European Network of
Transmission System Operators
for Electricity

Connection Network Codes – Introduction to the public consultation of Implementation Guidance Documents

- Introduction -

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1. Introduction

Overview of connection codes

The European Connection Network Codes - Requirements for Generators (RfG), Demand Connection Codes (DCC) and High Voltage Direct Current Connections (HVDC) – have been developed in accordance with Regulation (EU) 714/2009 and are cornerstones to fulfil the third energy package.

The first connection network code, which entered into force on 17 May 2016, is the Commission Regulation (EU) 2016/631 of 14. April 2016 establishing a network code on requirements for grid connection of generators (RfG). The Commission Regulations on DCC and HVDC followed after that - (EU) 2016/1388 of 17. August 2016 establishing a network code on demand connection (DCC), entering into force on 18 August 2016, and the Commission Regulation (EU) 2016/1447 of 26. August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (HVDC), entering into force on 8 September 2016 respectively.

In order to support the implementation of network codes at national level, and as required by the codes, ENTSO-E has produced non-binding guidance on implementation, which are also consulted by the stakeholders. This guidance is provided through so-called Implementation Guidance Documents (IGDs).

Legal background for IGDs

Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (RfG), (Article 58), Commission Regulation (EU) 2016/1388 of 17. August 2016 establishing a network code on demand connection (DCC) (Article 56) and the Commission Regulation (EU) 2016/1447 of 26. August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (HVDC) (Article 75) – Non-binding guidance on implementation - stipulate:

1. *No later than six months after the entry into force of this Regulation, the ENTSO for Electricity shall prepare and thereafter every two years provide non-binding written guidance to its members and other system operators concerning the elements of this Regulation requiring national decisions. The ENTSO for Electricity shall publish this guidance on its website.*
2. *ENTSO for Electricity shall consult stakeholders when providing non-binding guidance.*
3. *The non-binding guidance shall explain the technical issues, conditions and interdependencies which need to be considered when complying with the requirements of this Regulation at national level.*

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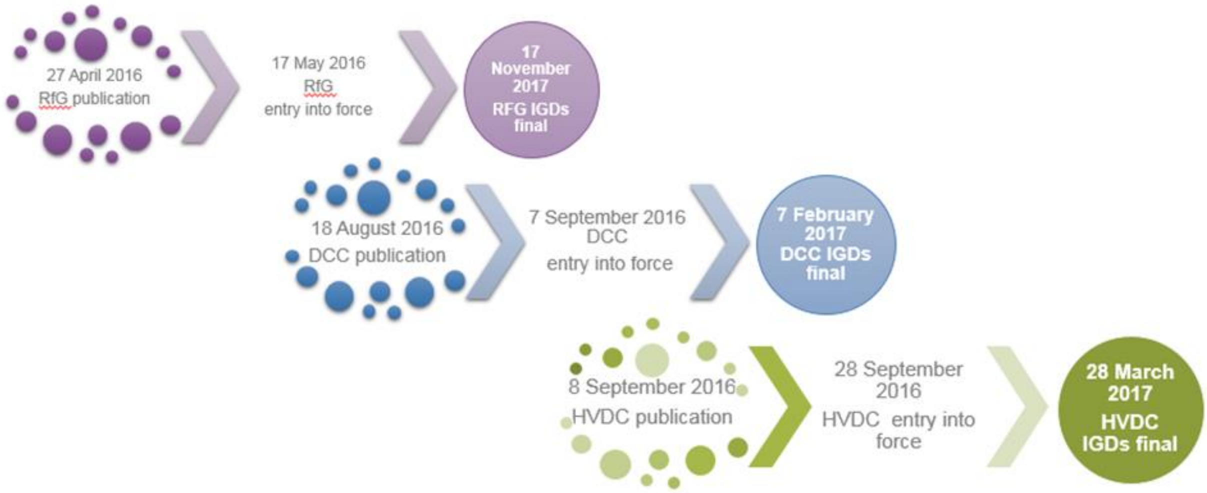

Figure 1: Timeline of adoption of connection network codes and deadlines for publishing different sets of IGDs.

Objectives of IGDs

The main objective of the implementation guidance is to support system operators in the process of determination on national level of non – exhaustive requirements during the national implementation. The objectives of the implementation guidance documents are:

- to facilitate a common understanding of technical issues specified in the connection network codes, in context of new technologies and new requirements (e.g. synthetic inertia)
- to deliver broader explanations and background information and to illustrate interactions between requirements,
- to recommend coordination/collaboration between network operators (TSO) where either explicitly required by the connection codes or reasonably exercised from a system engineering perspective,
- to give guidance to national specifications for non-exhaustive requirements, and
- to express the need of further harmonisation beyond what is requested by the CNCs when reasonable from a system engineering perspective.

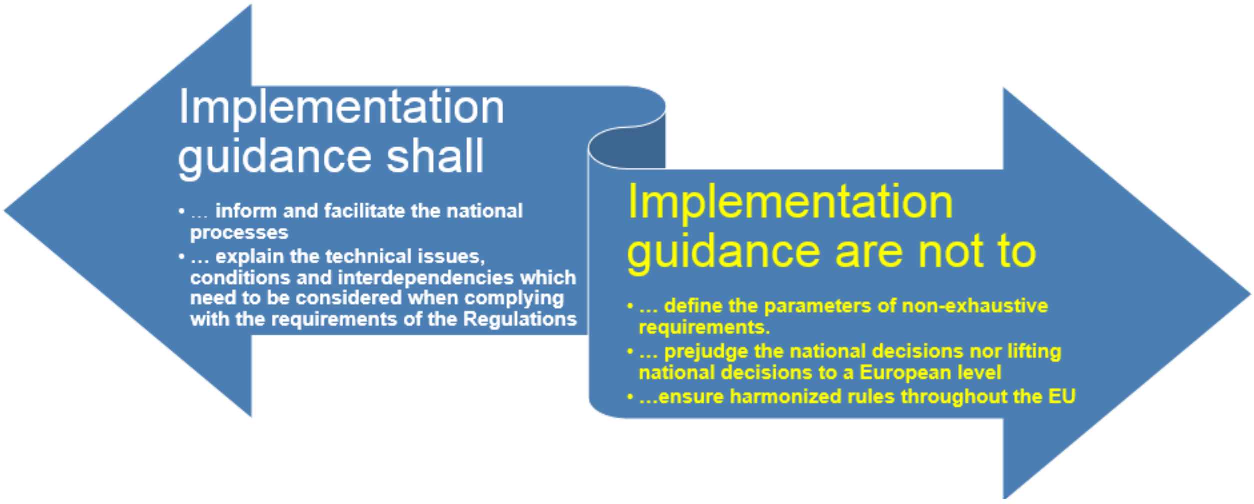

Figure 2: Scope of IGDs

Target audiences

IGDs are written for TSO staff who works and applies different connection codes.

How have IGDs been drafted?

The IGDs were drafted by ENTSO-E experts taking account of the input received from stakeholders during the process as follows:

- 23 September 2015 workshop - stakeholders were informed of the intent to draft IGDs and gave their initial views on how they saw this being accomplished. They wished to be strongly involved in the process. Consequently ENTSO-E organised ahead of the entry into force of the codes:
- A survey on Stakeholders' priority issues for IGDs. This survey took place between 25 December 2015 and 22 January 2016. As a result ENTSO-E has taken on board further topics for IGDs. The outcomes of the survey were presented in the workshop on 29 February 2016.
- A public stakeholder workshop on 29 February 2016 with the objective of defining the content of IGDs to address each of the priority issues previously identified. The outcomes can be accessed on the event site.
- 1 July – 15 August 2016 – ENTSO-E publishes draft IGDs for consultation from the RfG perspective. The comments received supported the update of the IGDs which ENTSO-E published on 17 November 2016 according to the RfG regulation.
- A public stakeholder workshop on 13 September 2016 aimed at checking the ENTSO-Es understanding of the stakeholders' consultation comments and to gather additional feasible suggestions.
- 8 December 2016 – 16 January 2017 - consultation of the updated IGDs from the DCC and HVDC perspective. The outcomes of this second consultation further enhanced the IGDs and ENTSO-E published these new/updated IGDs on March 8.

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- Regular input and updates from stakeholders on their expectations for the IGDs and regular updates on the next steps within the European Connection codes Stakeholder committee.

The IGDs were drafted from a topic perspective and therefore most of them cover more than one connection code simultaneously.

ENTSO-E experts have committed to proceed to the drafting of new IGDs or to improve the current ones in order to support the process of implementation of all the NCs.

Similar process regarding stakeholder involvement and consultations is followed for any new or updated IGDs that is produced beyond the legally required period of 6 months.

ENTSO-E has already conducted a public consultation for a set of four IGDs (one new and three updates) in April.

2. Implementation Guidance Documents on Frequency Stability Parameters

Over the last eight months ENTSO-E has been working on drafting a set of very important Implementation Guidance Documents (IGDs) on frequency stability related issues. These IGDs will greatly support the national implementation process and will provide more information and clarity to both TSOs and relevant stakeholders on a set of non-exhaustive requirements.

To complete this task efficiently, ENTSO-E has drafted and published at the beginning of March a Roadmap Guidance for frequency stability requirements (found in the overview of the consultation). The main goals of this roadmap (according to the Connection Codes as well) were to:

- Ensure coordinated approach at synchronous area level of the national implementation on frequency related parameters.
- Ensure transparency on the approaches, processes and decisions taken in each country
    - Timing of implementation guidance must be compatible with the timing of each country's national implementation process to be informed by this guidance. The overall timing is driven by the deadlines of NC RfG, which was the first connection code to enter into force.
    - Timing for the elaboration of European standards is also to be considered.
    - Coherence between Connection and Operation codes/guidelines need to be ensured.

The Roadmap involved:

- Extensive internal coordination incl. regional expert groups and system operation expertise.
- External coordination with stakeholders incl. three public workshops, a survey to manufacturers and further stakeholder discussions at the Grid Connection European Stakeholder Committee (GC ESC), to ensure timely and valuable feedback from different stakeholders.

How to respond to this consultation?

ENTSO-E has prepared the consultation in a transparent and open manner. When drafting the IGDs, the expectations of the relevant stakeholders have been taken into consideration **within their participation to the dedicated public workshops and the survey**.

The current IGD consultation is scheduled as follows:

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20 November – 21 December 2017 – ENTSO-E publishes eight (8) draft IGDs for consultation – six new and two updates (please see the list below). The comments received will support the finalization of the IGDs.

3. List of Implementation Guidance Documents on Frequency Stability Parameters

Style of IGDs

The IGDs were developed in an easy to read and short format and focus on the most relevant information of each topic. Each IGD includes information on the legal framework (Codes & Articles), objectives of the IGD, interdependencies between/in the codes, system and technology characteristics, further information, and recommendations on collaboration between the system operators at different levels and between them and grid users.

List of IGDs

No	Titles of IGD	Status	Short descriptions
1	Frequency Sensitive Mode	New	Frequency Sensitive Mode (or 'FSM') means the operating mode of a power-generating module or HVDC system in which the active power output changes in response to a change in system frequency, in such a way that it assists with the recovery to target frequency. The objective of this guidance document is to help to determine the main criteria/motivation for the specifications of the FSM capabilities of power generating modules at national level. For adequate specifications of the relevant parameters it is essential to be aware of the objective of the FSM functions and to understand how it interacts with other frequency stability requirements. For each synchronous area, proposals for national choices for the non-exhaustive FSM parameters are provided through this IGD.
2	Limited Frequency Sensitive Mode	New	The objective of this guidance document is to help to determine the main criteria/motivation for the specifications of the limited frequency sensitive mode capabilities of power generating modules at national level. Limited frequency sensitive mode at over-frequency (LFSM-O) is to be activated, when the system is in an emergency state of over-frequency and all frequency containment reserves (FCR) in negative direction have already been deployed.

			Limited frequency sensitive mode at under-frequency (LFSM-U) is to be activated, when the system is in an emergency state after of under-frequency and all frequency containment reserves (FCR) in positive direction have already been deployed. For adequate specifications of the relevant parameters it is essential to be aware of the objective of the LFSM-O/-U functions and to understand how it interacts with other frequency stability requirements and assumptions for a system defence plan. In order to implement comprehensively the LFSM-O/-U capabilities this implementation guidance may go beyond the explicit requests of NC RfG and will also make recommendations on further parameters, which are not addressed in this network code, but are nonetheless relevant to ensure an adequate performance of these features. For each synchronous area, proposals for national choices for the non-exhaustive LFSM-O/- U parameters are provided through this IGD.
3	Demand Response – System Frequency Control	New	Demand response is an important instrument for increasing the flexibility of the internal energy market and for enabling optimal use of networks. It should be based on customers' actions or on their agreement for a third party to take action on their behalf. A demand facility owner or a closed distribution system operator ('CDSO') may offer demand response services to the market as well as to system operators for grid security. In the latter case, the demand facility owner or the closed distribution system operator should ensure that new demand units used to provide such services fulfil the requirements set out in this Regulation, either individually or commonly as part of demand aggregation through a third party. In this regard, third parties have a key role in bringing together demand response capacities and can have the responsibility and obligation to ensure the reliability of those services, where those responsibilities are delegated by the demand facility owner and the closed distribution system operator. The objective of this guidance document is to help to determine the main criteria/motivation for the recommended settings and applications of the DR SFC capabilities of demand units at a synchronous system and national level. For adequate specifications of the relevant parameters it is essential to be aware of the objective of DR SFC, the deployment strategies that can be applied, and to understand how it interacts with other frequency stability requirements and assumptions for a system defence plan.

			In order to implement comprehensively the DR SFC capabilities, this implementation guidance will look beyond only DR SFC in the NC DCC, considering the proposed settings for LFSM outlined in other guidance documents. For each synchronous area, proposals for national choices for the non-exhaustive DR SFC parameters are provided in this IGD.
4	Frequency Ranges	New	This document addresses the frequency ranges required for the AC transmission and distribution lines including HVDC systems on the AC lines, the power generation and demand facilities. The general principle for the frequency range and time duration requirements are follows: • Frequency ranges for transmission and distribution network lines, including HVDC systems on the AC lines, to stay connected to the system shall be wider than for power generating and demand facilities • Frequency ranges for power generating facilities to stay connected to the system shall be wider than for demand facilities • Frequency ranges for demand facilities to stay connected to the system shall be narrower than for power generating facilities
5	Maximum Admissible active power reduction at low frequencies	New	The objective of this guidance document is to help determining the main criteria for the specifications/motivation, at national level, of the capability not to reduce active power output more than an admissible value due to frequency decrease. For adequate specifications of the relevant parameters it is essential to be aware of the objective of the requirement and to understand how it interacts with other frequency stability requirements and external factors such as power plant technology and ambient conditions. For each synchronous area, proposals for national choices for the non-exhaustive requirement on admissible active power reduction at low frequencies are provided through this IGD.
6	Automatic connection/reconnection and admissible rate of change of active power	New	This document addresses the issue of automatic connection/reconnection of power generating modules of type A, B and C. Automatic connection/reconnection is not allowed for type D power generating modules. The motivation for allowing automatic reconnection after an incidental disconnection or during system restoration is that neither the relevant TSO nor the relevant DSO can manage to respond to all individual start-up requests of power generating

			modules. In addition communication with type A power generating modules for connection/reconnection is not required. Hence they need to act autonomously according to a configured schedule in such cases. Automatic reconnection of power generating units after an incidental disconnection includes, but is not limited to, the following fundamental conditions: • Specifications of the voltage range, for which reconnection is allowed • Specifications of the frequency range, for which reconnection is allowed • Specification of a minimum observation time of voltage and frequency conditions • Specification of a maximum gradient of active power increase after reconnection Uncoordinated/uncontrolled reconnection of a large amount of distributed generation after system disturbance could result in system stability problems and cause system split or islanding. Therefore some basic rules/conditions for reconnection shall be specified. In addition, coordination between frequency ranges for reconnection of power generating modules and disconnection/reconnection of demand facilities shall also be taken into account where relevant. The document provides guidance on implementing the capability of power generating modules related to voltage and frequency ranges, observation time and gradient of active power increase for connection or reconnection. Recommendation on the preferred values of voltage and frequency intervals for automatic reconnection as well as a minimum observation time and maximum gradient of active power increase after reconnection is given in the methodology section of this document and is based on current practice and for Continental Europe (CE) on the ENTSO-E report on Dispersed generation impact on CE region security.
7	Rate-of-change-of-frequency withstand capability (RoCoF)	Updated	The requirement aims at ensuring that power generating modules (NC RfG), demand units offering Demand Response (DR) services (DCC), HVDC systems and DCconnected power park modules shall not disconnect from the network up to a maximum rate of change of frequency (df/dt). A large rate of change of frequency (RoCoF) may occur after a severe system incident (e.g. system split or loss of large generator in a smaller system). The facilities shall remain connected to contribute to stabilize and restore the network to normal

			operating states. The resulting RoCoF withstand capability will be an important input to calculate the essential minimum inertia (provided by the synchronous PGM with inherent inertia and by PPMs with synthetic inertia) for system stability in case of outage or system split, incl. asynchronous operation of control block. Therefore there is a direct link between RoCoF and inertia related requirements. Please note that this IGD would be updated in respect to frequency measurement criteria once the outcome of task force on this topic is finalized and published.
8	Need for synthetic inertia for frequency regulation	Updated	System inertia is an essential parameter for frequency stability of the electrical power system. It determines the initial rate of change of frequency in case of a sudden imbalance between supply and demand (e.g. trip of a large MW source or demand). A slower rate of change of frequency provides margins for activating automated active power reserves, predominantly via Frequency Sensitive Mode (FSM) (normal state) or Limited Frequency Sensitive Mode (LFSM) (emergency state). Replacement of conventional synchronous power generating modules, whose rotating masses inherently contribute to system inertia, by power park modules largely connected through power electronics results in a decrease in the Total System Inertia (TSI). Increased application of power electronic drives at the demand side also contributes to a decrease in inertia. This decrease in TSI combined with a higher frequency volatility, particularly if no countermeasures are taken, may become an essential aspect in context of frequency stability. The objective of this IGD is to provide guidance on Synthetic Inertia (SI) aspects to be considered when choosing relevant national parameters and opting in or out of nonmandatory requirements. It should be noted that the need for SI is less when the relevant TSO is experiencing or foreseeing modest penetration of RES. The challenge of maintaining frequency stability increases dramatically when total system inertia decreases at synchronous area (SA) level. Exceptionally, during rare system splits, some TSOs normally relying upon adequate inertia from elsewhere in the SA, could experience a lack of inertia for a short critical time. If insufficient inertia is available after a system split, this could result in a major challenge to prevent an immediate system collapse.