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Technical Assistance for the Connection Network Codes implementation in the Energy Community

19th ECDSO-E Meeting
July 13th, 2021

Agenda

1. Introduction and Background
2. Activities overview
3. Setting of methodologies for determination and definition of non-exhaustive parameters
4. Calculation of non-exhaustive parameters
5. Drafting of provisions
6. Mutual TSO and DSO connection issues and business processes

Introduction

Under the initiative and support of Energy Community,
EKC performed "Technical Assistance for the Connection Network Codes implementation" in the EnC

The focus is on technical assistance to Beneficiaries in further implementation of technical requirements set in:

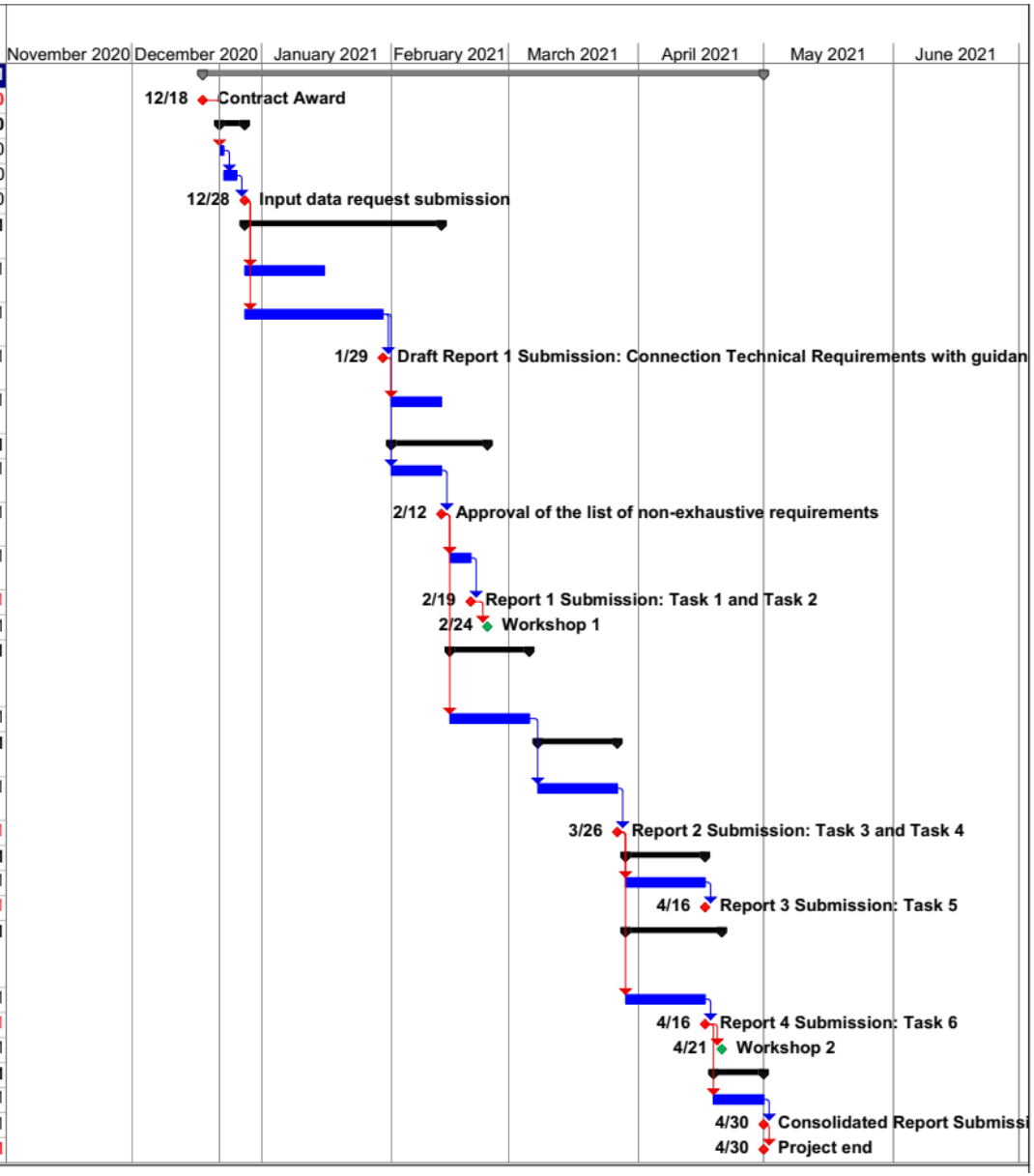
- **Network Code on requirements for grid connection of generators (NC RfG)**
- **Network Code on Demand connection (NC DC)**

Objectives:

- **Development of methodologies for determination of each non-exhaustive parameter that needs to be defined on a country level in line with ENTSO-E Implementation Guidelines and regional/national system characteristics**
- **Setting of non-exhaustive parameters**
- **Drafting the provisions which should be included in respective national legal/technical legislation**
- **Specify business processes which will require collaboration between TSO and DSO in the future**

Activities performed

ID	Task Name	Duration	Start	Finish
0	**Project summary bar**	**96 days**	**Fri 12/18/20**	**Fri 4/30/21**
1	**Contract Award**	**0 days**	**Fri 12/18/20**	**Fri 12/18/20**
2	**General**	**4 days**	**Tue 12/22/20**	**Mon 12/28/20**
3	Kick off meeting	1 day	Tue 12/22/20	Tue 12/22/20
4	Input data request preparation	3 days	Wed 12/23/20	Fri 12/25/20
5	Input data request submission	0 days	Mon 12/28/20	Mon 12/28/20
6	**TASK 1: Identification of connection technical requirements**	**35 days**	**Mon 12/28/20**	**Fri 2/12/21**
7	Input data provision/approval by beneficiaries	15 days	Mon 12/28/20	Fri 1/15/21
8	Identification of all non-exhaustive requirements	25 days	Mon 12/28/20	Fri 1/29/21
9	Draft Report 1 Submission: Connection Technical Requirements	0 days	Fri 1/29/21	Fri 1/29/21
10	Bilateral communication with beneficiaries	10 days	Mon 2/1/21	Fri 2/12/21
11	**TASK 2: Gap Analysis**	**17 days**	**Mon 2/1/21**	**Wed 2/24/21**
12	Gap analysis/identification of non-exhaustive requirements	10 days	Mon 2/1/21	Fri 2/12/21
13	Approval of the list of non-exhaustive requirements	0 days	Fri 2/12/21	Fri 2/12/21
14	Preparation of Report 1: Task 1 and Task 2	5 days	Mon 2/15/21	Fri 2/19/21
15	Report 1 Submission: Task 1 and Task	0 days	Fri 2/19/21	Fri 2/19/21
16	Workshop 1	0 days	Wed 2/24/21	Wed 2/24/21
17	**TASK 3: Setting of methodologies for determination of non-exhaustive requirements**	**15 days**	**Mon 2/15/21**	**Fri 3/5/21**
18	Methodology preparation	15 days	Mon 2/15/21	Fri 3/5/21
19	**TASK 4: Calculation of non-exhaustive parameters**	**15 days**	**Mon 3/8/21**	**Fri 3/26/21**
20	Implementation of the methodology for non-exhaustive parameters	15 days	Mon 3/8/21	Fri 3/26/21
21	Report 2 Submission: Task 3 and Task	0 days	Fri 3/26/21	Fri 3/26/21
22	**TASK 5: Drafting provisions**	**15 days**	**Mon 3/29/21**	**Fri 4/16/21**
23	Preparation of Report 3	15 days	Mon 3/29/21	Fri 4/16/21
24	Report 3 Submission: Task 5	0 days	Fri 4/16/21	Fri 4/16/21
25	**TASK 6: Mutual TSOs and DSO Connection Issues and Business Processes**	**17 days**	**Mon 3/29/21**	**Wed 4/21/21**
26	Business Processes review	15 days	Mon 3/29/21	Fri 4/16/21
27	Report 4 Submission: Task 6	0 days	Fri 4/16/21	Fri 4/16/21
28	Workshop 2	0 days	Wed 4/21/21	Wed 4/21/21
29	**Project Completion**	**10 days**	**Mon 4/19/21**	**Fri 4/30/21**
30	Preparation of Consolidated report	10 days	Mon 4/19/21	Fri 4/30/21
31	Consolidated Report Submission	0 days	Fri 4/30/21	Fri 4/30/21
32	**Project end**	**0 days**	**Fri 4/30/21**	**Fri 4/30/21**



Identification of connection technical requirements

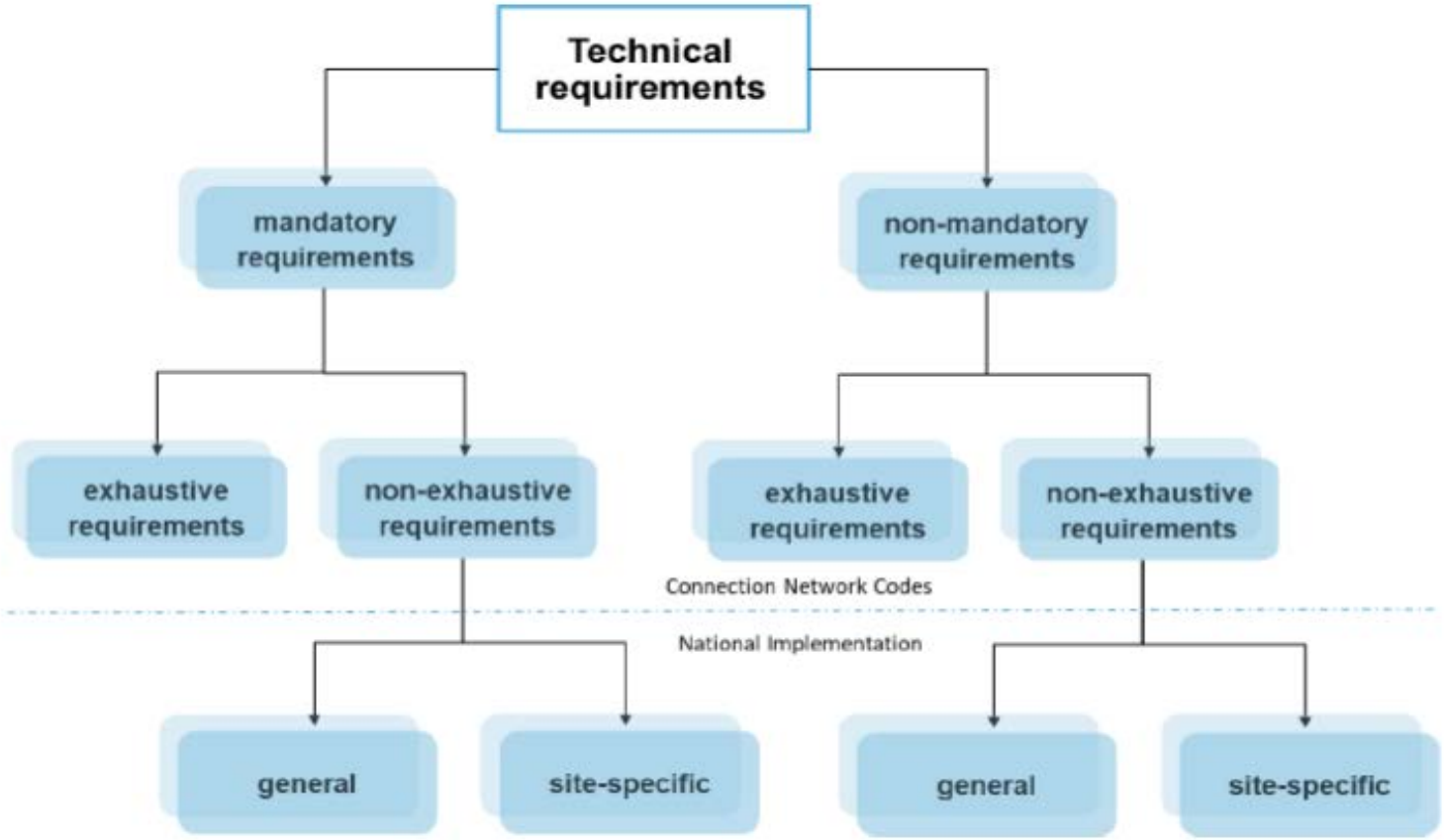
- Objectives
  - To identify a list of all non-exhaustive parameters in the NC RfG and NC DC
  - To determine general guidance for the definition of listed parameters
  - To assess modalities for their approval at national level
- The non-exhaustive parameters do not contain all the information or strict definition of parameters necessary to apply the requirements immediately
- Typically described as “TSO/relevant system operator shall define” or “defined by/determined by relevant system operator in coordination with TSO/relevant TSO”
- Definition criteria require coordination between TSOs at regional or synchronous area level or between TSO and DSO
- ENTSO-E Guidance document for national implementation for network codes on grid connection - PARAMETERS OF NON-EXHAUSTIVE REQUIREMENTS

Identification of connection technical requirements

- **Major clusters**
  - **Determination of significance (RfG only)**
  - **Frequency stability parameters**
  - **Voltage stability parameters**
  - **System defense and system restoration**
  - **Instrumentation, simulation models and protection**
- **Output of Task 1**
  - **Two lists of all non-exhaustive parameters given in NC RfG and NC DC**

Type	Non-Exhaustive Requirement	Non-Mandatory Requirement	Article	Applicability	Parameters to be defined	Timing of proposal	Proposer
	FAULT RIDE THROUGH CAPABILITY		14.3.a	B, C, D	Voltage-against-time profile	CNC national implementation	TSO
			14.3.a	B, C, D	pre-fault and post-fault conditions	CNC national implementation	TSO
			14.3.b	B, C, D	Voltage-against-time profile for asymmetric faults	CNC national implementation	TSO
			16.3.a.(i)	D	voltage-against-time profile	CNC national implementation	TSO
			16.3.a.(ii)	D	pre-fault and post-fault conditions	CNC national implementation	TSO
			16.3.c	D	Voltage-against-time profile for asymmetric faults	CNC national implementation	TSO

Technical Requirements



In national transposed CNC

National Grid Code

Gap analysis

- The objective was to analyze current status of national legislation related to definition of non-exhaustive parameters
- Current technical legislation is assessed to determine which non-exhaustive parameters have been already defined and analyze their applicability
- Assessment of transposition of Network Codes – PHLG Decision
- Direct bilateral communication is organized with relevant experts of beneficiary companies (TSO and DSO)
- The outcomes
  - Determination of rationalities behind used technical criteria for already determined non-exhaustive parameters
  - Deeper understanding of relevant national system characteristics necessary to develop suitable methodology

Bilateral Discussion

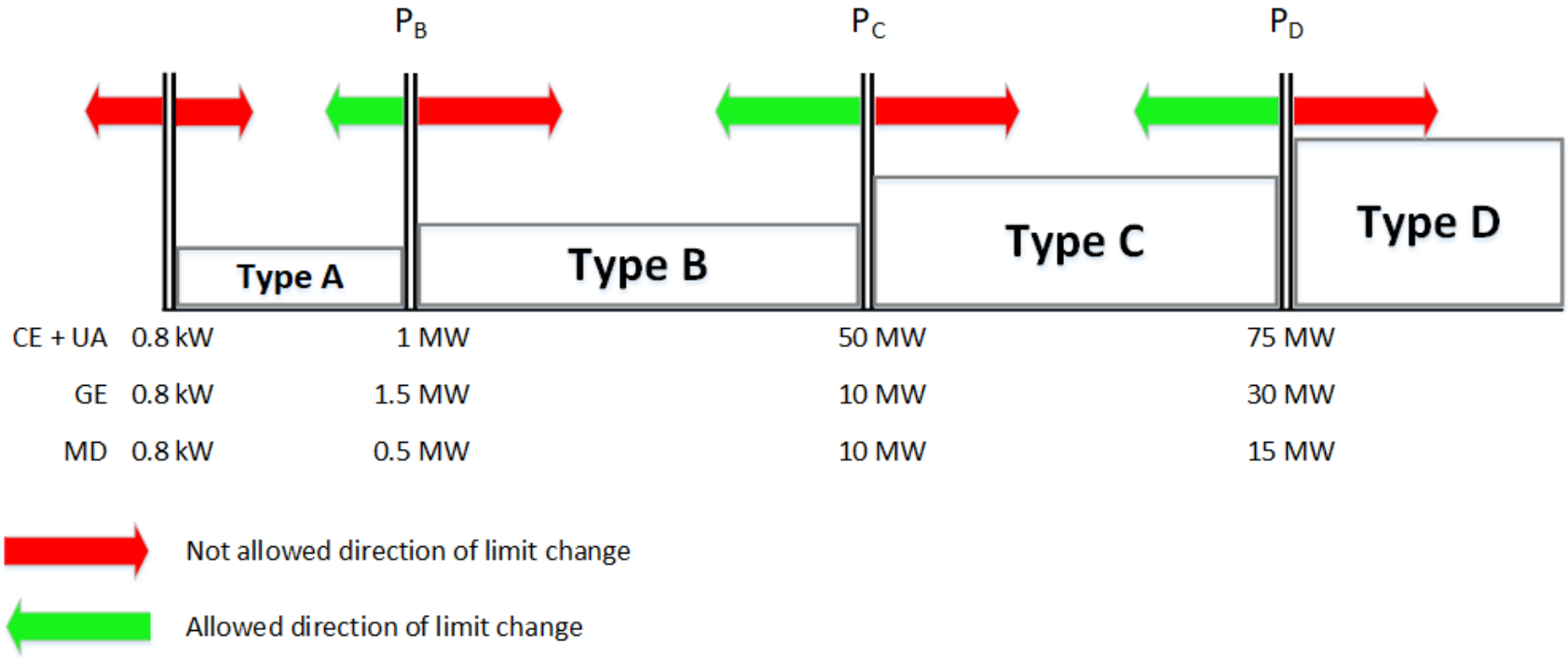
- Bilateral discussions with all beneficiaries took place during the week of February 8th
- Major topics
  - System separation in the Continental Europe Synchronous Area on 8 January 2021 (Reaction time, RoCoF, LFSM-O, Quality of FCR etc.)
  - TSO-DSO collaboration ➔ (Harmonization of connection requirements, frequency requirements in DSO grid, ancillary services from DSOs, RES integration)
  - Existing connection requirements
  - Voltage control issues
  - Development plans
  - Demand response plans

Setting of methodologies

- The methodology is developed considering the following documents and aspects:
  - Valid ENTSO-E Implementation guidance documents
  - Actual requirements in national grid codes
  - System characteristics related to frequency and voltage stability
  - Economic-efficiency of proposed parameters considering current technical capabilities of commercially available generating and demand units
  - Technology characteristics and constraints
  - Discussion with relevant experts from beneficiary companies (Task 2)
- Clustered in 5 categories: Determination of significance (RfG only) and Frequency related requirements, Voltage related requirements, System restoration related requirements and Instrumentation, simulation models and protections, for both RfG and DCC

- <u>Proposed methodology is based upon technical capabilities of commercially available generating and demand units, national system control strategies and requirements</u>

Determination of significance

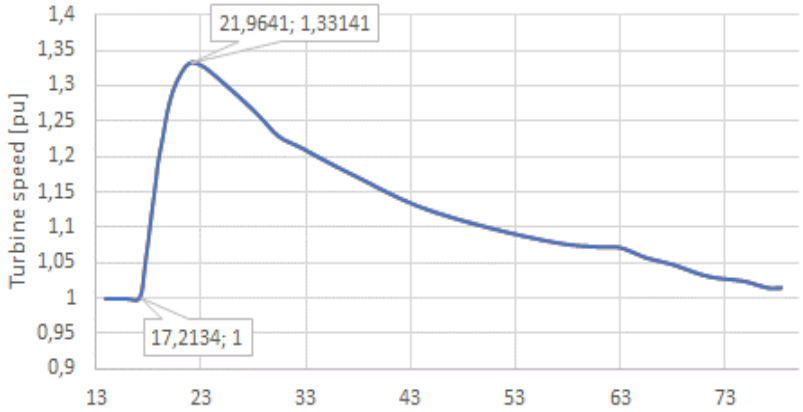


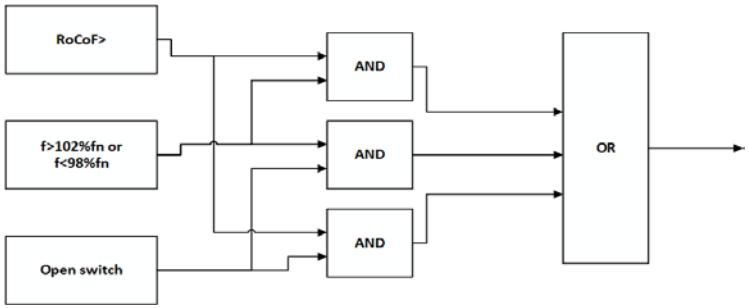
Determining factors:

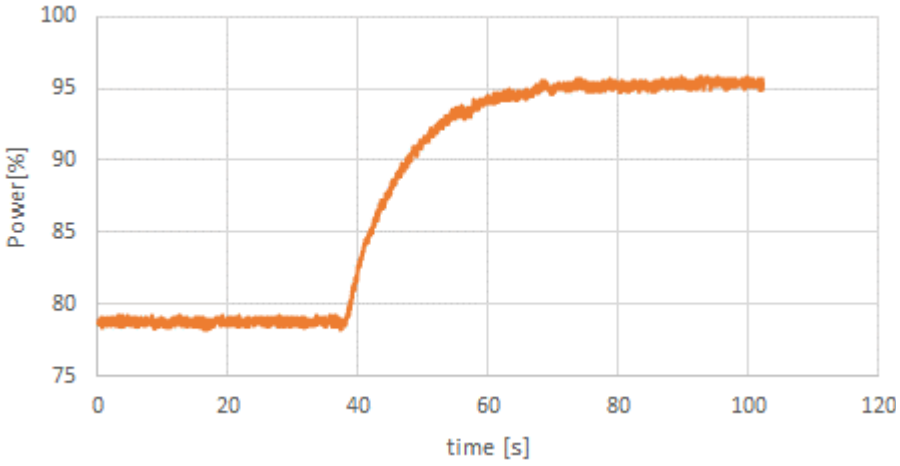
- **Minimum capacity which is connected at 110kV network**
- **Difference between requirements for type C/D, type B/C and type A/B PGMs**
  - **Type C/D: FRT requirement**
  - **Type B/C: Frequency related requirements, planned controllability of mid power PGMs by the RSO, voltage control requirements**
  - **Type A/B: Planned real-time observability of PGMs, applicability of FRT requirement**

Frequency Issues

- Frequency ranges
- RoCoF
- Frequency sensitivity mode
- LFSM – Overfrequency
- LFSM – Underfrequency
- Admissible Active Power Reduction
- Logic Interface and automatic connection to the network
- Frequency Stability
- Frequency Restoration Control
- Real-time monitoring of FSM
- Rates of Change of Active Power Output

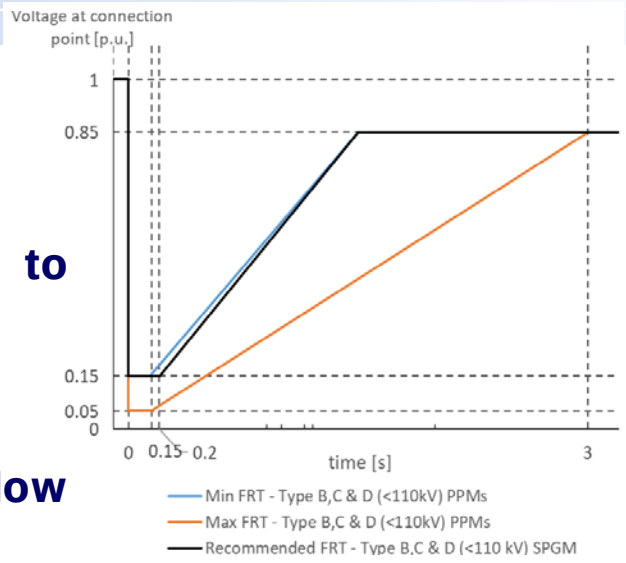


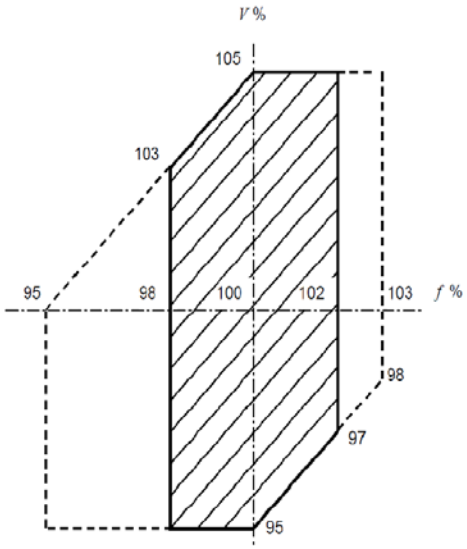


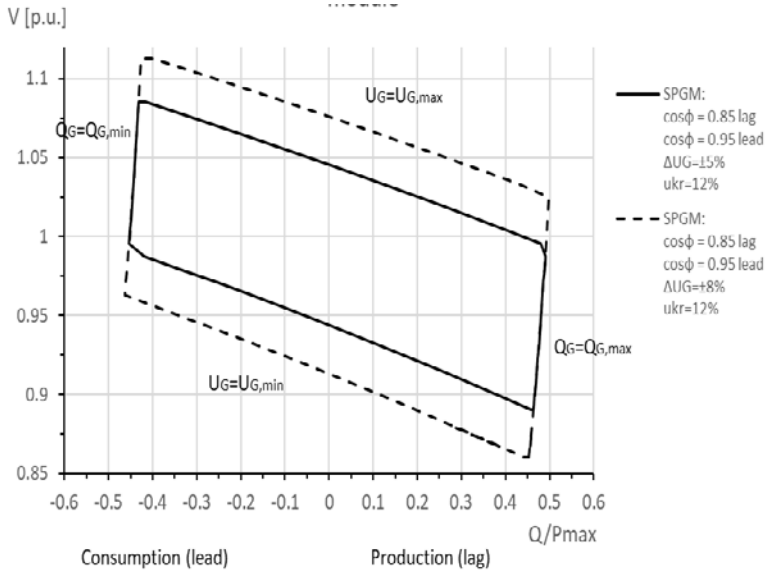


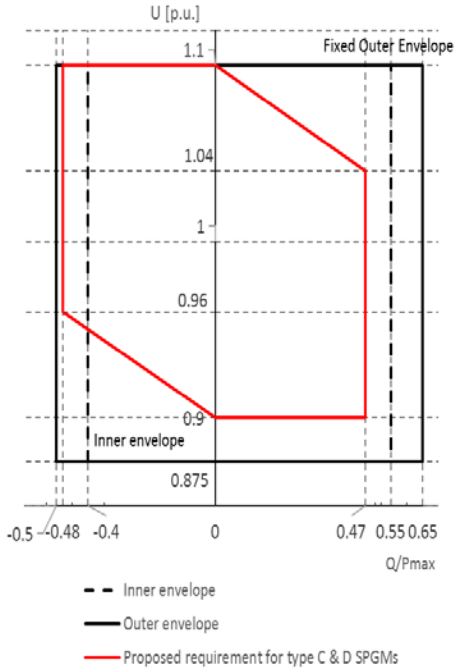
Voltage Issues

- Voltage ranges
- Fault ride through capability
- Automatic Disconnection due to Voltage Level
- Reactive Power Capability
- Reactive Power Capability below maximum power
- Fast fault current capability









System Restoration Issues

- **Reconnection Capability**
- **Black Start Capability**
- **Capability of Island Operation**
- **Operation following Tripping to Houseload**
- **Active Power Recovery SPGM**
- **Post Fault Active Power Recovery PPM**

Conditions for reconnection shall be the same as condition for Automatic Connection to the Network (subchapter 2.2.7):

- Voltage range: 0.9 pu ≤ U ≤ 1.1 pu; and
- Frequency range: 49.9 Hz ≤ f ≤ 50.05 Hz
- Minimum observation time: T_{obs}= 30 s + P_{ref}/PCmax·300 s
  - P_{ref} - Unit rated power;
  - P_{Cmax} - Maximum power for type C
- Maximum gradient of active power increase ≤ 20% of $P_{max/min}$

Due to congestion in the transmission network, outage of the transmission line or some other element of the system, possible ongoing process of black start, reconnection for PGM's type D without the permission of the dispatcher shall be forbidden.

Instrumentation, Simulation Models and Protection Issues

- Control and Protection Scheme and Settings
- Instrumentation (settings of the fault recording equipment, protocols for data exchange)
- Simulation Models
- Information Exchange
- Disconnection from grid caused by angular instability or loss of control
- Additional devices to be installed in power generating facility in order to preserve or restore system operation or security
- Step up transformer HV side neutral point earthing type

Agenda

1. Introduction and Background
2. Activities overview
3. Setting of methodologies for determination and definition of non-exhaustive parameters
    1. RfG non-exhaustive requirements
        1. Determination of significance
        2. Frequency Issues
        3. Voltage Issues
        4. System Restoration Issues
        5. Instrumentation, Simulation Models and Protections Issues
    2. DCC non-exhaustive requirements
        1. Frequency Issues
        2. Voltage Issues
        3. System Restoration Issues
        4. Instrumentation, Simulation
4. Calculation of non-exhaustive parameters
5. Drafting of provisions
6. Mutual TSO and DSO connection issues and business processes

DCC Frequency Issues

- **Frequency Ranges for over-frequency and under-frequency**
- **Rate of Change of Frequency**
- **Demand Response System Frequency Control**
  - **It is recommended that in the first phase necessary frequency parameters should be defined in such a way that DR SFC imitates LFSM-O and LFSM-U which are applied to generator units**
  - **Dead-band of control system should be defined in such a way that DR SFC is activated at full deployment of FCR (frequency containment reserves)**
  - **The maximum frequency deviation should be defined in such a way that DR SFC is full deployed before essential loads shading**

DCC Voltage Issues

- **Voltage Ranges**
  - The voltage range for the transmission-connected distribution systems with a voltage below 110 kV at the connection point, should be defined in accordance with applicable international standards
- **Automatic Disconnection Due to Voltage Level**
  - This site specific requirement should be defined by the relevant TSO during the connection phase of the TC DF or TC DS, but in due time for facility design
- **Reactive power capability for TC DF and TC DS**
  - Envisioned framework should be utilized to tackle existing problems regarding reactive power management and voltage support
  - In order to find best solution for reactive power management TSO and DSO should conduct joint analysis
- **Demand Response Service (DRS)**
  - The RSO have to specify and make public available the technical specifications in order to enable transfer of instructions and information
  - The technical specifications should be the same as for PGMs
- **Power Quality**

DCC System Restoration Issues

- **Short Circuit Requirements**
  - This calculation should be performed at least once per year and particularly in the case of deviation from the planned order of the connections to the transmission system
  - The results of the calculation should be publicly available as well as the used standard and the used parameters in the calculation
- **Low Frequency Demand Disconnection (LFDD)**
  - TSO defines LFDD scheme in accordance with SOGL and ER
  - Exact amount of demand to be disconnected in the particular TC facility and frequency threshold at which demand have to be disconnected, it cannot be specified generally
- **Low Voltage Demand Disconnection (LVDD)**
  - These are site specific and non-mandatory requirements
  - Before the individual TSO decides to implements these requirements, a study aiming to asses if TSO's control area is prone to voltage instability should be conducted
- **Conditions for Reconnection and Disconnection**
  - Only after permission of TSO

DCC Instrumentation Issues*

- **Electrical Protection Scheme and Settings**
  - The devices and settings should be specified in accordance with the characteristics of TC DS or the TC DF
  - Recommendation: Relevant TSO should have the right to demand from the TC DF owner or the TC DS to conduct the protection settings study
- **Control Requirements**
  - Precise schemes of the different control device and an initial settings should be given while issuing technical requirements for the connection – site-specific requirement
- **Information Exchanges**
  - It is strongly recommended that the requirements related to information exchange being defined in accordance with the Article 41 - 53 of the SO GL
- **Simulation Models**

**DCC Instrumentation, Simulation Models and Protections Issues*

Calculation of non-exhaustive parameters

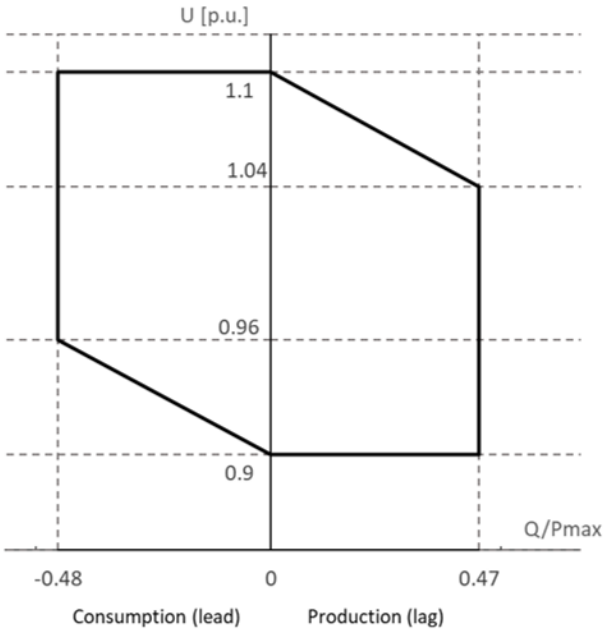
FCN	Non-exhaustive Requirement	Non mandatory Requirement	RfG NC Article No.	Applicability	Parameters/ Ranges/Values	Timing of Proposal		Proposer	RfG_Frequency_Issues - AI			RfG_Frequency_Issues - Proposal		
						Requirement as such	Values/Range of Requirement		Definition of Parameters/ Ranges/Values at national level	Defined in document/Article No.	Comments	Definition of Parameters	Methodology chapter	Comments
4	RoCoF	-	13(1)(b)	A,B,C,D	Specify RoCoF of the loss of main protection	S	S	RSO in coordination with the TSO				RoCoF: +1.5 Hz/s, -2 Hz/s Time window: 2 to 5 cycle time of algorithms of turbine controller combined with two other conditions (2 of 3)	3.2.2 Rate-of-Change-of-Frequency	
5	LFSM-O	-	13(2)(a)	A,B,C,D	Frequency threshold Droop settings	G	G (range) S (value before plant commissioning and to be reselected as appropriate using capabilities defined at CNC national implementation)	TSO				Frequency threshold: 50.2 Hz Droop: 4 %	3.2.4 Limited Frequency Sensitivity Mode - Overfrequency	
6	LFSM-O	X	13(2)(b)	A	Use of automatic disconnection and reconnection	G	G (value and criteria)	TSO	Under emergency conditions there is an expectation that some generation will continue to operate outside the statutory frequency limits. However, for Distributed Generators connected to the Distribution System it is likely that this could mean connection within an automatic low frequency load disconnection zone. Distributed Generator should ensure that all Protection on Generating Plant should have settings to co-ordinate with those on the low frequency load disconnection equipment which will be detailed by the DSO on request.	[30], IV.3.12.3		Disconnection: frequency threshold= 50.2 Hz + Pref/PAmax·0.3 Hz Reconnection: when frequency is less than frequency threshold= 50.1 Hz - Pref/PAmax·0.05 Hz, not less than 60 seconds Pref – Unit rated power; PAmax – Maximum power for type A.	3.2.4 Limited Frequency Sensitivity Mode - Overfrequency	

Tables with proposed values of non-exhaustive parameters are created for each beneficiary

Drafting of provisions

- **Provisions for national legislation are specified based upon methodologies for determination and calculation/setting of non-exhaustive parameters in Task 3 and Task 4**

Non-exhaustive Requirement	*Reactive power capability at maximum capacity i.e. U-Q/Pmax profile*
Article 18.2(b):	In addition to the Article 18(2)(b)(i), Figure 7 and Table 8 of **Transposed network code on requirements for grid connection of generators**, type C and D synchronous power generating modules will be able to provide reactive power at its maximum capacity according to the following figure



	According to the Article 18(2)(b)(iv) of **Transposed network code on requirements for grid connection of generators** type C and D synchronous power generating modules shall be capable of moving to any operating point within define U-Q/Pmax profile with undue delay upon the request of the relevant system operator, but no later than 10 minutes after the request is issued.
Applicability:	Type C and D SPGMs
Mandatory	
Dependencies:	***Reactive power capability below maximum capacity***

Mutual TSO and DSO connection issues and business processes

- Collaboration between TSO and DSO in the future considering defined non-exhaustive parameters as well as other relevant requirements stipulated in connection network codes
- Relevant processes
  - Determination of significance
  - Implementation of non-exhaustive parameters,
  - Technical conditions for connection
  - Derogation process
  - Compliance process
  - Process of changing Grid Codes (TSO and DSO)

Determination of significance

- Close TSO and DSO cooperation is required during the process of determination of significance
- TSO should create a proposal for determination of power thresholds, after coordination with DSO.
- All of the PGMs except of type D PGMs are going to be connected to the distribution grid (to be precise depending on the defined power threshold some of the type D PGMs can be also connected to the distribution grid).

Implementation of non-exhaustive parameters

- After transposition there are two possible ways to implement non-exhaustive requirements:
  - One way is to define new document in form of a bylaw common for both TSO and DSO in which all non-exhaustive parameters are defined (e.g. Connection codes).
  - Another way for implementation of non-exhaustive requirements, would be to define all non-exhaustive parameters in grid codes: DSO grid code and TSO grid cod
- Two processes of collaboration, according to the guidelines for non-exhaustive requirements implementation are identified:
  - DSO defines technical requirements that will be used on distribution level in cooperation with TSO
  - TSO defines technical requirement that will be used on distribution level

- Deliverable 4 (Task 6) specifies cooperation processes for all non-exhaustive parameters where necessary.

Technical conditions for connection

- **Two processes of collaboration between TSO and DSO in the domain of technical conditions are identified:**

  - **DSO issues technical conditions for connection;**

  - **Issuing technical conditions for connection of type D PGMs planned to be connected to distribution network in case when the PGM is going to be under TSO control.**

Derogation process

- Derogation process is defined as exhaustive in the CNC and thus it is independent of the process of implementation of non-exhaustive parameters.

- Two reasons for initiating the derogation process have been identified when TSO/DSO collaboration is required:

  - When PGFO seeking connection to distribution system requests derogation for condition resulting from non-exhaustive requirement defined by TSO.

  - When DSO requests derogation for conditions resulting from non-exhaustive requirements defined by TSO in DCC, in case when the condition cannot be met due to the lack of DSO infrastructure.

Compliance process

- Compliance process is defined as exhaustive in the CNC and thus it is independent of the process of implementation of non-exhaustive requirements.

- Compliance testing plan and procedure for PGMs connected to the distribution network. PFGO prepares Compliance test protocol. The protocol has to be approved by the DSO. If conditions result from general requirements defined by TSO, then Compliance test protocol has to be approved by the TSO.

- Regarding to compliance test TSO should at least be notified that the test is planned and to be informed about compliance test procedure. If condition that should be verified through the test results from general requirements defined by TSO, TSO shall participate in the test.

- After compliance testing is finished, for PGMs connected to distribution network, DSO confirms whether all conditions are met. A necessary prerequisite is TSO's positive opinion on compliance with general requirements defined by TSO, or site-specific requirements defined by the TSO or by the DSO in cooperation with the TSO.

Process of changing Grid Codes (TSO and DSO)

- Regarding TSO/DSO collaboration only the process of changing DSO Grid Code is considered

- Process when it is required to change the parameter that is defined by TSO.

- The process of changing and administering grid code is similar to the process of derogation. When a system operator requires a condition derogation for all users, the derogation process and the grid code modification process are identical processes.

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THANK YOU
FOR YOUR ATTENTION

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