European Network of
Transmission System Operators
for Electricity

entsoe

SELECTING NATIONAL MW BOUNDARIES

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

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DESCRIPTION

Codes(s) and Article(s)	**NC RfG** – Articles 5

Introduction	NC RfG defines the requirements applicable to power generating modules by placing generators into one of four 'type' categories A-D. These categories are based on the maximum capacity of the power generating module (PGM) and its connection voltage level. NC RfG defines the limit for maximum capacity threshold of types B, C and D for each of the 5 synchronous areas in Europe. As part of the national implementation of NC RfG, the relevant TSO of each member state needs to set banding thresholds within these maximum values – and so have a choice between applying the maximum MW boundaries as defined in Table 1 of Article 5 or, where it is reasonable (e.g.. to maintain for new generators capabilities which shall currently already apply to existing generators for reasons of system security..), choosing lower values. The purpose of this IGD is to report/share the criteria/motivation for the choice of the boundaries and to support coordination in this area.

NC frame

Article 5 of the NC Requirements for Generators defines the application of the thresholds contained in Table 1 of that Article based on the capacity of PGMs.

In order to take into consideration of the evolution of power supply systems and the corresponding change of system characteristics and performance, NC RfG allows to review periodically the threshold points between the types of generators.

The thresholds may change based on the evolution of the system due to different reasons like increasing penetration of renewable energy sources usually combined with a change from bulk generation by synchronous generators at transmission level towards embedded generation at distribution level often connected through power electronics, or increased cross border reliance.

The code sets out that the thresholds cannot be changed more frequently than every three years after the previous proposal. When such a change is made it will apply by default to new generators going forwards and the date of application to new generators has also to be determined at national level, taking account of the process applied when the code has been introduced.

Changes can also apply retrospectively but only where the process for retrospective application (article 4.3 of RfG) is followed. In this case only, and in accordance with article 4.3, a cost-benefit analysis (CBA) is required, but only to apply any revised requirements to existing generators.

Article 5, sections 2, 3 and 4 states:

"*Power generating modules within the following categories shall be considered as significant:*

(a) *connection point below 110 kV and maximum capacity of 0.8 kW or more (type A);*

(b) *connection point below 110 kV and maximum capacity at or above a threshold proposed by each relevant TSO in accordance with the procedure laid out in paragraph 3 (type B). This threshold shall not be above the limits for type B power generating modules contained in Table 1;*

(c) *connection point below 110 kV and maximum capacity at or above a* *threshold specified by each relevant TSO in accordance with paragraph 3 (type C). This threshold shall not be above the limits for type C power generating modules contained in Table 1; or*

(d) *connection point at 110 kV or above (type D). A power generating module is also of type D if its connection point is below 110 kV and its maximum capacity is at or above a threshold specified in accordance with paragraph 3. This threshold shall not be above the limit for type D power generating modules contained in Table 1.*

Synchronous areas	***Limit for maximum capacity threshold from which a power generating module is of type B***	***Limit for maximum capacity threshold from which a power generating module is of type C***	***Limit for maximum capacity threshold from which a power generating module is of type D***
Continental Europe	*1 MW*	*50 MW*	*75 MW*
Great Britain	*1 MW*	*50 MW*	*75 MW*
Nordic	*1.5 MW*	*10 MW*	*30 MW*
Ireland and Northern Ireland	*0.1 MW*	*5 MW*	*10 MW*
Baltic	*0.5 MW*	*10 MW*	*15 MW*

Table 1: Limits for thresholds for type B, C and D power generating modules

Proposals for maximum capacity thresholds for types B, C and D power generating modules shall be subject to approval by the relevant regulatory authority or, where applicable, the Member State. In forming proposals the relevant TSO shall coordinate with adjacent TSOs and DSOs and shall conduct a public consultation in accordance with Article 10. A proposal by the relevant TSO to change the thresholds shall not be made sooner than three years after the previous proposal.

Power generating facility owners shall assist this process and provide data as requested by the relevant TSO."

An example on threshold selection is available in Annex 1.
An example on the 3 years statement for threshold change is available in Annex 2.

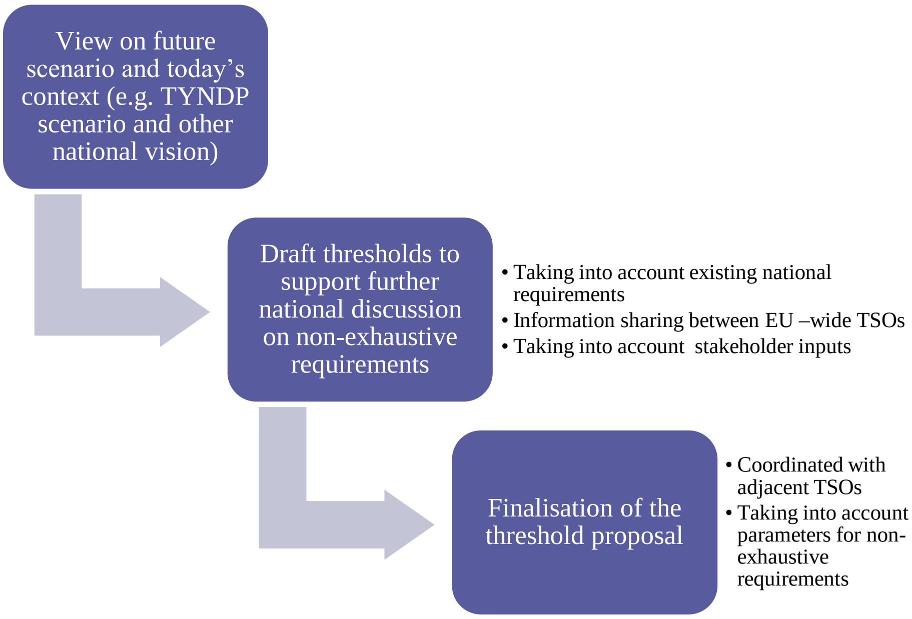
Further info	NC RfG introduces four categories of PGMs (Type A-D) by following the principle of subsidiarity and proportionality. The categories are defined by the voltage level of grid connection and the installed capacity of a PGM. The capacity thresholds are defined as limits of capacity threshold which define the maximum lower limit of each category leaving its final determination to the national level.

	Type B, C, D thresholds need to be determined at national level regarding the following points : - Maintaining requirements which already exists from previous national regulations and have proven their need and benefit through operational experience in normal and emergency network situations. - Taking into consideration the national generation portfolio characteristics and its evolution (e.g. level of penetration of renewable energy sources) - Taking into consideration national system characteristics and its evolution (e.g. rural/urban conditions, density of load and generation) - ensuring that requirements needed for guaranteeing security of supply will be fulfilled considering the peculiarities of each national systems (e.g. dependency on power imports from abroad) Key rationales for choosing A/B threshold include: • Need of fault-ride-through (FRT) capability of small generation units if otherwise the loss of a large volume of generation in case of a fault on the transmission network would jeopardize system security. • Need to increase observability of small generation units. Key rationale for choosing threshold B/C includes in addition to abovementioned motivations: • Frequency control capability of renewable energy sources (RES) generation: in case of high volumes of RES generation a large amount of conventional generation resources will be displaced and hence not be available to manage system security during certain periods. In this cases, the need of additional capacity to control frequency shall be evaluated, regarding the amount needed and the expected size of new generation units. Key rationale for choosing threshold C/D includes in addition to abovementioned reasons: • Need of FRT capability of large PGMs and units connected to typically the highest voltages of the grid, to guarantee the stability of the grid.

INTERDEPENDENCIES

Between the CNCs	MW boundary choices are not directly impacted by implementation of other connection codes, but these choices are indirectly impacting the national implementation of other connection codes (NC DCC and NC HVDC). As an example, the capabilities of a DSO to fulfil the requirement for reactive power exchange at its interface with the transmission system (as defined in the NC DCC) is impacted by the capabilities of the generating units connected within the distribution grid and the strength of the need for such a requirement is impacted by the capabilities of the generating units connected within the transmission grid. Generation has the capability to provide a number of important services to a system, including voltage regulation, frequency response, and short circuit contribution. The requirement for these capabilities to be applied is determined by the threshold value and hence when looking at its application the capabilities

	provided by other types of users must be considered.
With other NCs	MW boundary choices will affect capabilities of individual Users for application in system operation (SO) and market NC contexts. The most direct impact of these choices is in the definition of Significant Grid Users within the scope of the NC Emergency and Restoration (NC E&R) and System Operation Guidelines (SO GL) which are, for generators, "Existing and New Power Generating Modules of type B, C and D according to the criteria defined in Article 4(2) [NC RfG]".
System characteristics	The existing PGMs, their maximum capacity and connection voltage level, and also their support capability to the network to provide ancillary services (regarding frequency, voltage) and their anticipated lifecycle and replacement have an impact on the TSO needs regarding future PGMs and consequently on the choice regarding the thresholds. In this context, the structure of the network and the size of the control area shall be taken into account. The expected development of future PGM (e.g. module size, distribution and energy mix) is also a key issue, especially the RES development and the development of dispersed generation. System characteristics are a vitally important consideration of determining thresholds. Table 1 of the RfG in itself is reflective of the size of the each synchronous system. Hence determining the necessary portfolio of capabilities required from the generation fleet for a system both immediately and its evolution over the life expectancy of the generator[s] is essential in determining the threshold that should be applied to each type of generator.
Technology characteristics	It has been determined with stakeholders and the industry that the application of table 1 to the various types of generators is both practical and technically achievable. Besides the type A-D classification, the requirements are further categorized as follows: - requirements applicable to all PGMs - requirements applicable to synchronously connected PGMs - requirements applicable to Power Park Modules (PPMs), which are PGM either non-synchronously connected to the network or connected through power electronics - requirements applicable to AC connected offshore Generation For example, FRT capability requirement defined by NC RfG is different for PPM and synchronously connected PGM. See NC RfG requirements regarding generators type A, B, C, D in annex 3.
COORDINATION	
Methodology principles recommended for co-ordination	



TSO – TSO	RfG Article 5 (3): "In forming proposals the relevant TSO shall coordinate with adjacent TSOs and DSOs…". Coordination shall focus on a coherent approach to the criteria for the choice of the specific threshold values at national level.
TSO – DSO	RfG Article 5 (3): "In forming proposals the relevant TSO shall coordinate with adjacent TSOs and DSOs…" Coordination of connection network codes requirements between TSOs and DSOs, in particular within the TSO's control area is important. However, this is subject to DSO involvement in national implementation procedures anyway and hence not specifically addressed by this IGD.
RNO – Grid User	RfG Article 5 (4): "Power generating facility owners shall assist this process and provide data as requested by the relevant TSO." RfG Article 5 (4): "TSO shall … conduct a public consultation in accordance with Article 10" The involvement of relevant stakeholders when defining the thresholds definition will be guaranteed through public consultation.

Annex 1: Example on thresholds selection

Synchronous area :	Threshold for Type B	Threshold for Type C	Threshold for Type D
Continental Europe (max. thresholds allowed by NC RfG)	1 MW	50 MW	75 MW
Voltage level	< 110 kV	< 110 kV	≥ 110 kV
Country choice	$P_B \leq 1$ MW	$P_c \leq 50$ MW	$P_D \leq 75$ MW

In each synchronous area, maximum thresholds values have been defined in the NC Rfg.
In any case, a generator with a connection point at 110 kV or above is within the range for type D.
Each country that belongs to this synchronous area has to make hiw own choice on those threshold values (below or equal to the values defined in NC RfG), with a consideration of the abovementioned criteria, such as:

- The way of managing connection process at national level
- Technical requirements that have to be considered to guarantee security of supply

Threshold values proposal (for exemple P_B, P_C, P_D) is made by the relevant TSO which shall :

- organize a public consultation with stakeholders
- ensure coordination with adjacents TSO/DSO

Threshold values proposal has to be approved by the relevant national regulatory authority or the Member State where applicable.

Annex 2: Proposal to change the thresholds – Example on the 3 years statement

In this example the implication of a TSO decision to propose a new set of thresholds 3 years from a previous proposal of maximum thresholds (Table B), are discussed. The following table sets out two possible changes to the selected threshold values, one raising the limit and one lowering the limit:

Synchronous area : Continental Europe	Lower threshold for Type A	Threshold for Type B	Threshold for Type C	Threshold for Type D
Max. thresholds allowed by NC RfG)	0.8 kW	1 MW	50 MW	75 MW
Original thresholds selected by TSO	0.8 kW	0.8 MW	50 MW	75 MW
New thresholds proposal 1. (min. 3 years after previous proposal)	0.8 kW	$P_B < 0.8$ MW	$P_c < 50$ MW	$P_D < 75$ MW
New thresholds proposal 2. (min. 3 years after previous proposal)	0.8 kW	$0.8MW < P_B < 1$ MW	$P_c < 50$ MW	$P_D < 75$ MW
Voltage level	< 110 kV	< 110 kV	< 110 kV	≥ 110 kV

Table C: Example of proposal for thresholds submitted three years after Table B selection

In this case the existing maximum allowable limits were originally selected by the TSO for both Type C and D generators, but a lower limit of 0.8MW was selected for Type B (the maximum being 1.0MW). Consequently after three years following a review the options on what values could be selected for Type C and D generators differ from that of Type B.

For either the of new threshold proposals (1 or 2) the only choice is to reduce the type C or D thresholds from 50 and 75 MW respectively.

However for Type B the limit could be raised or lowered and therefore different consequences will result.

For threshold proposal 1, the selection of a lower threshold for type B would mean that a higher number of future generators would be required to meet the capabilities of type B, widening the number of generators that will have these enhanced capabilities. This would undoubtedly be in response to a need being identified for an increase in these capacities to meet operational needs in future years.

As part of this selection a decision would be required on whether existing power generating module with a maximum capacity of P_B, that was previously qualified as type A, and now within the range for type B should have retrospective requirements placed on them.

If it was the intention to apply type B requirements to this generator then this would need to follow the process set out in article 5.5 for the retrospective application of requirements to existing equipment. A CBA is required as part of this process. A CBA would **not**, however, be required to apply the requirements to a new generator connecting after the date of the proposal and which would therefore be designated within the modified thresholds as applicable.

In proposal 1, the same consideration and methodology should also apply to the selection of the thresholds for type C and D generation.

For threshold proposal 2, the selection of a lower threshold for type C and D would follow the same consideration and methodology as with proposal 1 as they can only be lowered. However for the threshold for type B the proposal is to raise the limit which would mean that a lower number of future generators would be required to meet the capabilities of type B.

Although article 5.5 could apply in this case as the capabilities for type A would automatically be met by the capabilities of type B, it is almost evitable that a TSO would not seek or could justify respective application allowed for under this article. Therefore no respective application would apply.

Annex 3: NC RfG requirements regarding generators type A, B, C, D

General Requirements:

Title	Requirement type	Type A	Type B	Type C	Type D
FREQUENCY RANGES	Frequency stability	X	X	X	X
LIMITED FREQUENCY SENSITIVE MODE (OVERFREQUENCY)	Frequency stability	X	X	X	X
RATE OF CHANGE OF FREQUENCY WITHSTAND CAPABILITY	Frequency stability	X	X	X	X
CONSTANT OUTPUT AT TARGET ACTIVE POWER	Frequency stability	X	X	X	X
MAXIMUM POWER REDUCTION AT UNDERFREQUENCY	Frequency stability	X	X	X	X
AUTOMATIC CONNECTION	Frequency stability	X	X	X	X
REMOTE SWITCH ON/OFF	Frequency stability	X	X		
ACTIVE POWER REDUCTION	Frequency stability		X		
ACTIVE POWER CONTROLLABILITY AND CONTROL RANGE	Frequency stability			X	X
DISCONNECTION OF LOAD DUE TO UNDERFREQUENCY	Frequency stability			X	X
FREQUENCY RESTORATION CONTROL	Frequency stability			X	X
FREQUENCY SENSITIVE MODE	Frequency stability			X	X
LIMITED FREQUENCY SENSITIVE MODE (UNDERFREQUENCY)	Frequency stability			X	X
MONITORING OF FREQUENCY RESPONSE	Frequency stability			X	X
CONTROL SCHEMES AND SETTINGS	General system management		X	X	X
INFORMATION EXCHANGE	General system management		X	X	X
PRIORITY RANKING OF PROTECTION AND CONTROL	General system management		X	X	X
TRANSFORMER NEUTRL-POINT TREATMENT	General system management			X	X
ELECTRICAL PROTECTION SCHEMES AND SETTINGS	General system management		X	X	X
INSTALLATION OF DEVICES FOR SYSTEM OPERATION AND/ OR SECURITY	General system management			X	X
INSTRUMENTATION FOR FAULT AND DYNAMIC BEHAVIOUR RECORDING	General system management			X	X
LOSS OF STABILITY	General system management			X	X
RATE OF CHANGE OF ACTIVE POWER	General system management			X	X
SIMULATION MODELS	General system management			X	X
SYNCHRONISATION	General system management				X
AUTO RECLOSURES	Robustness of Generating Units			X	X
STEADY-STATE STABILITY	Robustness of Generating Units			X	X
RECONNECTION AFTER AN INCIDENTAL DISCONNECTION DUE TO A NETWORK DISTURBANCE	System restoration		X	X	X
BLACK START	System restoration			X	X
CAPABILITY TO TAKE PART IN ISOLATED NETWORK OPERATION	System restoration			X	X
QUICK RE-SYNCHRONISATION	System restoration			X	X
HIGH/LOW VOLTAGE DISCONNECTION	Voltage stability			X	
VOLTAGE RANGES	Voltage stability				X

Synchronous generating modules requirements:

Title	Requirement type	Type A	Type B	Type C	Type D
POST FAULT ACTIVE POWER RECOVERY	Robustness of Generating Units		X	X	X
FAULT RIDE THROUGH CAPABILITY OF SYNCHRONOUS GENERATORS CONNECTED BELOW 110 kV	Robustness of Generating Units		X	X	
FAULT RIDE THROUGH CAPABILITY OF SYNCHRONOUS GENERATORS CONNECTED AT 110 kV OR ABOVE	Robustness of Generating Units				X
CAPABILITIES TO AID ANGULAR STABILITY	Robustness of Generating Units				X
VOLTAGE CONTROL SYSTEM (SIMPLE)	Voltage stability		X	X	
REACTIVE POWER CAPABILITY (SIMPLE)	Voltage stability		X		
REACTIVE POWER CAPABILITY AT MAXIMUM ACTIVE POWER	Voltage stability			X	X
REACTIVE POWER CAPABILITY BELOW MAXIMUM ACTIVE POWER	Voltage stability			X	X
VOLTAGE CONTROL SYSTEM	Voltage stability				X

PPMs requirements:

Title	Requirement type	Type A	Type B	Type C	Type D
SYNTHETIC INERTIA CAPABILITY	Frequency stability			X	X
POST FAULT ACTIVE POWER RECOVERY	Robustness of Generating Units		X	X	X
FAULT RIDE THROUGH CAPABILITY OF POWER PARK MODULES CONNECTED BELOW 110 kV	Robustness of Generating Units		X	X	
FAULT RIDE THROUGH CAPABILITY OF POWER PARK MODULES CONNECTED AT 110 kV OR ABOVE	Robustness of Generating Units				X
REACTIVE CURRENT INJECTION	Voltage stability		X	X	X
REACTIVE POWER CAPABILITY (SIMPLE)	Voltage stability		X		
PRIORITY TO ACTIVE OR REACTIVE POWER CONTRIBUTION	Voltage stability			X	X
REACTIVE POWER CAPABILITY AT MAXIMUM ACTIVE POWER	Voltage stability			X	X
REACTIVE POWER CAPABILITY BELOW MAXIMUM ACTIVE POWER	Voltage stability			X	X
REACTIVE POWER CONTROL MODES	Voltage stability			X	X
POWER OSCILLATIONS DAMPING CONTROL	Voltage stability			X	X

Differences between moving from B→C:

General Requirements	Requirement type	Type B	Type C
ACTIVE POWER REDUCTION	Frequency stability	X	
ACTIVE POWER CONTROLLABILITY AND CONTROL RANGE	Frequency stability		X
DISCONNECTION OF LOAD DUE TO UNDERFREQUENCY	Frequency stability		X
FREQUENCY RESTORATION CONTROL	Frequency stability		X
FREQUENCY SENSITIVE MODE	Frequency stability		X
LIMITED FREQUENCY SENSITIVE MODE (UNDERFREQUENCY)	Frequency stability		X
MONITORING OF FREQUENCY RESPONSE	Frequency stability		X
TRANSFORMER NEUTRL-POINT TREATMENT	General system management		X
INSTALLATION OF DEVICES FOR SYSTEM OPERATION AND/ OR SECURITY	General system management		X
INSTRUMENTATION FOR FAULT AND DYNAMIC BEHAVIOUR RECORDING	General system management		X
LOSS OF STABILITY	General system management		X
RATE OF CHANGE OF ACTIVE POWER	General system management		X
SIMULATION MODELS	General system management		X
AUTO RECLOSURES	Robustness of Generating Units		X
STEADY-STATE STABILITY	Robustness of Generating Units		X
BLACK START	System restoration		X
CAPABILITY TO TAKE PART IN ISOLATED NETWORK OPERATION	System restoration		X
QUICK RE-SYNCHRONISATION	System restoration		X
HIGH/LOW VOLTAGE DISCONNECTION	Voltage stability		X

Synchronous Generator Requirements	Requirement type	Type B	Type C
REACTIVE POWER CAPABILITY (SIMPLE)	Voltage stability	X	
REACTIVE POWER CAPABILITY AT MAXIMUM ACTIVE POWER	Voltage stability		X
REACTIVE POWER CAPABILITY BELOW MAXIMUM ACTIVE POWER	Voltage stability		X

PPMs Requirements	Requirement type	Type B	Type C
SYNTHETIC INERTIA CAPABILITY	Frequency stability		X
REACTIVE POWER CAPABILITY (SIMPLE)	Voltage stability	X	
PRIORITY TO ACTIVE OR REACTIVE POWER CONTRIBUTION	Voltage stability		X
REACTIVE POWER CAPABILITY AT MAXIMUM ACTIVE POWER	Voltage stability		X
REACTIVE POWER CAPABILITY BELOW MAXIMUM ACTIVE POWER	Voltage stability		X
REACTIVE POWER CONTROL MODES	Voltage stability		X
POWER OSCILLATIONS DAMPING CONTROL	Voltage stability		X

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Differences between moving from C→D:

General Requirements	Requirement type	Type C	Type D
SYNCHRONISATION	General system management		X
HIGH/LOW VOLTAGE DISCONNECTION	Voltage stability	X	
VOLTAGE RANGES	Voltage stability		X

Synchronous Generator Requirements	Requirement type	Type C	Type D
FAULT RIDE THROUGH CAPABILITY OF SYNCHRONOUS GENERATORS CONNECTED AT 110 kV OR ABOVE	Robustness of Generating Units		X
CAPABILITIES TO AID ANGULAR STABILITY	Robustness of Generating Units		X
VOLTAGE CONTROL SYSTEM (SIMPLE)	Voltage stability	X	
VOLTAGE CONTROL SYSTEM	Voltage stability		X

PPMs Requirements	Requirement type	Type C	Type D
FAULT RIDE THROUGH CAPABILITY OF POWER PARK MODULES CONNECTED BELOW 110 kV	Robustness of Generating Units	X	
FAULT RIDE THROUGH CAPABILITY OF POWER PARK MODULES CONNECTED AT 110 kV OR ABOVE	Robustness of Generating Units		X

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