1: " The network code(s) shall set out hov quirements related to frequency and active p I reactive power management"	v the TS ower co	O defines the ntrol and to	



Requirement:	Maximu	n Active Power Reduction at Low Frequencies						
Reference to NC RfG:	Article 8	Article 8(1) (e)						
Cross-border impact:	Frequent transmis Frequent Deviatio occur ev immedia already a	Frequency without any doubt is the parameter of an interconnected electricity gransmission and distribution system, which has the largest cross-border impact. Frequency is the same across a synchronous area and across all voltage levels. Deviations of frequency from its nominal value due to load imbalances therefore occur everywhere at the same time and affect all Power Generating Modules mmediately. Active power reduction at low frequencies aggravates a situation where already a lack of generation persists and shall be limited as much as possible.						
Exhaustive requirement	:	Non-exhaustive requirement:	х					
Justification:	 The system of the system of the	 The frequency-sensitivity of synchronous areas is different according to their system characteristics and generation portfolio. Whereas larger systems with more inherent inertia are less sensitive, the opposite applies to smaller system with less inherent inertia. The admissible active power reduction also needs to be weighed against the risk of instability and loss of a Power Generating Module by each TSO in its responsibility area. Active power reduction at low frequencies aggravates a situation where already a lack of generation persists and shall be limited as much as possible. 						
Principle/Methodology	only:	(Ranges of) values/parameters given:	х					
Justification:	 Frec Limi gene Adm insta 	uency-sensitivity is different for synchronous areas. tations on maximum active power out at low frequer eration technologies and ambient conditions. hissible active power reduction also needs to be weig ability and loss of a Power Generating Module.	ncies dep hed agai	oend on nst the risk of				
Alternative solutions:	 Exce adve All P resp and jeop 	 Excessive active power frequency response reserves to be contracted, which has adverse impact on cost-effectiveness. All Power Generating Modules, who shall deliver active power frequency response cannot run at their maximum power output, resulting in less efficiency and - in case of RES - potentials of carbon-free generation are not used. This may jeopardize achieving EU energy policy targets. 						
Link to FWGL:	 para requ para volta para (e.g. 	graph 2.1: " Furthermore, the network code(s)sha irements on significant grid users in relation to the re- imeters contributing to secure system operation, inclu- age parameters;" graph 2.1.3: " the detail of possible deviations of s voltage, frequency) that generation units must withs	ll define elevant s uding i ignifican stand"	the ystem Frequency and it parameters				



Requirement:	Remote S	Remote Switch On/Off					
Reference to NC RfG:	Article 8(1) (f)					
Cross-border impact:	In particu security, Power Go security.	In particular in emergency situations which may endanger system stability and security, network operators need to have the possibility to instruct the output of Power Generating Modules to be able to meet their responsibilities for system security.					
Exhaustive requirement	:	х	Non-exhaustive requirement:				
Justification:	The mere requeste	e capab d.	ility to receive an instruction to cease active	power o	utput is		
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	 The active option Further spective only 	smalles ve powe on to se her spe ific syst onsibili	at types of Power Generating Modules are not er output, therefore the minimum feature to electively switch them on/off remotely. Actifications beside the general principle/methe tem characteristics and communication infras ty area of each network operator and can be	t control control 1 odology tructure specifie	llable in their their output is an depend on the e in the d at that level		
Alternative solutions:	Limitatio achieving	ns on p g EU en	enetration of dispersed (RES) generation, how ergy policy targets.	wever th	nis will jeopardize		
Link to FWGL:	 para tech volto para signi the T 	graph 2 nical re age and graph 3 ificant <u>g</u> TSO and	2.1: " The network code(s) shall set out hov equirements related to frequency and active p I reactive power management" 3.2: " The network code(s) shall set the requ grid user to be able to receive and to execute a d/or DSO,"	v the TSC ower con uiremen the instr	O defines the ntrol and to t for every ructions sent by		



Requirement:	Automat	ic Conr	nection				
Reference to NC RfG:	Article 8(1) (g)					
Cross-border impact:	Connecti changes which are to mainta Hence, th	onnection of Power Generating Modules triggers dynamic processes, because it hanges the system state. In particular in disturbed situations automatic connections, rhich are out of any control by the network operator, need to be restricted in order o maintain or restore system security and to avoid an aggravation of disturbances. lence, the conditions for automatic connections need to be specified.					
Exhaustive requirement	:						
Justification:	Condition responsil	ns for a pility ar	nutomatic connection depend on system char- rea of each TSO and therefore shall be specific	acteristi ed at tha	cs in the at level.		
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	 In pa expl auto Furt spec spec 	 In particular smaller Power Generating Modules are connected without prior explicit authorization by the network operator, therefore conditions for automatic connection need to be specified. Further specifications beside the general principle/methodology depend on the specific system characteristics in the responsibility area of each TSO and can be specified at that level only. 					
Alternative solutions:		Limitat howev	ions on penetration of (RES) generation with er this will jeopardize achieving EU energy po	out inhe licy targ	rent inertia, ets.		
Link to FWGL:	• para (re)c	graph : connect	2.1.3: " The network code(s) shall define mathematics in the grid in disturbed/critical operating	inimum state	conditions for "		



Requirement:		Active	Power Reduction				
Reference to NC RfG:		Article	9(2) (a)				
Cross-border impact:		In particular in emergency situations which may endanger system stability and security, network operator need to have the possibility to instruct the output of Power Generating Modules to be able to meet their responsibilities for system security.					
Exhaustive requirement	:	х	Non-exhaustive requirement:				
Justification:	The mero requeste	e capab d.	ility to receive an instruction to reduce active	e power	output is		
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	 Sma The systa Furt spec resp only 	ller typ necess em stat her spe tific sys onsibili	es of Power Generating Modules have no ope ary feature, in particular in emergency situati bility and security, is an option to control thei ecifications beside the general principle/meth tem characteristics and communication infras ty area of each network operator and can be	erationa ons whic r output odology structure specifie	l staff on site. ch may endanger remotely. depend on the e in the d at that level		
Alternative solutions:	Limitatio achievin	ns on p g EU en	enetration of dispersed (RES) generation, ho ergy policy targets.	wever th	nis will jeopardize		
Link to FWGL:	 para tech volto para sign the 	igraph 2 nical re age and igraph 3 ificant g TSO and	2.1: " The network code(s) shall set out how equirements related to frequency and active p I reactive power management" 3.2: " The network code(s) shall set the req grid user to be able to receive and to execute d/or DSO,"	v the TSC ower co uiremen the instr	D defines the ntrol and to t for every ructions sent by		



Requirement:	Fault-rid	e-throu	gh Capability of Power Generating Modules c	connecte	ed below 110 kV		
Reference to NC RfG:	Article 9	vrticle 9(3) (a)					
Cross-border impact:	Riding th which in The fault extended main cor	tiding through faults is important in terms of system frequency and voltage stability, which in turn are fundamental requirements for cross-border trading. The fault ride through requirement for Types B and C (unlike for Type D) are not extended down to zero retained voltage at the point of connection, reflecting that the main concern is a simultaneous loss of generation of multiple units connected below					
	reduces Failure to units is c	10 kV, associated with a fault at the highest voltage levels (110kV and above). This educes the needed severity of the requirement. ailure to deliver robustness against a simultaneous loss of generation of multiple nits is clearly a major system security issue with cross-border issues.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	The para at a natio combina	The parameters for the voltage against time profile are left for the TSO to determine at a national level while respecting the provisions of Article 4(3). This allows for a combination of taking into account existing requirements and local needs which vary.					
Principle/Methodology only:			(Ranges of) values/parameters given:	х			
Justification:	Ranges o proportio existing r	f paran onate a networl	neters for national choices are provided which pproach reflecting varying system needs (e.g. k protection schemes (both transmission and	h mainta . level of distribu	ain a RES) and tion).		
Alternative solutions:	Leave the required therefore system s	Leave the capability for market to deliver. However, this would not deliver the required certainty for planning and operation of the power system and would therefore lead to major restrictions in the development of RES in order to maintain system security.					
Link to FWGL:	 para betv appl sign secu 	graph 2 veen th y. Furth ificant <u>c</u> re syste o Fa	2.1: " The network code(s) shall define the p. e significant grid user's equipment and the ne hermore, the network code(s) shall define the grid users in relation to the relevant system po em operation, including: ult-ride-through capability"	hysical c etwork to requiren aramete	connection point o which they nents on rs contributing to		



Requirement:	Reconne	Reconnection after an incidental Disconnection due to a Network Disturbance					
Reference to NC RfG:	Article 9	rticle 9(4) (a)					
Cross-border impact:	Reconne the circu The abse Continer Following system to a conseq	Reconnection after an incidental disconnection due to a network disturbance must fit the circumstances. The absence of this capability was demonstrated as a cross border issue in Continental Europe during the major 3 way system split on 4 November 2006. Following the system split uncontrolled reconnections caused the restoration of the system to be prolonged as the TSOs were hindered in resynchronising the islands. As a consequence mass consumer disconnections prolonged in many countries.					
Exhaustive requirement	:		Non-exhaustive requirement:	x			
Justification:	 Artic conc subj The and 	 Article 8 (4) a) refers to a TSO decision pursuant to Article 4(3) defining specific conditions for reconnection and also define that automatic reconnection shall be subject to prior authorisation by the Relevant Network Operator. The above limitation in the requirement is necessary in order to be proportionate and fit for local circumstances. 					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	lt is impo best app Generati	ortant t roach f ng Moo	hat the local conditions are taken into accour for the required coordination between TSOs, I dule Owners.	it when DSOs an	considering the d Power		
Alternative solutions:	Rely on r Europe s substant during m	Rely on markets to behave as required when needed. However, the Continental Europe system split in 4 November 2006 demonstrated that this can lead to substantial delays in restoration following loss of demand and creates further risks during major disturbances.					
Link to FWGL:	 para be a oper will 	graph ble to e rating s be agre	2.1.3: " The network code(s) shall set out ho execute their control activities in normal and in states. Specific parameters for operation outsin ered bilaterally between generation units and s	w gener n alert (d de these system o	ration units must disturbed) e operating states operators"		



Requirement:	Control S	cheme	s and Settings				
Reference to NC RfG:	Article 9((5) (a)					
Cross-border impact:	Dynamic operatin is largely	ynamic behaviour of Power Generating Modules, in particular in disturbed system perating conditions is crucial for system stability as a whole. This dynamic behaviour s largely determined by the unit's control schemes and settings.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	 Mair Continuity indivith evalue with 	 Maintaining transmission system stability is a responsibility of the Relevant TSO. Control schemes and settings of Power Generating Modules are designed individually; therefore they cannot be described exhaustively on a European level with their impact on transmission system stability. This impact needs to be evaluated taking into account regional system characteristics and shall be agreed with the Relevant Network Operator and the Relevant TSO. 					
Principle/Methodology only:		х	(Ranges of) values/parameters given:				
Justification:	 Continuity Only deta dependent 	rol sch vidually the pr iled val end on	emes and settings of Power Generating Modu - inciple/methodology can be described in the ues and parameters, which need the network the individual scheme.	ules are network < operat	designed code, the or's consent,		
Alternative solutions:	Leave thi However system.	Leave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.					
Link to FWGL:	• para be a oper will l	graph 2 ble to e ating s be agre	2.1.3: " The network code(s) shall set out he execute their control activities in normal and in tates. Specific parameters for operation outsi ed bilaterally between generation units and s	ow gene n alert (d de these system o	eration units must disturbed) e operating states perators"		



Requirement:	Protectic	on Sche	mes and Settings				
Reference to NC RfG:	Article 9(rticle 9(5) (b)					
Cross-border impact:	Proper n particula from agg circuit fa	roper network protection is essential for maintaining system stability and security, in articular in case of disturbances to the system. Protection schemes shall prevent om aggravation of disturbances and limit their consequences (e.g. selective short-rcuit fault clearance).					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	 Main Network Prot Mod syste Pow regio of the 	Maintaining system stability and security is a responsibility of the Relevant Network Operator. Protection schemes and settings of the network and of Power Generating Modules need to be well coordinated in order to fulfil its purpose of maintaining system stability and security. The schemes and settings depend on both the Power Generating Module's and the network's protection strategies, as well as regional system characteristics and thus have to be further specified at the level of the Relevant Network Operator.					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	 Prot Mod prot Only deta dependent 	ection lules de ection the pr iled val	schemes and settings of the network and of P epend on both the Power Generating Module' strategies, as well as regional system characte inciple/methodology can be described in the lues and parameters, which need to be coordi the individual scheme and system characteris	ower Ge 's and th eristics. network inated a tics.	enerating ne network's code, the nd agreed		
Alternative solutions:	Leave thi However system.	eave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.					
Link to FWGL:	 para requi para for p 	graph 2 iremen meters protecti	2.1: " Furthermore, the network code(s)sha ts on significant grid users in relation to the re contributing to secure system operation, incl on devices and settings;"	ll define elevant s uding	the system Requirements		



Requirement:	Priority F	Priority Ranking of Protection and Control					
Reference to NC RfG:	Article 9	(5) (c)					
Cross-border impact:	Protectic priority i of staff a	Protection of the network and the Power Generating Module need to have highest priority in order to maintain system stability and security, as well as health and safety of staff and the public.					
Exhaustive requirement	:	х	Non-exhaustive requirement:				
Justification:	 A rai prec othe A ha strat 	 A ranking needs to be given in order to specify which capabilities shall take precedence when designing the protection and control schemes, if conflicting otherwise. A harmonised ranking shall apply to achieve a common basis for operational strategies for secure system operation. 					
Principle/Methodology only:			(Ranges of) values/parameters given:				
Justification:	A ranking values/p	g specif aramet	ies the priority of certain types of requiremeners are given by such a priority list.	nts. No			
Alternative solutions:	Leave the However system.	Leave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.					
Link to FWGL:	 para requi para for p 	graph 2 iremen meters protecti	2.1: " Furthermore, the network code(s)sha ts on significant grid users in relation to the re contributing to secure system operation, incl on devices and settings; …"	III define elevant s uding	the system Requirements		



Requirement:	Informat	nformation Exchange					
Reference to NC RfG:	Article 9((5) (d)					
Cross-border impact:	Adequate Module of and secu state of t Generati direct op	Adequate information exchange between network operators and Power Generating Module operators is a prerequisite for network operators to maintain system stability and security. Network operators continuously need to have an overview over the state of the system, which includes information on the operating conditions of Power Generating Modules as well as the possibility to communicate with them in order to direct operational instructions.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	The mere to be exc operation	e capab changeo nal stra	ility to exchange information is required. Det d (communication infrastructure, protocols) o tegies of the Relevant Network Operator and	ails on t lepend c l the Rel	he information on the evant TSO.		
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	Further s operation each net	pecificanal stra work o	ations beside the general principle/methodol tegy and communication infrastructure in the perator and TSO and can be specified at that	ogy dep e respon level onl	end on sibility area of y.		
Alternative solutions:	Have no based on available	require extens withou	ment and leave capability to the market. How sive experience, that the required minimum c ut detailing what is required.	wever, it apability	is unlikely, / will be made		
Link to FWGL:	 para requ oper para signi oper impo grid and, 	graph a iremen ator ar graph a ificant g rational act upo user to /or DSC	3.1: " The network code(s) shall set out the ts to coordinate and ensure information shar ad significant grid user" 3.2: " The network code(s) shall set the required grid user to be able and obliged to provide the information to the DSO and TSO that their co n. The network code(s) shall set the requirement be able to receive and to execute the instruct of, on a contractual basis or in critical operating	procedu ing betw uiremen e necesso onnectio ent for e tions sen g state."	ires and veen System t for every ary real-time n has significant very significant it by the TSO		



Requirement:	Active Po	Active Power Controllability						
Reference to NC RfG:	Article 10	D(2) (a)						
Cross-border impact:	In particu security, Power G security.	In particular in emergency situations which may endanger system stability and security, network operators need to have the possibility to instruct the output of Power Generating Modules to be able to meet their responsibilities for system security.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	The capa adjustme operatio	bility to ents, lik n philos	o adjust an active power setpoint is requested e time periods and accuracy, depend on the r sophy and on technical capabilities of the Pov	d. Details network ver Gene	s of such operator's erating Module.			
Principle/Methodology	only:	х	(Ranges of) values/parameters given:					
Justification:	 Larg whic instr Furt spec resp only 	er type th allow tuctions her spe ific syst onsibili	s of Power Generating Modules have more co v for more flexible control of output following s. ecifications besides the general principle/meth tem characteristics and communication infras ty area of each network operator and can be	omplex o retwor nodology tructure specifie	control structures k operator y depend on the e in the d at that level			
Alternative solutions:	Leave the However system.	Leave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.						
Link to FWGL:	 para tech volto para signi the 	graph 2 nical re age and graph 3 ificant <u>g</u> TSO and	2.1: " The network code(s) shall set out how equirements related to frequency and active p I reactive power management" 3.2: " The network code(s) shall set the requ grid user to be able to receive and to execute a d/or DSO,"	v the TSC ower con uiremen the instr	D defines the ntrol and to t for every uctions sent by			



Requirement:	Limited F	requer	ncy Sensitive Mode - Underfrequency				
Reference to NC RfG:	Article 10	Article 10(2) (b)					
Cross-border impact:	Frequence transmiss Frequence Deviation occur eve immediat If load im Power Ge range of stability a output of preventin	Frequency without any doubt is the parameter of an interconnected electricity cransmission and distribution system, which has the largest cross-border impact. Frequency is the same across a synchronous area and across all voltage levels. Deviations of frequency from its nominal value due to load imbalances therefore occur everywhere at the same time and affect all Power Generating Modules mmediately in a common way regardless of their size and voltage level of connection. I load imbalances are not removed and frequency deviations increase, masses of Power Generating Modules will disconnect due to frequency, which is out of the range of their design for operation. This will result in a deterioration of system stability and security, which can be overcome by a smooth increase of active power poutput of Power Generating Modules at low frequencies, and which aims at preventing from load shedding.					
Exhaustive requirement	:	х	Non-exhaustive requirement:				
Justification:	 Due harn capa frequ Inhe sync frequ Smoo used Gene parti 	 Due to their immediate cross-border impact, frequency requirements need to be harmonised as much as possible. In order to consider appropriately the capabilities of generation technologies some flexibility is needed for setting the frequency threshold of activation, the droop and the initial delay of activation. Inherent inertia of the electricity supply system decreases due to less synchronous generators connected in future; consequently larger sudden frequency deviations occur in case of load imbalances. Smooth increase of active power output of Power Generating Modules can be used at low frequencies to maintain system stability from those Power Generating Modules which have headroom available because of operation at partial load. 					
Principle/Methodology	only:		(Ranges of) values/parameters given:	Х			
Justification:	 Freq Deviaries affect their As fa Mod outp cont 	uency i ations o t all Po size ar ar as teo ules sh ut of P racted	is the same across a synchronous area and ac of frequency from its nominal occur everywho ower Generating Modules immediately in a co nd voltage level of connection. chnically feasible, a common behaviour of all hall be endeavoured to achieve a smooth incre ower Generating Modules at low frequencies active power frequency response reserves.	cross all ere at th ommon v Power C ease of a beyond	voltage levels. e same time and way regardless of Generating active power full activation of		
Alternative solutions:	Excessive impact of active po power ou free gene	Excessive active power frequency response reserves to be contracted with adverse impact on cost-effectiveness. All Power Generating Modules, which shall deliver active power frequency response on a contractual basis cannot run at their maximum power output, resulting in less efficiency and - in case of RES - potentials of carbon-free generation are not used.					
Link to FWGL:	 para requ para volto para (e.g. 	graph 2 iremen meters age par graph 2 voltag	2.1: " Furthermore, the network code(s)sha ots on significant grid users in relation to the re- s contributing to secure system operation, incl rameters; Load-Frequency control related is 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	II define elevant s uding sues" significa stand	the system Frequency and nt parameters "		



Requirement:	Frequency	/ Sensi	tive Mode					
Reference to NC RfG:	Article 10(article 10(2) (c)						
Cross-border impact:	Frequency transmission Frequency Deviations occur ever immediate If load imb Power Ger range of the stability are output of R	requency without any doubt is the parameter of an interconnected electricity ransmission and distribution system, which has the largest cross-border impact. requency is the same across a synchronous area and across all voltage levels. eviations of frequency from its nominal value due to load imbalances therefore ccur everywhere at the same time and affect all Power Generating Modules nmediately in a common way regardless of their size and voltage level of connection. I load imbalances are not removed and frequency deviations increase, masses of ower Generating Modules will disconnect due to frequency, which is out of the ange of their design for operation. This will result in a deterioration of system tability and security, which can be overcome by a reduction/increase of active power utput of Power Generating Modules at high/low frequencies.						
Exhaustive requirement	:	х	Non-exhaustive requirement:					
Justification:	 Due to harmo capab setting maxim Inhere synchi freque Removineede 	Due to their immediate cross-border impact, frequency requirements need to be harmonised as much as possible. In order to consider appropriately the capabilities of generation technologies some flexibility still has to remain for setting the frequency threshold of activation, deadband, droop, initial delay and maximum time of activation. Inherent inertia of the electricity supply system decreases due to less synchronous generators connected in future; consequently larger sudden frequency deviations occur in case of load imbalances. Removal of load imbalances by active power frequency response reserves is needed to maintain system stability.						
Principle/Methodology	only:		(Ranges of) values/parameters given:	х				
Justification:	 Freque Deviat affect their s As far Modu power 	iency i tions c all Po size an as tec iles sha r frequ	s the same across a synchronous area and ac of frequency from its nominal occur everywhe wer Generating Modules immediately in a co id voltage level of connection. chnically feasible, a common behaviour of all all be endeavoured to achieve a removal of lo uency response reserves.	cross all ere at th mmon v Power C pad imba	voltage levels. he same time and way regardless of Generating alances by active			
Alternative solutions:	 Excess advers Limita this w 	sive ac se imp ations vill jeop	ctive power frequency response reserves to b bact on cost-effectiveness. on penetration of (RES) generation without ir bardize achieving EU energy policy targets.	e contra	acted, which has inertia, however			
Link to FWGL:	 paragu requir param voltag paragu (e.g. v 	raph 2 rement neters ge paro raph 2 voltage	2.1: " Furthermore, the network code(s)sha ts on significant grid users in relation to the re contributing to secure system operation, incl ameters; Load-Frequency control related is 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	II define elevant . uding sues" significa stand	the system Frequency and nt parameters ″			



Requirement:	Frequen	cy Rest	oration Control				
Reference to NC RfG:	Article 10	D(2) (d)					
Cross-border impact:	Frequence transmis Frequence Deviation same tim immedia deviation	Frequency without any doubt is the parameter of an interconnected electricity ransmission and distribution system, which has the largest cross-border impact. Frequency is the same across a synchronous area and across all voltage levels. Deviations of frequency from its nominal value therefore occur everywhere at the same time and affect all Power Generating Modules immediately in a common way mmediately regardless of their size and voltage level of connection. Any frequency deviation shall be mitigated by restoring frequency at its nominal value.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	 Freq pow devi Freq area and need 	 Frequency restoration to its nominal value is essential in order to release active power frequency response reserves previously activated due to frequency deviations in order to be able to use them again in case of new deviations. Frequency restoration control is performed in a different way in the synchronous areas depending on their historical development and their system characteristics and operational strategies. The detailed capabilities have to consider this and need to be further specified accordingly. 					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	• Furt cons reste	her par ideration	ameters can only be specified on national lev on the system characteristics and operational control.	el taking strateg	g into ies for frequency		
Alternative solutions:	Leave the However system.	Leave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.					
Link to FWGL:	 para requipara volta para (e.g. 	graph 2 iremen meters age par graph 2 voltag	2.1: " Furthermore, the network code(s)sha ots on significant grid users in relation to the re- s contributing to secure system operation, incl rameters; Load-Frequency control related is 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	II define elevant : uding sues" significa stand	the system Frequency and nt parameters ″		



Requirement:	Low Free	Juency	Load Disconnection			
Reference to NC RfG:	Article 10	D(2) (e)				
Cross-border impact:	Frequence transmiss Frequence Deviation occur eve immedia If load im Power Ge range of stability a frequence	Frequency without any doubt is the parameter of an interconnected electricity ransmission and distribution system, which has the largest cross-border impact. Frequency is the same across a synchronous area and across all voltage levels. Deviations of frequency from its nominal value due to load imbalances therefore occur everywhere at the same time and affect all Power Generating Modules mmediately in a common way regardless of their size and voltage level of connection. I load imbalances are not removed and frequency deviations increase, masses of Power Generating Modules will disconnect due to frequency, which is out of the ange of their design for operation. This will result in an endangerment of system tability and security, which can be overcome by load disconnections at low requencies.				
Exhaustive requirement	:	х	Non-exhaustive requirement:			
Justification:	The mere	e capab	ility to disconnect load other than auxiliary s	upply is I	requested.	
Principle/Methodology	only:	х	(Ranges of) values/parameters given:			
Justification:	 Load to re Furt 	l discor estore a her spe	nection at low frequencies is a common prac balance in load and generation. cifications beside the general principle/meth	ctise eme odology	ergency feature are not needed.	
Alternative solutions:	 Exce adve All P resp and jeop 	 Excessive active power frequency response reserves to be contracted, which has adverse impact on cost-effectiveness. All Power Generating Modules, who shall deliver active power frequency response cannot run at their maximum power output, resulting in less efficiency and - in case of RES - potentials of carbon-free generation are not used. This may jeopardize achieving EU energy policy targets. 				
Link to FWGL:	 para requipara volta para (e.g. 	graph 2 iremen imeters age par graph 2 voltag	2.1: " Furthermore, the network code(s)sha ts on significant grid users in relation to the r contributing to secure system operation, incl ameters; Load-Frequency control related is 2.1.3: " the detail of possible deviations of e, frequency) that generation units must with	III define elevant s luding sues" significa stand	the system Frequency and nt parameters "	



Requirement:	Monitori	ng of F	SM					
Reference to NC RfG:	Article 10	D(2) (f)						
Cross-border impact:	Frequence transmis Frequence Deviation occur event immedia If load im Power G range of stability soutput o	requency without any doubt is the parameter of an interconnected electricity ransmission and distribution system, which has the largest cross-border impact. requency is the same across a synchronous area and across all voltage levels. reviations of frequency from its nominal value due to load imbalances therefore ccur everywhere at the same time and affect all Power Generating Modules nmediately in a common way regardless of their size and voltage level of connection. Ioad imbalances are not removed and frequency deviations increase, masses of ower Generating Modules will disconnect due to frequency, which is out of the ange of their design for operation. This will result in a deterioration of system tability and security, which can be overcome by a reduction/increase of active power utput of Power Generating Modules at high/low frequencies.						
Exhaustive requirement	:		Non-exhaustive requirement:	Х				
Justification:	 The correction Active and Henered apprendict 	 The mere capability to monitor active power frequency response and the corresponding minimum parameters are requested. Active power frequency response is a feature with high impact on system stability and security, because it aims at maintaining the generation – load equilibrium. Hence the TSO shall be in a position to monitor whether this service is appropriately provided as contractually agreed and remunerated. 						
Principle/Methodology	only:	х	(Ranges of) values/parameters given:					
Justification:	Further s operatio each TSC	pecific nal stra) and ca	ations beside the general principle/methodolo tegy and communication infrastructure in the an be specified at that level only.	ogy depo e respon	end on sibility area of			
Alternative solutions:	Have no based or available	require extens withou	ement and leave capability to the market. How sive experience, that the required minimum ca ut detailing what is required.	vever, it apability	is unlikely, v will be made			
Link to FWGL:	 para requi oper para sign oper impo grid and, 	graph : iremen rator ar graph : ificant g rational act upo user to /or DSC	3.1: " The network code(s) shall set out the p ots to coordinate and ensure information shari ad significant grid user" 3.2: " The network code(s) shall set the requi grid user to be able and obliged to provide the l information to the DSO and TSO that their co n. The network code(s) shall set the requirement be able to receive and to execute the instruct D, on a contractual basis or in critical operating	procedur ing betw irement necesso nnectio ent for e ions sen g state."	res and reen System for every ary real-time n has significant very significant t by the TSO			



Requirement:	High/low	High/low Voltage Disconnection					
Reference to NC RfG:	Article 10	D(3) (a)					
Cross-border impact:	Disconne in contex coordina	Disconnection of Power Generating Modules beyond operating ranges can be critical In context of prompt restoration of service and is a cross-border issue in terms of coordination of restoration.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	The requ Relevant local leve	The requirement makes two references to further details / decisions from the Relevant Network Operator pursuant to Article 4 (3). Delegating details to national / local level is appropriate to ensure good coordination of restoration plans.					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	Details ir coordina	ncludin _໌ tion.	g values to be added at national / local level to	o ensure	e essential local		
Alternative solutions:	Have no decisions after a m	require by Pov ajor dis	ment at all at European level, but rely upon i wer Generating Module Owners. This could le sturbance and absence of equitable burden sl	ndividua ad to slo haring.	l operational ow restoration		
Link to FWGL:	 para betv appl sign secu 	graph 2 veen th y. Furth ificant <u>c</u> re syste Freque	2.1: " The network code(s) shall define the p e significant grid user's equipment and the ne hermore, the network code(s) shall define the grid users in relation to the relevant system po em operation, including: ncy and voltage parameters;"	hysical c etwork to requiren aramete	onnection point o which they nents on rs contributing to		



Requirement:	Steady-s	Steady-state Stability						
Reference to NC RfG:	Article 10	D(4) (a)						
Cross-border impact:	Stable op to be rob	Stable operation is the foundation for cross-border trading. Generators are required to be robust and deliver steady state stability over the full operating range.						
Exhaustive requirement	ent: X Non-exhaustive requirement:							
Justification:	Stable op trading. expected	Stable operation is a fundamental basis for system operation and cross-border trading. No specific parameters are prescribed in NC RfG, nor are such parameters expected at a national level.						
Principle/Methodology only:		х	(Ranges of) values/parameters given:					
Justification:	No speci capabilit	fic para y.	meters are prescribed in NC RfG, nor require	d to defi	ne the required			
Alternative solutions:	Rely on r acceptab border p and oper	Rely on markets to encourage generators to deliver stable operation. This is not acceptable as it could result in large scale system wide disturbances including cross border power oscillations and would not facilitate clear assumptions in system design and operation.						
Link to FWGL:	• para be a oper will	graph 2 ble to e rating s be agre	2.1.3: " The network code(s) shall set out ho execute their control activities in normal and i tates. Specific parameters for operation outsi red bilaterally between generation units and s	w gener n alert (d de these system o	ation units must disturbed) operating states perators"			



Requirement:	Auto Rec	Auto Reclosures					
Reference to NC RfG:	Article 10	D(4) (b)					
Cross-border impact:	Power G without system is Auto-rec immedia particula condition	Power Generating Modules need to have the capability to withstand auto-reclosures without tripping in order to avoid widespread consequential system impact while the system is weak after a fault. Possible impact includes cross-border loss of supply. Auto-reclosure is a key TSO measure to quickly restore circuits in the network mmediately after a fault. This prepares the system for a further fault, which is particularly important for avoiding consumer disconnections under adverse conditions (e.g. bad weather), when multiple faults may occur in a short period.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	Details o Article 9	f the ca (6) (a).	pability are subject to coordination and agree	ement a	ccording to		
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	The requarts agreeme	iremen nt on p	t is given in principle only, with details subject rotection schemes and settings.	ct to coo	rdination and		
Alternative solutions:	 Have Gen robu follo Such of ge the acce of vi 	 Have no requirement on Power Generating Modules, hoping that the Power Generating Modules will have adequate operational / market incentive to be robust and stay connected during automatic system restoration switching following faults. Such incentives do not exist and therefore could result in risk of substantial loss of generation at the time the system is already disturbed. Also, it would not allow the TSOs to plan the system design and operation with any certainty. This is not acceptable from a point of view of system security and therefore from the point of view of providing a stable platform for cross-border trading. 					
Link to FWGL:	 para whic mus 	graph 2 ch kinds t withst	2.1.3: " The network code(s) shall define situ of network faults, which electrical distance) . cand, while remaining connected to the grid	iations ii that g ″	n general (e.g. eneration units		



Requirement:	Black Sta	Black Start Capability					
Reference to NC RfG:	Article 1	Article 10(5) (a)					
Cross-border impact:	Black sta in which	rt capa cross b	bility is critical to restoration of a power syste order trading can be resumed after a major d	em to a s listurbar	stable condition nce.		
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	 Artic Ope Ope This inte 	 Article 10 (5) a) contains reference to Article 4 (3) for the Relevant N Operator to define the timeframe for restoration and the Relevant N Operator defines the voltage limits. This achieves an appropriate level of subsidiarity, while ensuring the interest. 					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	 The Rele Leav and 	 The requirement is given only in broad principle. Details are defined locally by the Relevant Network Operator. Leaving details to local level is appropriate to achieve the optimal arrangement and ensuring that the relevant parties are well co-ordinated at a local level. 					
Alternative solutions:	 Blac adec and of su An c requ whe Mod 	k start (quate le may th upply. optimal uiremer n requi dule Ow	could be entirely left to market. However, th evel of certainty to deliver efficient planning b erefore result in less efficient system restorat level of reliance on market (in procurement) hts at a principle level and ensure that the ser red, without unnecessary investments for the yners.	is would between cions, wi is ensur vices car e Power	not achieve an adjacent TSOs th longer losses ed by leaving the n be delivered Generating		
Link to FWGL:	 para (re)c code activ for c gene proc netv elab In po mini agre • 	agraph 2 connect e(s) sha vities in operation redures vork co- orate ta articula imum ro- red bass House operat Black s Island	2.1.3: " The network code(s) shall define mir ion to the grid in disturbed/critical operating Il set out how generation units must be able t normal and in alert (disturbed) operating sta on outside these operating states will be agree units and system operators. Coordination req for reconnection after tripping shall be define de(s) for the different parties involved. The ne heir different roles and responsibilities. r for the following services the network code(equirements for those generators providing th is: load operation including the minimum duratio ion; tart; and operation."	nimum co state. Th o execut tes. Spec ed bilate uiremen ed transp twork co s) shall s nem on c on of hou	onditions for the network the their control cific parameters the and the sand the sa		



Requirement:	Capabilit	Capability to take part in Island Operation						
Reference to NC RfG:	Article 10	D(5) (b)						
Cross-border impact:	Island op reduced significar island in Europe is	and operation occurs seldom. The consequences of islanding are significantly duced if all plants remain in operation. The absence of this quality played a gnificant part in turning a severe disturbance into a total blackout for the Italian and in September 2003. Consequences can be widespread as during the Continental prope islanding on 4 November 2006.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	 The Artic This system 	The requirement refers to decision of the Relevant Network Operator pursual Article 4 (3) for Types C & D. This provides an appropriate level of subsidiarity while protecting the wider system needs.						
Principle/Methodology	only:	х	(Ranges of) values/parameters given:					
Justification:	 Pred a min This adec syste 	 Predominantly, the requirement focuses on principles, although part 2) describes a minimum power reduction capability (to 55%). This compromise ensures that proven experience is shared and delivers an adequate minimum performance, with equitable sharing between users of system resilience. 						
Alternative solutions:	 Have base mad This expension 	 Have no requirement and leave capability to the market. However, it is unlikely, based on extensive experience, that the required minimum capability will be made available without detailing what is required. This would also be undesirable both for network operators (capture best practice experience) and for cost-effective European manufacturing. 						
Link to FWGL:	 para (re)c code activ for o gene proc netw elabo In po mini agre O O 	graph 2 onnect (s) sha vities in peratic eration edures vork cou orate ti articula mum re ed basi House operati Black s Island d	2.1.3: " The network code(s) shall define mir ion to the grid in disturbed/critical operating Il set out how generation units must be able t normal and in alert (disturbed) operating sta on outside these operating states will be agree units and system operators. Coordination req for reconnection after tripping shall be define de(s) for the different parties involved. The ne heir different roles and responsibilities. r for the following services the network code(equirements for those generators providing th is: load operation including the minimum duration for; tart; and operation."	nimum c state. Th o execut tes. Spe ed bilate nuiremer ed transp twork co s) shall s nem on c on of ho	onditions for the network the their control cific parameters the their control cific parameters the the the the the the contractually- use load			



Reference to NC RfG: Article 10(5) (c) Cross-border impact:: Quick re-synchronisation is important in terms of restoring the power system after a major disturbance. This may have cross-border consequences in large disturbances. Exhaustive requirement: Non-exhaustive requirement: X Justification: Reference is made in Article 10 (5) c) 3) to Article 4 (3) for selecting the duration of continued operation. This provides an appropriate level of subsidiarity while protecting the wider system needs. Principle/Methodology only: X (Ranges of) values/parameters given: Justification: The requirement is kept as a principle rather than specifically calling for house load operation, in order to maximise the freedom for designers. By specifying in general terms rather than calling for trip to house-load for all Power Generating Modules, it avoids unnecessary investments, e.g. for hydro stations. Alternative solutions: Require house load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification). Link to FWGL: paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their controd activ	Requirement:	Quick Re-synch	Quick Re-synchronization Capability					
Cross-border impact: Quick re-synchronisation is important in terms of restoring the power system after a major disturbance. This may have cross-border consequences in large disturbances. Exhaustive requirement: Non-exhaustive requirement: X Justification: Reference is made in Article 10 (5) c) 3) to Article 4 (3) for selecting the duration of continued operation. This provides an appropriate level of subsidiarity while protecting the wider system needs. Principle/Methodology only: X (Ranges of) values/parameters given: Justification: The requirement is kept as a principle rather than specifically calling for house load operation, in order to maximise the freedom for designers. By specifying in general terms rather than calling for trip to house-load for all Power Generating Modules, it avoids unnecessary investments, e.g. for hydro stations. Alternative solutions: Require house load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification). Link to FWGL: paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network co	Reference to NC RfG:	Article 10(5) (c						
Exhaustive requirement: X Justification: Reference is made in Article 10 (5) c) 3) to Article 4 (3) for selecting the duration of continued operation. This provides an appropriate level of subsidiarity while protecting the wider system needs. Principle/Methodology only: X (Ranges of) values/parameters given: Justification: The requirement is kept as a principle rather than specifically calling for house load operation, in order to maximise the freedom for designers. By specifying in general terms rather than calling for trip to house-load for all Power Generating Modules, it avoids unnecessary investments, e.g. for hydro stations. Alternative solutions: Require house load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification). Link to FWGL: paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameters for operation units det these operating states will be agreed bilaterally between generation	Cross-border impact:	Quick re-synch major disturba	ronisation is important in terms of restoring th nce. This may have cross-border consequence	ne powe s in large	r system after a e disturbances.			
Justification: Reference is made in Article 10 (5) c) 3) to Article 4 (3) for selecting the duration of continued operation. This provides an appropriate level of subsidiarity while protecting the wider system needs. Principle/Methodology only: X (Ranges of) values/parameters given: Justification: The requirement is kept as a principle rather than specifically calling for house load operation, in order to maximise the freedom for designers. By specifying in general terms rather than calling for trip to house-load for all Power Generating Modules, it avoids unnecessary investments, e.g. for hydro stations. Alternative solutions: Require house load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification). Link to FWGL: paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameters for operation units and system operators. Coordination requirements and procedures for reconnection after tripping shall be defined transparently in the network code(s) for the dif	Exhaustive requirement	:	Non-exhaustive requirement:					
Principle/Methodology only: X (Ranges of) values/parameters given: Justification: • The requirement is kept as a principle rather than specifically calling for house load operation, in order to maximise the freedom for designers. By specifying in general terms rather than calling for trip to house-load for all Power Generating Modules, it avoids unnecessary investments, e.g. for hydro stations. Alternative solutions: • Require house load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification). Link to FWGL: • paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameterss for operation units and system operators. Coordination requirements and procedures for reconnection after tripping shall be defined transparently in the network code(s) for the different parties involved. The network code(s) shall elaborate their different roles and responsibilities.	Justification:	 Reference of continu This provio system ne 	Reference is made in Article 10 (5) c) 3) to Article 4 (3) for selecting the duration of continued operation. This provides an appropriate level of subsidiarity while protecting the wider system needs.					
Justification: The requirement is kept as a principle rather than specifically calling for house load operation, in order to maximise the freedom for designers. By specifying in general terms rather than calling for trip to house-load for all Power Generating Modules, it avoids unnecessary investments, e.g. for hydro stations. Alternative solutions: Require house load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification). Link to FWGL: paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameters for operation outside these operating states will be agreed bilaterally between generation units and system operators. Coordination requirements and procedures for reconnection after tripping shall be defined transparently in the network code(s) for the different parties involved. The network code(s) shall elaborate their different roles and responsibilities. 	Principle/Methodology	only: X						
 Alternative solutions. Require noise load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification). Link to FWGL: paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameters for operation outside these operating states will be agreed bilaterally between generation units and system operators. Coordination requirements and procedures for reconnection after tripping shall be defined transparently in the network code(s) for the different parties involved. The network code(s) shall elaborate their different roles and responsibilities. 	Justification:	The requir load opera By specifying ir Generating Mc	The requirement is kept as a principle rather than specifically calling for house load operation, in order to maximise the freedom for designers. Ty specifying in general terms rather than calling for trip to house-load for all Power Generating Modules, it avoids unnecessary investments, e.g. for hydro stations.					
Link to FWGL: • paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameters for operation outside these operating states will be agreed bilaterally between generation units and system operators. Coordination requirements and procedures for reconnection after tripping shall be defined transparently in the network code(s) for the different parties involved. The network code(s) shall elaborate their different roles and responsibilities.	Alternative solutions:	 Require no suggested allow cost Having no restoration manufactu 	Require house load operation. The requirement is kept more general than suggested by the FWGL in order to make it more proportionate and hence to allow cost savings for some technologies. Having no requirement at all, could lead to an inadequate capability for fast restoration (with unequal burden sharing) and or less competitive European manufacturing (absence of a clear specification).					
In particular for the following services the network code(s) shall set out the minimum requirements for those generators providing them on a contractually- agreed basis: O House load operation including the minimum duration of house load operation;	Link to FWGL:	 paragraph (re)connect code(s) she activities in for operation procedures network co elaborate In particul minimum agreed bas House opera 	 paragraph 2.1.3: " The network code(s) shall define minimum conditions for (re)connection to the grid in disturbed/critical operating state. The network code(s) shall set out how generation units must be able to execute their control activities in normal and in alert (disturbed) operating states. Specific parameters for operation outside these operating states will be agreed bilaterally between generation units and system operators. Coordination requirements and procedures for reconnection after tripping shall be defined transparently in the network code(s) for the different parties involved. The network code(s) shall elaborate their different roles and responsibilities. In particular for the following services the network code(s) shall set out the minimum requirements for those generators providing them on a contractually-agreed basis: House load operation including the minimum duration of house load operation; 					



Requirement:	Loss of St	loss of Stability					
Reference to NC RfG:	Article 10	(6) (a)					
Cross-border impact:	Loss of st and secur occur, int cleared su system m	oss of stability or loss of control of a Power Generating Module is a threat to stability nd security of other Power Generating Modules and to the system as a whole. It may ccur, inter alia, as a consequence of a short-circuit in the network, if this fault is not eared sufficiently fast. Other phenomena, like power oscillations in the transmission ystem may put a risk to stability of Power Generating Modules as well.					
Exhaustive requirement	:	Non-exhaustive requirement: X					
Justification:	 Loss netw syste In ord again contri of los chara 	Loss of stability or controllability of a Power Generating Module is a situation the network needs to be protected against in order to avoid adverse impacts on system stability and security as a whole. In order to protect the Power Generating Module against damage and the system against further disturbances and instability, a module which has lost stability or controllability shall be disconnected from the network. The criteria for detection of loss of stability or loss of control may depend on regional system characteristics and need to be agreed with the relevant network operator.					
Principle/Methodology only: X (Ranges of) values/parameters given:							
Justification:	 The gamma Crite syste opera 	 The generality of disconnection in case of loss of stability or control is required by the network code. Criteria for detection of loss of stability or loss of control may depend on regional system characteristics and need to be agreed with the relevant network operator. 					
Alternative solutions:	Leave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.						
Link to FWGL:	• para be al oper will b	graph 2 ble to e ating s be agre	2.1.3: " The network code(s) shall set out hexecute their control activities in normal and is tates. Specific parameters for operation outsi ped bilaterally between generation units and s	ow gene n alert (c de these system o _l	ration units must listurbed) operating states perators"		



Requirement:	Instrume	Instrumentation for Fault and Dynamic Behaviour Recording						
Reference to NC RfG:	Article 10	D(6) (b)						
Cross-border impact:	Adequat after dist system s operator and to di	Adequate dynamic behaviour of Power Generating Modules, in particular during and after disturbances to the system, is a prerequisite for network operators to maintain system stability and security. Recordings of such behaviour enable the network operators to analyse the system behaviour in critical states, e.g. for risk assessments, and to draw conclusions for possible improvements, if applicable.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	Network behaviou to the sy and its co	Network operators need to have access to data which characterise the dynamic behaviour of Power Generating Modules, in particular during and after disturbances to the system in order to have the possibility to further investigate such behaviour and its consequences to system stability and security.						
Principle/Methodology	nly: X (Ranges of) values/parameters given:							
Justification:	The requ such pro and the I	The requirement specifies data provision by Power Generating Modules. Details on such provision need to be defined and agreed between the relevant network operator and the Power Generating Module.						
Alternative solutions:	Have no based or available	Have no requirement and leave capability to the market. However, it is unlikely, based on extensive experience, that the required minimum capability will be made available without detailing what is required.						
Link to FWGL:	 para requioper para signioper oper oper oper oper oper oper oper 	graph 3 niremen rator an graph 3 ificant <u>g</u> rational act upo user to /or DSO	3.1: " The network code(s) shall set out the p ts to coordinate and ensure information shar od significant grid user" 3.2: " The network code(s) shall set the requ grid user to be able and obliged to provide the information to the DSO and TSO that their co n. The network code(s) shall set the requirement be able to receive and to execute the instruct of, on a contractual basis or in critical operating	procedur ing betw irement e necesso pnnection ent for e tions sen g state."	es and veen System for every ary real-time n has significant very significant t by the TSO			



Requirement:	Simulatio	Simulation Models					
Reference to NC RfG:	Article 10	D(6) (c)					
Cross-border impact:	Network stability a simulatic modellec Generati not possi	letwork operators need to simulate the system behaviour with regard to system tability and security in order to detect early possible weaknesses or threats. For such imulations models of all components of the system need to be mathematically nodelled. In addition network operators need to simulate the compliance of Power Generating Modules with the provisions of this network code, if compliance tests are not possible or not sufficient.					
Exhaustive requirement	:	Non-exhaustive requirement: X					
Justification:	 The signiant of the signiant of the significant of the significant of the simple com these simple com the simple	The steady-state and dynamic behaviour of Power Generating Modules has a significant impact on system stability and security. Hence, they need to be adequately modelled for the corresponding simulations, which are performed regularly by the network operators. The requirements for such models depend on the scope of simulations to be performed. Depending on the scope of simulations to be performed by the network operator, simple standard models or more sophisticated models are needed. If more comprehensive and detailed models are needed in particular for dynamic studies, these need to be explicitly required from the Power Generating Module Owner.					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	The deta only be s	The details of the simulation models depend on the scope of the simulations and can only be specified in this context.					
Alternative solutions:	Have no based on available	Have no requirement and leave capability to the market. However, it is unlikely, based on extensive experience, that the required minimum capability will be made available without detailing what is required.					
Link to FWGL:	• para requi	graph 3 iremen ator ar	3.1: " The network code(s) shall set out the p its to coordinate and ensure information shar nd significant grid user"	procedur ing betw	res and veen System		



Requirement:	Installati	Installation of Devices for System Operation and/or Security					
Reference to NC RfG:	Article 10	D(6) (d)					
Cross-border impact:	This requ devices,	his requirement contributes to system security, as it allows for installation of evices, which support this purpose.					
Exhaustive requirement	:	Non-exhaustive requirement: X					
Justification:	 The code This on s 	The mere option to agree on such devices, which are not covered by this network code otherwise, is introduced by this requirement. This requirement is a precautionary option for unpredictable issues with impact on system security.					
Principle/Methodology	y only: X (Ranges of) values/parameters given:						
Justification:	Further s covered	Further specifications can only be made, if an issue is identified, which shall be covered by this requirement.					
Alternative solutions:	Have no based or available	Have no requirement and leave capability to the market. However, it is unlikely, based on extensive experience, that the required minimum capability will be made available without detailing what is required.					
Link to FWGL:	paragrap to coordi significai	h 3.1: ' inate ar nt grid i	" The network code(s) shall set out the proce nd ensure information sharing between Sys user"	edures ai tem opei	nd requirements rator and		



Requirement:	Rate of C	hange	of Active Power					
Reference to NC RfG:	Article 10	Article 10(6) (e)						
Cross-border impact:	Fast char to deviat paramete which ha synchror nominal and affeo their size	ast changes of active power output may lead to load imbalances and consequently o deviations of frequency from its nominal value. Frequency without any doubt is the parameter of an interconnected electricity transmission and distribution system, which has the largest cross-border impact. Frequency is the same across a ynchronous area and across all voltage levels. Deviations of frequency from its ominal value due to load imbalances therefore occur everywhere at the same time nd affect all Power Generating Modules immediately in a common way regardless of heir size and voltage level of connection.						
Exhaustive requirement	:	Non-exhaustive requirement: X						
Justification:	 In pa activ This affee char takir Rapi part freq freq char 	 In particular RES Power Generating Modules may be subject to sudden changes in active power output due to their prime mover dependency (e. g. wind fronts). This may result in significant load imbalances, if large RES power parks are affected simultaneously. In order to mitigate such rapid changes, the rate of change of active power needs to be limited. Further details need to be specified taking into consideration system and operational characteristics. Rapid changes of active power output by RES Power Generating Modules in particular, have to be compensated by other modules providing active power frequency response in order to balance load and generation. As active power frequency response reserves cannot be activated indefinitely fast, the rate of change of active power needs to be limited. 						
Principle/Methodology	nodology only: X (Ranges of) values/parameters given:							
Justification:	 The dependent of the depend	 The detailed parameters of limiting rate of change of active power output depend on a number of system and operational characteristics. System inertia has impact on the magnitude of frequency deviations in case of load imbalances and thus indirectly influences the admissible rate of change of active power output. Activation time of active power frequency response determines how fast load imbalances can be mitigated. 						
Alternative solutions:	 Exce adve Limit this 	 Excessive active power frequency response reserves to be contracted, which has adverse impact on cost-effectiveness. Limitations on penetration of (RES) generation without inherent inertia, however this will jeopardize achieving EU energy policy targets. 						
Link to FWGL:	 para requi para volto para (e.g. 	graph 2 iremen meters age par graph 2 voltag	2.1: " Furthermore, the network code(s)sha ts on significant grid users in relation to the r contributing to secure system operation, incl ameters;" 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	III define elevant s luding significat stand	the system Frequency and nt parameters "			



Requirement:	Transfor	Fransformer Neutral-Point Treatment					
Reference to NC RfG:	Article 10	D(6) (f)					
Cross-border impact:	Proper e transforr ensure sy	Proper earthing arrangements of the neutral-point at the network side of step-up cransformers are crucial for reliable detection of faults by network protection to ensure system stability and security.					
Exhaustive requirement	:	Non-exhaustive requirement: X					
Justification:	 Neu prot The Network 	 Neutral-point treatment of transformers is essential for the functioning of protection schemes and settings. The neutral-point treatment needs to be specified further by the Relevant Network Operator due to its earthing arrangements and regional earthing conditions of the network. 					
Principle/Methodology	Principle/Methodology only: X (Ranges of) values/parameters given:						
Justification:	Further s Relevant condition	Further specifications on the neutral-point treatment can only be made by the Relevant Network Operator taking into consideration earthing arrangements and conditions.					
Alternative solutions:	Leave the However system.	Leave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system.					
Link to FWGL:	• para men tribu	graph 2 ts on si iting to	2.1: " Furthermore, the network code(s)sha gnificant grid users in relation to the relevant secure system operation, …"	III define system	the require- parameters con-		



Requirement:	Moderni	Modernisation or Replacement of Equipment					
Reference to NC RfG:	Article 10	D(6) (g)					
Cross-border impact:	The requ stability this purp these rec	he requirements of this network code are needed in order to maintain system tability and security, which is the overall objective of this network code. To achieve his purpose as many Power Generating Modules as reasonably possible shall meet hese requirements.					
Exhaustive requirement	ment: Non-exhaustive requirement: X						
Justification:	 The such as fa on s relevent of the such as fa on s relevent of the such as fa on s relevent of the such as the s	 The Relevant Network Operator and/or the Relevant TSO need to be aware of such changes to Power Generating Modules due to modernisation/replacements as far as they relate to requirements of this network code, because of the impact on system stability and security. If reasonably possible, compliance with the relevant requirements of this network code shall be achieved in such a case. Further specifications on compliance of modernised existing Power Generating Modules with the requirements of this network code need an investigation of the individual case, which shall be initiated by this requirement. This strikes a balance between the code's focus on new units and the treatment of existing installations. 					
Principle/Methodology	only: X (Ranges of) values/parameters given:						
Justification:	The requ to be giv values/p	The requirement itself describes a principle/methodology. No values/parameters are to be given. The investigation of the individual case will reveal, whether values/parameters for this specific case are needed.					
Alternative solutions:	Do nothi Owners t of the ins is it acce requirem applicati to requir investme sustainal is needed	Do nothing. However it is rather common practise of Power Generating Facility Owners to modernise/reinforce their installations and this often includes an increase of the installed generation capacity (e. g. Repowering of RES generation units). While is it acceptable, that existing generators shall not be enforced to meet the requirements of this network code (except for an application for retroactive application is made) for their remaining lifetime, it is on the other hand appropriate to require compliance in cases of modernisation/reinforcement, because such investments target, amongst others, at extending the lifetime rendering such units a sustainable part of the future generation portfolio, for which this set of requirements is needed.					
Link to FWGL	• para sign secu	igraph i ificant g ire syste	2.1: " The network code(s) shall define the re grid users in relation to the relevant system po em operation,"	equirem aramete	ents on rs contributing to		



Requirement:	Voltage I	Voltage Ranges						
Reference to NC RfG:	Article 1	1(2) (a)						
Cross-border impact:	Voltage r a synchro networks	oltage ranges are critical to secure planning and operation of a power system within synchronous area. These needs to be coordinated between adjacent interconnected etworks. This can often be a cross border issue.						
Exhaustive requirement	:	X Non-exhaustive requirement:						
Justification:	This requ one volta room for	This requirement is given exhaustively in tables 6.1 and 6.2. There is an exception for one voltage range in Continental Europe. Because of the size of this system, there is oom for limited variation, while retaining wider coordination.						
Principle/Methodology	only: (Ranges of) values/parameters given: X							
Justification:	DetaTher and	 Details are given for in tables 6.1 and 6.2. There is a clear need to coordinated between adjacent interconnected networks and therefore operating ranges need to be specified. 						
Alternative solutions:	Have no in planni operatin	Have no defined voltage ranges. However, this would lead to widespread uncertainty in planning and operation of the system with respect to operation beyond normal operating conditions.						
Link to FWGL:	 para betv appl sign secu 	 paragraph 2.1: " The network code(s) shall define the physical connection point between the significant grid user's equipment and the network to which they apply. Furthermore, the network code(s) shall define the requirements on significant grid users in relation to the relevant system parameters contributing to secure system operation, including: Frequency and voltage parameters;" 						



Requirement:	Voltage (Voltage Control System (simple)					
Reference to NC RfG:	Article 1	1(2) (b)					
Cross-border impact:	Voltage cross bo can spre applied requirer	oltage control for Types B and C Synchronous Power Generating Modules can be a ross border issue. The absence of such a facility can lead to voltage instability which an spread to neighbouring systems. The absence of a voltage control system, if pplied to many Power Generating Modules may remove the fundamental equirement for cross-border trading, namely system stability.					
Exhaustive requirement:		X Non-exhaustive requirement:					
Justification:	A simple This is ex	A simple high level principle requirement is provided for the voltage control system. This is exhaustive.					
Principle/Methodology or	nly: X (Ranges of) values/parameters given:						
Justification:	 Only over In co prop 	Only a high level principle is defined for the voltage control: "without instability over the entire operating range". In context of size of units and their potential impact this is considered proportionate and appropriate in context of cross-border aspects.					
Alternative solutions:	Leave th However system. /	eave this requirement to market incentives to deliver the necessary stability. However, there would be no certain basis upon which to plan and operate the system. A voltage control system is required to ensure voltage stability.					
Link to FWGL:	• para tech man	graph 2 nical re ageme	2.1: " The network code(s) shall set out how quirements related to and to voltage and r nt"	the TSO eactive µ	defines the power		



Requirement:	Fault-ride above	Fault-ride-through Capability of Power Generating Modules connected at 110 kV or above						
Reference to NC RfG:	Article 1	Article 11(3) (a)						
Cross-border impact:	Failure to instabilit Nordic A caused a Copenha The abilit is central Weaker I system d contribut generato	ailure to ride through faults for synchronous generators can create major system istability with cross-border implications. This condition has been experienced in the ordic Area, where failure of large generators to ride through a fault in Sweden aused a total system black-out for an extended period, including a black-out of openhagen in Denmark. The ability to ride through faults on the ≥ 110kV system even for 0 V retained voltage central to system security. It has to be implemented in all systems. Example: /eaker FRT capability and robustness of large synchronous generators during a major /stem disturbance (the Italian islanded system in Sept 2003) are thought to have pontributed to the total collapse (frequency instability). This resulted from 15 large enerators failing to ride through faults during the system split.						
Exhaustive requirement:			Non-exhaustive requirement:	х				
Justification:	 In or TSO: Thes som beer deci: syste At a (by r unde achie 	 In order to reflect geographical differences (between synchronous areas and TSOs) key parameters are left to be defined at a national level, see Table 7.1. These differences also reflect more severe fault duration FRT requirements in some countries (Nordic synchronous area) where total system shut down has been experienced. This experience has lead subsequently due to political decisions to raising the degree of FRT cover to a further level, securing the system integrity for double contingencies. At a European level it is at the same time undesirable to waste these investments (by not allowing the tougher requirements (250ms) to be retained) and also undesirable to force all others to make the further investments needed to achieve this higher level of security. 						
Principle/Methodology or	only: (Ranges of) values/parameters given: X							
Justification:	 Rang abov choi FRT Stak long no ir of at 	 Ranges of values are given to allow appropriate national choices, e.g. as discussed above. At a national level it is important that there is good coordination between choice of parameters and choice of initial pre-fault system conditions which the FRT capability has to be demonstrated against. Stakeholders have correctly pointed out that the worst combination possible of long durations and most severe pre fault conditions are not achievable. There is no intention to have such combinations. This aspect has to be taken proper care of at the national level, within the national processes (Article 4(3)). 						
Alternative solutions:	Have no appropri would re restrictio	Have no requirement relying on market incentives. However, there are no appropriate market incentives for this basic capability. Absence of this requirement would result in an unacceptable lower level of system security and lead to major restrictions in development of RES in.						
Link to FWGL:	 para betw appl signi secu 	graph 2 veen th y. Furth ficant <u>c</u> re syste o Fa	2.1: " The network code(s) shall define the part e significant grid user's equipment and the ne nermore, the network code(s) shall define the grid users in relation to the relevant system part em operation, including: ult-ride-through capability"	hysical c twork to requirer aramete	connection point o which they nents on rs contributing to			



Requirement:	Synchron	ization					
Reference to NC RfG:	Article 11	Article 11(4) (a)					
Cross-border impact:	Larger Po relevant of instabi be possib frequenc needed in	arger Power Generating Modules shall be connected only after authorisation by the elevant network operator. Otherwise, if connection conditions are not fulfilled, a risk of instability of the unit or the security of the system may result. Furthermore it has to be possible to connect a Power Generating Module, even if system parameter like requency or voltage deviate from their nominal values, in particular, if these units are needed in disturbed operating situations in order to restore normal conditions.					
Exhaustive requirement			Non-exhaustive requirement:	х			
Justification:	To mana conditior authoriza conditior	ge syste is for co ition ar is.	em stability and security the relevant network onnection of Power Generating Modules. Both nd values/ranges of system parameters need t	operato n connec o be cov	r shall specify tion rered by such		
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	Detailed character Power Ge	parame ristics, v eneratio	eters for connection conditions depend on reg which have impact on stable connection and s ng Module.	ional sys ubseque	stem ent operation of a		
Alternative solutions:	Leave thi However	s requi , there	rement to market incentives to deliver the neo would be no certain basis upon which to plan	cessary s and ope	stability. erate the system.		
Link to FWGL:	 para techi volto para signi TSO 	graph 2 nical re Ige and graph 3 ficant <u>g</u> and/or	2.1: " The network code(s) shall set out how quirements related to frequency and active po reactive power management" 3.2: " The network code(s) shall set the requ grid user to be able to receive and to execute to DSO, …"	the TSO ower con irement he instru	defines the trol and to for every actions sent by the		



Requirement:	Reactive	eactive Power Capability for type B Synchronous Power Generating Modules						
Reference to NC RfG:	Article 12	rticle 12(2) (a)						
Cross-border impact:	Reactive foundation Modules Therefor reflects t	Reactive power is a key component in terms of voltage stability, which in turn is the oundation for cross-border trading. For Type B Synchronous Power Generating Modules the influence on overall system voltage stability will vary with location. Therefore the requirement for Type B Synchronous Power Generating Modules reflects this.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	 The to A prov For ⁻ need 	 The Relevant Network Operator shall have the right to adopt a decision pursuant to Article 4(3) determining the capability of a Power Generating Module to provide Reactive Power. For Type B this is a proportional and appropriate approach to allow the local needs to influence the requirements. 						
Principle/Methodology	only:	х	(Ranges of) values/parameters given:					
Justification:	The pring keep the	ciple of require	the requirement stated only in order to optir ement proportional in different local circumst	nise loca ances.	al freedom and to			
Alternative solutions:	No requi market ir Power G appropri	No requirement leaving market incentives to deliver adequate capacity. However, market incentives are usually absent at connection points for Type B Synchronous Power Generating Modules. Therefore the approach adopted is a proportionate and appropriate approach to allow the local needs to influence the requirements.						
Link to FWGL:	• para signi secu	graph 2 ficant g re syste 0 Re	2.1: " The network code(s) shall define the re grid users in relation to the relevant system po em operation, including: quirements for reactive power;"	equirem aramete	ents on rs contributing to			



Requirement:	Post-fau	lt Active	e Power Recovery				
Reference to NC RfG:	Article 1	2(3) (a)					
Cross-border impact:	Power re after fau versus re predomi For smal power re frequence disconne	Power recovery after a fault is important in order to restore the pre-fault operation after fault clearance. The relative priority of restoring the reactive power and voltage versus restoring real power and frequency depends upon the system size, predominantly of the synchronous area. For smaller synchronous areas (with less system inertia than larger areas) the real power restoration is particular time critical, in order to avoid reaching a system frequency following a large sudden power imbalance which results in demand disconnection.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	 This purs Reco This diffe 	 This requirement is only specified as the Relevant TSO shall adopt a decision pursuant to Article 4 (3) specifying magnitude and time for Active Power Recovery. This level of delegation to national level is appropriate to adequately reflect the different needs of the different sizes of synchronous areas. 					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	Ranges a issues of of syster	re not the na n inerti	provided. This is left open to deal nationally v ture of the network as well as changes over ti a.	with the me of th	combination of ne expected level		
Alternative solutions:	Have no demand Modules	Have no requirement. However, this could result in significantly increased danger of demand disconnection and unequal treatment of Synchronous Power Generating Modules.					
Link to FWGL:	 para betv appl sign secu 	ngraph 2 veen th ly. Furtl ificant g ire syste Fault-r	2.1: " The network code(s) shall define the p e significant grid user's equipment and the ne hermore, the network code(s) shall define the grid users in relation to the relevant system po em operation, including: ide-through capability"	hysical c etwork to requirer aramete	connection point o which they ments on rs contributing to		



Requirement:	Reactive	e Powe	r Capability at Maximum Active Power			
Reference to NC RfG:	Article 1	.3(2) (b)			
Cross-border impact:		Reactive power is a key component in terms of voltage stability, which in turn is the foundation for cross-border trading. For Type C and D Synchronous Power Generating Modules the influence on overall system voltage stability will vary with location. Therefore the requirement for Type C and D Synchronous Power Generating Modules reflects this.				
Exhaustive requirement	:		Non-exhaustive requirement:	Х		
Justification:	The pow Therefo proport	The power system need for Reactive Power is influenced by local conditions. Therefore the requirements are not specified in an exhaustive manner in order to be proportional to local needs.				
Principle/Methodology	rinciple/Methodology only:		(Ranges of) values/parameters given:	Х		
Justification:	Ranges requirer	of reac nents a	tive power allow national / local choices to are appropriate to local conditions and ensu	be made, en uring proport	suring ionality.	
Alternative solutions:	 Relvent has The to e 	 Rely upon markets to deliver adequate reactive capability. However, experience has shown that markets are better suited to optimise the use of reactive power than ensure adequate capability and therefore liquidity in the market. The requirement is proportionate in order in order to secure Reactive Capability to ensure system stability for the full range of operating conditions. 				
Link to FWGL:	● par sigr sect	agraph nificant ure syst Requi	2.1: "… The network code(s) shall define th grid users in relation to the relevant systen tem operation, including: rements for reactive power; …"	e requiremer n parameters	nts on contributing to	



Requirement:	Reactive	eactive Power Capability below Maximum Active Power						
Reference to NC RfG:	Article 13	3 (2) (c)						
Cross-border impact:	Reactive foundati Modules Therefor reflects t	Reactive power is a key component in terms of voltage stability, which in turn is the oundation for cross-border trading. For Type C and D Synchronous Power Generating Modules he influence on overall system voltage stability will vary with location. Therefore the requirement for Type C and D Synchronous Power Generating Modules eflects this.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	The capa capacity point. Th	city is o is, the o is is pro	only defined in outline. The requirement state capability shall be to be able to operate at eve oportionate and it allows local needs to be co	es that w ery possi nsiderec	hatever the ible operating 1.			
Principle/Methodology only:		х	(Ranges of) values/parameters given:					
Justification:	This is a	orincipl	e requirement. There is no range involved in	this part				
Alternative solutions:	 Have no requirement for this capability, rely entirely on market signals. However, this would not be appropriate and proportionate for this size of plant in context of required flexibility required for stable operation of the system. Experience has shown that markets are better suited to utilise capability than to secure the capability and hence ensuring a liquid market in operation. 							
Link to FWGL:	 para sign secu ○ 	graph 2 ificant g re syste Require	2.1: " The network code(s) shall define the re grid users in relation to the relevant system po em operation, including: ements for reactive power;"	equirem aramete	ents on rs contributing to			



Requirement:	Voltage (Control	System				
Reference to NC RfG:	Article 14	Article 14(2) (a)					
Cross-border impact:	Voltage border i Power G The abso spread t border t	Voltage control for Types D Synchronous Power Generating Modules can be a cross border issue. The presence of an effective voltage control for Type D Synchronous Power Generating Modules is essential for voltage stability. The absence of a voltage control system may lead to voltage instability which can spread to neighbouring systems, removing the fundamental requirement for cross- border trading, namely system stability.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	The requ contribut considera Generati	The requirement carries reference to Article 4 (3) introducing national / local contributions to complete the requirement. This is a proportional measure, allowing consideration of local conditions. It also allows for agreement with the Power Generating Facility Owner.					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	 The asso conc The stab 	require ciated cerns w voltage ility.	ement sets out the principle requirements wit ranges. This is appropriate and proportional t ithout limiting design freedom in how to delive control system requirement is included in or	hout spo o define ver this. der to e	ecifying any the main system nsure system		
Alternative solutions:	Have no requirement, but rely instead upon market encouragement. However, this is a topic unlikely to be suitable for market to deliver the certainty required for system planning and operation.						
Link to FWGL:	• para tech man	graph i nical re ageme	2.1: " The network code(s) shall set out how equirements related to and to voltage and rent"	the TSO eactive µ	defines the power		



Requirement:	Reactive I	Reactive Power Capability for type B Power Park Modules						
Reference to NC RfG:	Article 15	5(2) (a)						
Cross-border impact:	Reactive foundatic overall sy Type B Pc	eactive power is a key component in terms of voltage stability, which in turn is the oundation for cross-border trading. For Type B Power Park Modules the influence on verall system voltage stability will vary with location. Therefore the requirement for ype B Power Park Modules reflects this.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	 The F to Ar Mode For T to all 	 The Relevant Network Operator shall have the right to adopt a decision pursuant to Article 4(3) determining the capability of a Synchronous Power Generating Module to provide Reactive Power. For Type B Power Park Modules this is a proportional and appropriate approach to allow the local needs to influence the requirements. 						
Principle/Methodology only: X		х	(Ranges of) values/parameters given:					
Justification:	The princ keep the	iple of require	the requirement stated only in order to optir ement proportional in different local circumst	nise loca tances.	al freedom and to			
Alternative solutions:	 No results In ad mark typic This a content 	 No requirement could be implemented, hoping that the market would encourage such capability. In addition to the weakness of markets to deliver capacity to ensure liquid markets, there are unlikely to be any markets at all for these services at the typical connection points of Type B Power Park Modules. This alternative approach would not be proportional to the system needs in context of the rapidly expanding volume of embedded generation. 						
Link to FWGL:	 paraţ signij secui I 	graph 2 ficant <u>c</u> re syste Require	2.1: " The network code(s) shall define the re grid users in relation to the relevant system po em operation, including: ements for reactive power;"	equireme aramete	ents on rs contributing to			



Requirement:	Reactive	Reactive Current Injection						
Reference to NC RfG:	Article 1	5(2) (b)	and (c)					
Cross-border impact:	Reactive injecting Both of t are esser trading.	Reactive current injection is critical to both recovering the voltage during faults and to njecting enough current quickly enough for system protections to function reliably. 3oth of these aspects which are part of the fault-ride-through family of requirements are essential to system stability which in turn is the foundation for cross-border trading.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	The requ for the c local nee	iremen urrent i ds and	It refers to Article 4 (3) in respect national / T njection. This freedom allows national choice to take account of existing requirements.	SO choic es to refle	es of parameters ect developing			
Principle/Methodology	only:	х	(Ranges of) values/parameters given:					
Justification:	 Prov 10m The deve oppo seve pres 	ide in t s) as a require cloping ortuniti re asyr cribing	he main principles, although it contains also on national choice. Iment is a good balance between a clear state system need (driven by increases in RES pene es to build on national existing arrangements nmetrical faults (which have less widespread detailed technical specifications or implemen	ement of etration s, particu impact), ntations.	e (not less than the common increases) and larly for the less without			
Alternative solutions:	Rely on markets to deliver the required current injection capability. However, this is a detailed technical area which markets are not well equipped to deliver solutions for which can be relied upon in planning and operation of the power systems.							
Link to FWGL:	 para betv appl sign secu 	 paragraph 2.1: " The network code(s) shall define the physical connection point between the significant grid user's equipment and the network to which they apply. Furthermore, the network code(s) shall define the requirements on significant grid users in relation to the relevant system parameters contributing to secure system operation, including: Fault-ride-through capability" 						



Requirement:	Post-faul	Post-fault Active Power Recovery					
Reference to NC RfG:	Article 1	5(3) (a)					
Cross-border impact:	Post faul turn is a	ost fault power recovery is important in terms of system frequency stability, which in urn is a fundamental requirement for cross-border trading.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	The urge overall sy and the t system in national	The urgency of post fault recovery varies between systems depending upon the overall system inertia, which in turn depends upon the synchronous area system size and the types of generation. A high proportion of RES (wind and PV) tend to lower the system inertia. Because of these variations, the detailing of the requirement is left to national level in accordance with Article 4 (3).					
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	No speci and time variation	fic rang for Act s in nee	es are specified. It is up to the national level t ive Power recovery. This is proportionate to r ed between synchronous areas.	o deteri reflect tl	mine magnitude ne large		
Alternative solutions:	Leave th not facili	is issue tate eff	to the market to deliver. However, the conse fective system design, planning and operation	quent u	ncertainty would		
Link to FWGL:	 para betv appl sign secu 	graph 2 veen th ly. Furth ificant <u>c</u> re syste Fault-ri	2.1: " The network code(s) shall define the part e significant grid user's equipment and the ne permore, the network code(s) shall define the grid users in relation to the relevant system part em operation, including: ide-through capability"	hysical c twork to requirer aramete	connection point o which they nents on rs contributing to		



Requirement:	Synthetic	: Inertia	a Capability				
Reference to NC RfG:	Article 16	Article 16(2) (a)					
Cross-border impact:	Frequence distributi same acr from its r same tim regardles Synchror changes change o taken. It is there naturally contribut	requency is the parameter of an interconnected electricity transmission and istribution system which has the largest cross-border impact. The frequency is the ame across a synchronous area and across all voltage levels. Deviations of frequency rom its nominal value due to load imbalances therefore occur everywhere at the ame time and affect all Power Generating Modules immediately in a common way egardless of their size and voltage level of connection. ynchronous Generators have an inherent capability to resist / slow down frequency hanges which many RES technologies do not have. This will result in larger rate of hange of frequency during high RES production, at least unless counter measures are aken. t is therefore paramount in allowing further expansion of RES which does not naturally contribute to inertia, to provide a synthetic component to make its ontribution.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	This is an developi	i area w ng expe	which is still under development. It is therefor erience to be introduced at a national level.	e approp	oriate to allow		
Principle/Methodology	only:	х	(Ranges of) values/parameters given:				
Justification:	From the (not mat stated or methods expected	e combi ure) an nly as a such a l systen	nation of circumstances of a topic which is ur d varying needs between synchronous areas, high level principle and non-mandatory. This s fast acting frequency response to be consid n conditions.	nder rapi this req also allo ered, if a	id development uirement is ows alternative adequate for the		
Alternative solutions:	Leave top the critic importar	Leave topic out and allow market to deliver solutions when mature. However, due to the critical nature of this topic in context of allowing RES integration to progress, it is important to provide a firm signal about the system need at this stage.					
Link to FWGL:	 para on si cont para para (e.g. 	graph 2 ignifica ributing meters agraph voltag	2.1: " Furthermore, the network code(s)shall nt grid users in relation to the relevant systen g to secure system operation, including Free s;" 2.1.3: " the detail of possible deviations of s e, frequency) that generation units must with	l define t n param quency a ignifican stand ⁻	the requirements eters and voltage at parameters "		



Requirement:	Reactive	Reactive Power Capability at Maximum Active Power					
Reference to NC RfG:	Article 16	5(3) (b)					
Cross-border impact:	Reactive foundation influence	Reactive power is a key component in terms of voltage stability, which in turn is the oundation for cross-border trading. For Type C and D Power Park Modules the nfluence on overall system voltage stability will vary with location.					
Exhaustive requirement	:		Non-exhaustive requirement:	х			
Justification:	The powe Therefore proportic	he power system need for Reactive Power is influenced by local conditions. herefore the requirements are not specified in an exhaustive manner in order to be proportionate to local needs.					
Principle/Methodology	only:		(Ranges of) values/parameters given:	х			
Justification:	Ranges o requirem appropria	f reacti ients ar ateness	ve power are provided to allow national / loc opropriate to local conditions, ensure proport 5.	al choice cionality	es of and		
Alternative solutions:	 Rely has s than Inad prod Limit 	 Rely upon markets to deliver adequate reactive capability. However, experience has shown that markets are better suited to optimise the use of reactive power than ensure adequate capability and therefore liquidity in the market. Inadequate reactive capability would be a consequence (under high RES production) of this alternative with associated additional system security risks. Limitations in RES developments could therefore be a result of this alternative. 					
Link to FWGL:	 para signi secu ○ 	graph 2 ficant <u>c</u> re syste Require	2.1: " The network code(s) shall define the re grid users in relation to the relevant system po em operation, including: ements for reactive power;"	equirem aramete	ents on rs contributing to		



Requirement:	Reactive	Reactive Power Capability below Maximum Active Power						
Reference to NC RfG:	Article 16	5(3) (c)						
Cross-border impact:	Reactive foundatio influence	Reactive power is a key component in terms of voltage stability, which in turn is the foundation for cross-border trading. For Type C and D Power Park Modules the influence on overall system voltage stability will vary with location.						
Exhaustive requirement	:		Non-exhaustive requirement:	х				
Justification:	The powe Therefore proportion	The power system need for Reactive Power is influenced by local conditions. Therefore the requirements are not specified in an exhaustive manner in order to be proportionate to local needs.						
Principle/Methodology	only:		(Ranges of) values/parameters given:	х				
Justification:	The requ associate voltage s	iremen ed with tability	t is specified with ranges to allow for nationa local conditions of voltage stability, with the across the full operating range.	I / local aim to a	choices chieve certainty			
Alternative solutions:	 Rely has s than Inad prod Limit 	 Rely upon markets to deliver adequate reactive capability. However, experience has shown that markets are better suited to optimise the use of reactive power than ensure adequate capability and therefore liquidity in the market. Inadequate reactive capability would be a consequence (under high RES production) of this alternative with associated additional system security risks. Limitations in RES developments could therefore be a result of this alternative. 						
Link to FWGL:	 para signi secu ○ 	graph 2 ficant <u>o</u> re syste Require	2.1: "… The network code(s) shall define the re grid users in relation to the relevant system po em operation, including: ements for reactive power; …"	equireme aramete	ents on rs contributing to			



Requirement:	Reactive Power Control Modes							
Reference to NC RfG:	Article 16(3) (d)							
Cross-border impact:	Voltage control for Types C and D Power Park Modules can be a cross border issue. The absence of such a facility can lead to voltage instability which can spread to neighbouring systems. The absence of a voltage control system, if applied to many Power Park Modules may remove the fundamental requirement for cross-border trading, namely system stability.							
Exhaustive requirement:			Non-exhaustive requirement:	х				
Justification:	This requirement allows 3 in principle different control modes. This allows the selection to reflect the national / local needs.							
Principle/Methodology only:			(Ranges of) values/parameters given:	х				
Justification:	A choice of control mode as well as parameter choices allowed the requirement to reflect varied national / local needs.							
Alternative solutions:	Have no requirement. However, this alternative has the risk of the appropriate control mode not being available across the manufacturing range and also lacks clarity for the European RES manufacturing industry.							
Link to FWGL:	 paragraph 2.1: " The network code(s) shall set out how the TSO defines the technical requirements related to and to voltage and reactive power management" 							



Requirement:	Priority to Active or Reactive Power Contribution						
Reference to NC RfG:	Article 16(3) (e)						
Cross-border impact:	This is a part of the Fault Ride Through family of requirements. Failure to ride through faults (which risks simultaneous loss of large volumes of generation) at a time when the system is already disturbed carries a significant risk of loss of stability, the condition which is a pre-requisite for cross-border trading. Priority for power contribution is a cross-border issue as the wrong choice may lead to avoidable frequency or voltage instability.						
Exhaustive requirement:			Non-exhaustive requirement:	х			
Justification:	The TSO shall decide pursuant to Article 4 (3). This requirement is non-exhaustive in order to reflect the different priorities between on the one hand small synchronous areas (urgency of real power recovery for frequency stability) and on the other large synchronous areas (with less urgency on real power and more focus on voltage restoration).						
Principle/Methodology only:			(Ranges of) values/parameters given:	х			
Justification:	A choice is involved, although it is only between two options. This is needed to reflect system-specific conditions.						
Alternative solutions:	Have no requirement . However, this could result in sub-optimal choices which could lead to system instability. The uncertainty would also create unnecessary difficulties in system planning and operation.						
Link to FWGL:	 paragraph 2.1: " The network code(s) shall define the physical connection point between the significant grid user's equipment and the network to which they apply. Furthermore, the network code(s) shall define the requirements on significant grid users in relation to the relevant system parameters contributing to secure system operation, including: Fault-ride-through capability" 						



Requirement:	Power Oscillations Damping Control						
Reference to NC RfG:	Article 16(3) (f)						
Cross-border impact:	Power system oscillations can spread across borders and if inadequate measures are taken, it can result in angular (dynamic) instability. Therefore the means to prevent such instability must be considered a cross-border issue.						
Exhaustive requirement:			Non-exhaustive requirement:	х			
Justification:	This is a non-exhaustive requirement because many technologies already inherently provide such a capability and for others the need for special measures is under development.						
Principle/Methodology only: X		х	(Ranges of) values/parameters given:				
Justification:	 Only the high level principle is specified. It is intended to be applied only where needed combined with a selection of versions of Power Park Modules for which the need for special measured is justified. 						
Alternative solutions:	Have no requirement. However, considering the importance of damping power system oscillations to the stability of the European power system, it is important that a clear message is provided to manufacturers. Where there is no need for special measures these will be avoided.						
Link to FWGL:	 paragraph 2.1: " The network code(s) shall set out how the TSO defines the technical requirements related to and to voltage and reactive power management" 						