Report on Inter-TSO coordination in connection network codes implementation

Working Group CNC

12 December 2017

Content

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1 Objective and scope

Pursuant to Commission Regulation (EU) No 2016/631 establishing a network code on requirements for grid connection of generators (NC RfG), Commission Regulation (EU) 2016/1388 establishing a network code on demand connection (NC DCC) and Commission Regulation (EU) 2016/1447 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (NC HVDC) – later on referred to as the Connection Network Codes (CNCs) – transmission system operators (TSOs) are responsible to coordinate when establishing certain requirements at the national level. For some requirements, the coordination shall take place at the synchronous area level; for others, it is required between adjacent TSOs.

The objective of this report is to present the process of explicitly required coordination or reasonably undertaken collaboration between European TSOs when implementing at national level the CNCs, because of the cross-border impact of these specifications at synchronous area level. This report shall provide an overview over coordination and collaboration activities performed so far (until the date of collection of TSO's answers) between adjacent TSOs or at synchronous area level.

TSOs' coordination/collaboration when implementing the CNCs consists of working closely together in specifications for national implementation to ensure that the objectives of NCs RfG, DCC and HVDC are achieved. This coordination/collaboration shall guide the national implementation but not impair the decision making prerogatives of the relevant entities at national level.

Chapter 2 provides an overview over the CNC topics, which are subject to TSO coordination/collaboration, either explicitly required by each of the CNCs or reasonably undertaken, because of the cross-border impact of these specifications at synchronous area level.

Chapter 3 describes the process how the relevant information/data have been collected and compiled for this report.

Chapter 4 provides a detailed analysis on the extent of TSO coordination/collaboration perceived so far based on the feedback received from the TSOs.

The conclusions/recommendations from this report are summarized in Chapter 5.

2 Coverage of TSO coordination/collaboration

Pursuant to NC RfG Articles 13(2) and 15(2)(c)(i), NC DCC Articles 29(2)(e), 29(2)(g) and 37(5) and NC HVDC Articles 13(3), 17(2), 18(1) and 18(5), TSO coordination is required when developing specifications for definite values or ranges of parameters. The rationale for this coordination is typically the synchronous area relevance of these specifications. It covers in particular requirements, which are related to system frequency issues. In addition, for a number of further requirements TSO coordination is not explicitly required, but collaboration would reasonably make sense from a system engineering perspective for the same reasons. Annex I of this report provides an overview over the relevant requirements of each CNC.

Furthermore a specific request of coordination between adjacent TSOs when defining the maximum thresholds of the generator type classifications is imposed by NC RfG Article 5(3):

"*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.*"

Additional requests for coordination between adjacent TSOs are defined by DCC and HVDC.

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3 Information/data collection and compilation

A survey for information/data collection was provided to all the ENTSO-E members to facilitate this report. This survey was carried out in the period 10. August 2017 – 04. October 2017

With this survey it has been gathered general information about TSO coordination/collaboration as well as the state of coordination for each item. For that purpose each ENTSO-E member was requested to deliver information on coordination/collaboration which includes at least: the coordination item in question, involved TSOs and further details on coordination/collaboration activities. Table 1 shows the template, which was used for this survey.

NC RfG / DCC/ HVDC – TSO coordination for implementation explicitly required / reasonably required (inter-adjacent TSOs…Synchronous Area)						
Coordination Item	**Involved TSOs**	**When (if there were many events please provide all the dates)**	**Number of coordination events/activities**	**Status of discussion**	**Format used for the coordination**	**Comments**

Table 1. Survey template on TSO coordination/collaboration

4 Analysis of TSO coordination/collaboration

4.1 Participation

The following map shows the TSOs/countries that have responded to the survey[1].

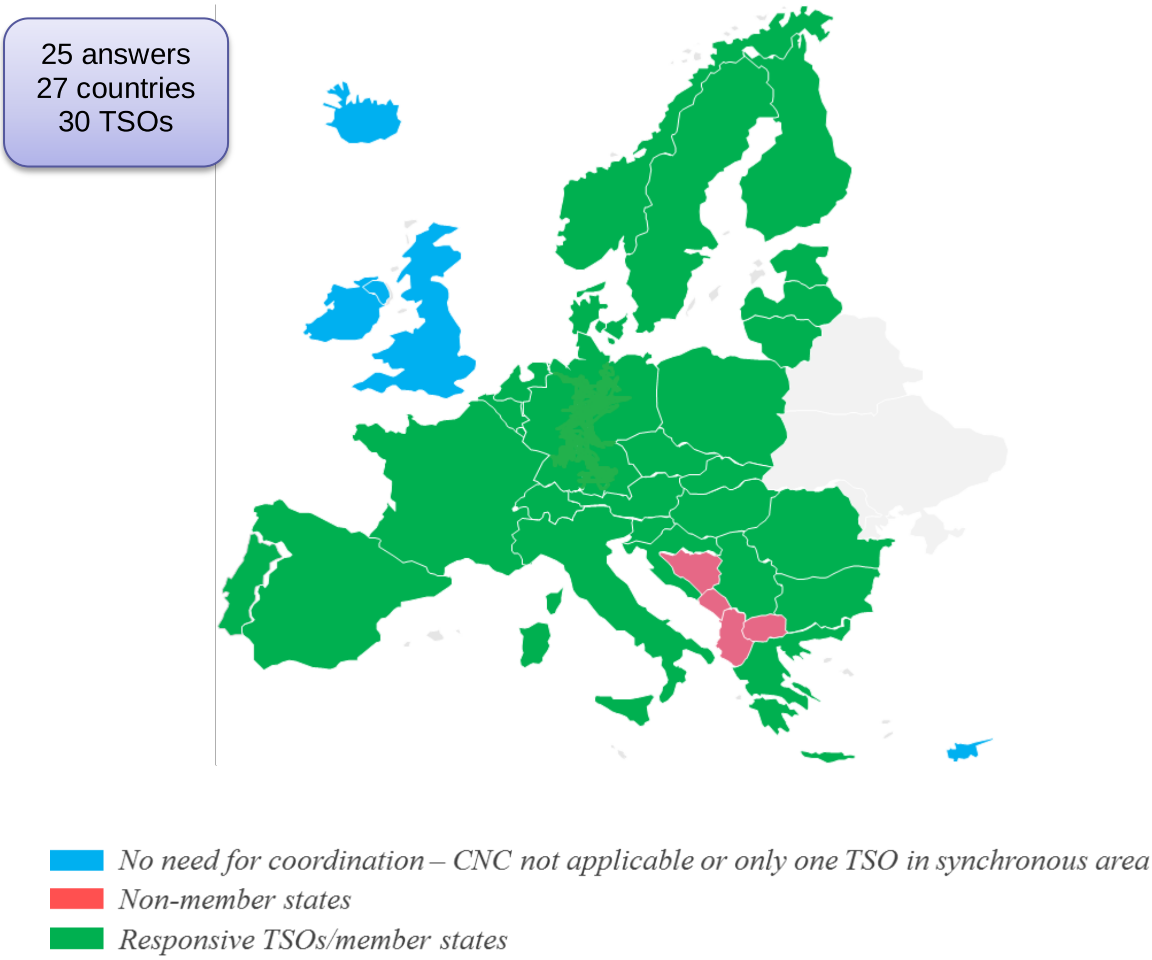

Figure 1. Map of participation.

All green-coloured countries in the map above have either answered to the survey regarding Inter-TSO coordination or have replied to ENTSO-E providing a briefing note about their progress with regards to this matter.

4.2 General information about Inter-TSO coordination during the implementation process.

General information about process of coordination/collaboration:

[1] The four German TSOs and the three Baltic TSOs have provided common answers each.

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- *Average time to specify the parameters of the non-exhaustive requirements under explicit inter-TSO coordination (in months).*

The following table provides a rough estimation by each TSO about the average time they observed (or expected) for achieving a complete definition of non-exhaustive requirements parameters under explicit coordination between TSOs.

TSOs	***Estimation of average time to specify non-exhaustive requirements parameters***
APG, CEPS, ELES, ELIA, energinet.dk, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, Litgrid, Elering AS, HOPS, MAVIR, RTE, SEPS, Tennet NL, REN, Terna, CREOS.	*Process in progress, estimation of time not feasible.*
ESO EAD, JSC EMS, REE, Statnett, Fingrid	*5 -10 months*
Transelectrica, Svenska Kraftnät, PSE.	*10-18 months*
Swissgrid	*12-24 months*

Table 2. Average time to specify the non-exhaustive requirements parameters (under Inter-TSO coordination)

- *General procedures for coordination (inter-TSO coordination events or communications) that have occurred during the implementation process*

The general procedure for coordination is mainly based on physical meetings, e-mails and web conferences used in order to facilitate the discussion and the coordination between the involved TSOs also on non-mandatory coordination items. The majority of TSOs have organized the discussion through the ENTSO-E Working groups. In particular the discussions have been carried out mainly through:

  - Workshops at European level;
  - Network Code Link Persons (NCLP) which is a network of ENTSO-E members on CNC implementation issues (more than 5 web conference/year through NCLP).

In addition to the above mentioned forums, the majority of the TSOs acknowledges the importance of the interactions and experience shared within the Connection Network Code Working Group (WG CNC) which is a dedicated ENTSO-E working group managed under the supervision and within the framework of the System Development Committee (SDC). The responsibility of this group r is to provide implementation guidance as foreseen by NC RfG Article 58 and equitable articles of NCs DCC and HVDC). WG CNC meetings are considered to constitute coordination/collaboration amongst TSOs on the issues covered by implementation guidance, which is provided by numerous Implementation Guidance Documents (IGDs). These IGDs are publicly available on ENTSO-E network codes website.

For requirements implying coordination at synchronous area level, the majority of the interactions have occurred involving the entire WG CNC and was supplemented by additional meetings from other expert groups either within ENTSO-E or initiated by adjacent TSOs.

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TSOs have carried out coordination on a bilateral or multilateral basis, mainly through physical meeting, workshops and web conference/e-mail (in average 5 meetings per group have been reported).

- *Main problems which have occurred during the coordination process. If any, it is mentioned if and how they have been resolved.*

Out of 30 TSOs which have answered to the survey a large percentage of the TSOs (70%) did not report any problems.

Five TSOs have underlined the need to consider the national system characteristics (different structure of grid, differences in the penetration level of renewables and in general different structure of generation mix) for the national CNC implementation, and the different degree of development of connection requirements. Some countries have already experienced an advanced development of renewable energy sources and consequently have already defined and updated a set of connection requirements on the light of this development, which has already demonstrated its need and benefits through operational experience in normal and emergency network situations;

Other singular comments were received as potential problems:

  - Alignment of timing of TSOs coordination with the timing of the national implementation processes.
  - Coordination with non EU Member States.
  - For non EU members, dependency on the transposition of the EU Regulation into national law.
  - Lack of information on DSO's network-connected Power Generation Modules behaviour (e.g. fault-ride-through capability)

- *Other observations from the inter-TSO coordination:*

Most of the TSOs have not observed any problems during the implementation process regarding TSO coordination. In general the aim of the coordination meetings was to present the argumentation for the proposals and to arrive to a better mutual understanding of the different rationales and motivations. Occasionally, experts from outside the concerned synchronous areas were invited to attend the meetings in order to share experience of connection and operation of specific installations like HVDC links. The priority of synchronous areas /adjacent cooperation is observed.

Depending on the experience made in the past, TSOs may choose different approaches for dealing with specific situations. It is very important to take into consideration operational contracts and other agreements between system users and the relevant network operators when comparing national approaches for specifying non-exhaustive requirements.

It was pointed out that the public workshops, where the draft IGDs were presented, are considered supportive for the implementation of the requirements on national level.

4.3 Statistics on coordination at synchronous area level

4.3.1 NC RfG

4.3.1.1 TSO coordination for implementation explicitly required

This section covers requirements for which coordination is explicitly specified by NC RfG.

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4.3.1.1.1 Article 13 (2): LFSM-O parameters; Article 15 (2)(c)(i): LFSM-U parameters

With regard to the limited frequency sensitive mode - overfrequency (LFSM-O)/ limited frequency sensitive mode - underfrequency (LFSM-U), the relevant TSO shall determine for its control area in coordination with the TSOs of the same synchronous area several parameters of these non-exhaustive requirements to ensure minimal impacts on neighbouring areas.

According to the replies received from the survey, the majority of them have addressed this aspect.

- *Number of coordination events/activities*

  With regards to the number of events of TSO coordination, more than half of the respondents have attended 3 or more events.

TSOs	*Number of coordination events/activities*
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, PSE, TERNA, Transelectrica, Svenska Kraftnät, Fingrid, CEPS, ELES, ELIA, Elering AS, JSC EMS, TransnetBW GmbH, REE, RTE, Tennet NL, Litgrid, energinet.dk, HOPS	*≥3*
Swissgrid, MAVIR	*1-2*
APG, ESO EAD, REN, SEPS, IPTO	*No indication / waiting for synchronous area coordination (HOPS)*

Table 3. Number of coordination events/activities by aspect – LFSM-O/LFSM-U

- *Level of advance in coordination completion by aspect*

  Within Baltic and Nordic synchronous areas the coordination has been completed while in most of the countries from the Continental Europe synchronous area it is in progress.

TSOs	*Level of coordination completion*
energinet.dk, Litgrid, Elering AS, Statnett,* Svenska Kraftnät*, Fingrid	*Completed*
APG, CEPS, ELES, ELIA, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, JSC EMS, PSE, REE, REN, RTE, Swissgrid, TERNA, Transelectrica, Tennet NL, MAVIR.	*In progress*
ESO EAD, SEPS, HOPS, IPTO	*No indication*

Table 4. Level of coordination completion by aspect – LFSM-O/LFSM-U

4.3.1.2 TSO collaboration for implementation reasonably required

This section covers coordination which is not explicitly requested by the NC RfG but would reasonably make sense from a system engineering perspective.

4.3.1.2.1 Article 13 (1)(a): Frequency Ranges

With regard to frequency ranges, a power generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in NC RfG. Coordination at synchronous area level of time period for operation for certain frequency ranges under specification by each TSO is reasonably expected.

- *Number of coordination events/activities by aspect*

  The number of TSO coordination events ranges from 1 to 5 depending on the synchronous area. For example within the Baltic synchronous area 2 events have been reported, while in Continental Europe the number is between 1 to 5. Half of the TSOs from Continental Europe report 5 or more events to set the frequency ranges (including WG CNC meetings). No answers have been received from the Nordic synchronous area.

TSOs	*Number of coordination events/activities*
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, TERNA, PSE, Transelectrica, REE, TenneT NL, energinet.dk, ELIA, RTE, Litgrid, Elering AS, JSC EMS, ELES, CEPS, HOPS	*≥4*
Swissgrid, MAVIR, ESO EAD	*1-3*
Fingrid, REN, IPTO, Stattnet, Svenska Kraftnät, SEPS	*No indication*

Table 5. Number of coordination events/activities by aspect - Frequency Ranges

- *Level of advance in coordination completion by aspect*

  Within the Baltic synchronous area the coordination has been completed while in most of the countries from Continental Europe it is in progress. The frequency ranges were discussed in an ENTSO-E public workshop on 20. July 2017 and will be defined and agreed after a further workshop on 04. October 2017 including the corresponding IGDs by end of 2017. France and Spain reported that they have completed their coordination process.

4.3.1.2.2 Article 13 (1)(b): RoCoF withstand capability

With regard to rate of change of frequency (RoCoF) withstand capability, a power generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to a value specified by the relevant TSO, unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection. The relevant system operator, in coordination with the relevant TSO, shall specify this rate-of-change-of-frequency-type loss of mains protection.

Minimum RoCoF withstand capability should reasonably be defined at synchronous level without prejudice to define a more onerous capability at national level if needed for system security in case of system splits or islanding.

- *Number of coordination events/activities by aspect*

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The number of TSO coordination events ranges from 1 to 5 depending on the synchronous area. For example within the Baltic synchronous area 2 events have been reported, while in Continental Europe the number is between 1 to 5. Almost half of the TSOs from Continental Europe have attended 5 or more events (including WG CNC meetings) in order to set RoCoF withstand capability.

TSOs	*Number of coordination events/activities*
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, TERNA, PSE, Transelectrica, REE, Tennet NL, energinet.dk, Litgrid, Elering AS, JSC EMS, ELIA, RTE,CEPS, ELES	≥5
HOPS	*3-4*
Swissgrid, MAVIR, ESO EAD	*1-2*
Fingrid, REN, IPTO, Stattnet, Svenska Kraftnät, SEPS	*No indication*

Table 6. Number of coordination events/activities by aspect- RoCoF withstand capability

- *Level of advance in coordination completion by aspect*

  Within the Baltic synchronous area the coordination has been completed while in most of the countries from Continental Europe it is in progress. The RoCoF withstand capability was discussed in an ENTSO-E public workshop on 20. July 2017 and will be defined and agreed after a further workshop on 04. October 2017 including the corresponding IGD by end of 2017.

4.3.1.2.3 Article 13(4): Admissible active power reduction at low frequencies

According to NC RfG, the relevant TSO shall specify the admissible active power reduction from maximum output at low frequency in its control area as a rate of reduction within specific boundaries. However, coordination at synchronous area level on the frequency-dependent admissible active power reduction taking into account technology limitations should be pursued.

- *Number of coordination events/activities by aspect*

  Within the Baltic synchronous area the number of events was 2 and in Continental Europe most of the TSOs organized between 1 and 5 events in order to set the admissible active power reduction at low frequencies (including WG CNC meetings).

TSOs	*Number of coordination events/activities*
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, TERNA, PSE, Transelectrica, REE, energinet.dk, Litgrid, Elering AS, JSC EMS, ELIA, RTE, ELES,CEPS	≥5
TenneT TSO (NL) , HOPS	*3-4*

Swissgrid, MAVIR, ESO EAD	1-2
Fingrid, REN, IPTO, Stattnet, Svenska Kraftnät, SEPS	No indication

Table 7. Number of coordination events/activities by aspect - Admissible active power reduction at low frequencies

- *Level of advance in coordination completion by aspect*

  Both in Baltic and Continental Europe synchronous areas the coordination is in progress.

4.3.1.2.4 Article 13 (7): Frequency ranges of automatic connection and gradient of active power increase

The RfG requires the relevant TSO to specify the conditions under which a power generating module is capable of connecting automatically to the network. Those conditions shall include:

a) frequency ranges within which an automatic connection is admissible, and a corresponding delay time; and

b) maximum admissible gradient of increase in active power output.

Coordination on synchronous area level of these ranges and gradients is desirable from the point of view of cross-border affection within interconnected systems.

- *Number of coordination events/activities by aspect*

  The number of TSO coordination events ranges from 1 to 3 depending on the synchronous area. For example within the Baltic synchronous area 2 events have been reported, while in Continental Europe the number is between 1 to 3. More than half of the TSOs from Continental Europe have organized 3 or more events in order to set Frequency ranges of automatic connection and gradient of active power increase (including WG cNC meetings).

TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, TERNA, PSE, Transelectrica, REE, ELES, Tennet NL, HOPS, energinet.dk, CEPS, Litgrid, Elering AS, JSC EMS, ELIA, RTE	≥3
Swissgrid, MAVIR, ESO EAD	1-2
Fingrid, REN, IPTO, Stattnet, Svenska Kraftnät, SEPS	No indication

Table 8. Number of coordination events/activities by aspect - Frequency ranges of automatic connection and gradient of active power increase

- *Level of advance in coordination completion by aspect*

  Both in Baltic and Continental Europe synchronous areas the coordination is in progress. CEPS reported that this requirement has not been discussed so far.

4.3.1.2.5 Article 14 (4)(a): Automatic reconnection after an incidental disconnection

According to NC RfG the relevant TSO shall specify the conditions under which a power generating module from type B onwards is capable of reconnecting to the network after an incidental disconnection caused by a network disturbance. Coordination of the parameters of this requirement is desirable within interconnected systems.

- *Number of coordination events/activities by aspect*

  The number of TSO coordination events ranges from 2 to 3 depending on the synchronous area. For example the Baltic synchronous area 2 events have been reported, while in Continental Europe the number is between 1 to 3. More than a half of the TSOs from Continental Europe have organized 3 or more events (including WG CNC meetings).

TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, TERNA, PSE, Transelectrica, REE, ELES, TenneT NL, HOPS, energinet.dk, CEPS, RTE, Litgrid, Elering AS, JSC EMS, ELIA	≥3
Swissgrid, MAVIR	2
ESO EAD	1
Fingrid, REN, IPTO, Stattnet, Svenska Kraftnät, SEPS	No indication

Table 9. Number of coordination events/activities by aspect - Automatic reconnection after an incidental disconnection

- *Level of advance in coordination completion by aspect*

  Both in Baltic and Continental Europe synchronous areas the coordination is in progress. CEPS reported that this requirement has not been discussed so far.

4.3.1.2.6 Article 15 (2)(d): FSM parameters

Concerning frequency sensitive mode (FSM) capability, a number conditions/requirements shall apply as specified by the relevant TSO. Coordination at synchronous area level of most of the FSM parameters and of the duration of active power frequency response provision is reasonably expected. The methodology of selecting FSM parameters for FSM should coordinated to ensure proper overall Control Block active power frequency response. In fact, most of TSOs have reported physical meetings for coordination (both ad hoc and ENTSO-E WG CNC meetings), web conferences and e-mail exchange. Some TSOs have also mentioned the organisation of public workshops.

- *Number of coordination events/activities by aspect*

  With regards to the TSO coordination number of events, about half of the TSOs have attended to 3 or more events, and the majority have reported some kind of interaction.

TSOs	Number of coordination events/activities
REE, Statnett, PSE, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, Eles, Transeletrica, Terna, CEPS, Fingrid, Svenska Kraftnät, Tennet NL, energinet.dk, HOPS, RTE, Litgrid, Elering AS, Elia, JSC EMS	≥3
Swissgrid, ESO EAD, MAVIR	1-2
SEPS, APG, REN, IPTO	0/no indication

Table 10. Number of coordination events/activities by aspect - FSM parameters

- *Level of advance in coordination completion by aspect*

  Within Nordic synchronous area the coordination has been completed while in most of the countries from CE it is in progress. JSC EMS has also reported that they have completed their coordination process.

TSOs	Level of coordination completion
Statnett, JSC EMS, Fingrid, Svenska Kraftnät	Completed
REE, RTE, swissgrid, PSE, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH,Elia, Eles, APG, Transeletrica, Terna, CEPS, REN, Litgrid, AS , Elering, MAVIR	In progress
SEPS, energinet.dk, ESO EAD, Tennet NL, HOPS, IPTO	No indication

Table 11. Level of coordination completion by aspect - FSM parameters

4.3.1.2.7 Article 15 (5)(c)(iii): Quick re-synchronisation

According to NC RfG, power generating modules shall be capable of continuing operation following tripping to house load, irrespective of any auxiliary connection to the external network. The minimum operation time shall be specified by the relevant system operator in coordination with the relevant TSO, taking into consideration the specific characteristics of prime mover technology.

RfG does not explicitly ask for TSO coordination, however, taking into account the cross-border impact of this requirement it reasonably makes sense, without preventing from defining different values if needed to ensure safety of the system in case of system splits or islanding.

- *Level of advance in coordination completion by aspect*

  With regards to the TSO coordination number of events, almost half of the TSOs have attended to 3 or more events.

TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, Transelectrica, TERNA	≥3
ELIA, Litgrid, AS, Elering, Swissgrid, JSC EMS	1-2
Fingrid, SEPS, Statnett, Svenska Kraftnät, Tennet NL, APG, CEPS, ELES, energinet.dk, ESO EAD, HOPS, IPTO, MAVIR, PSE, REN, RTE	0 / No indication

Table 12. Number of coordination events/activities by aspect - Quick re-synchronisation

- *Level of advance in coordination completion by aspect*

  No TSO has reported the finalization of the coordination. Almost half of the TSOs have answered they are in progress.

TSOs	Level of coordination completion
APG, ELIA, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, JSC EMS, REN, Swissgrid, TERNA, Transelectrica, RTE	In progress
CEPS, ELES, energinet.dk, ESO EAD, Fingrid, HOPS, IPTO, Litgrid, AS, Elering, MAVIR, PSE, Statnett, Svenska Kraftnät, Tennet NL, SEPS	No indication

Table 13. Level of coordination completion by aspect- Quick re-synchronisation

4.3.1.2.8 Article 15 (6)(e): Maximum limits on rates of change of active power output

According to NC RfG the relevant system operator shall specify, in coordination with the relevant TSO, minimum and maximum limits on rates of change of active power output (ramping limits) in both an up and down direction of change of active power output for a power generating module, taking into consideration the specific characteristics of prime mover technology.

Notwithstanding the above, coordination at synchronous area level of rate of change of active power output ramp rate ranges may need to be defined taking into account technology constraints (within these ranges TSOs will specify the needed ramp rates during the national implementation)

- *Number of coordination events/activities by aspect*

  Roughly half of the TSOs have reported 3 or more events in coordination of this aspect. All of them have been carried out outside WG CNC meetings (ad-hoc physical meetings, workshops, e-mails and teleconferences).

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TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, Transelectrica, TERNA, Tennet NL, RTE	≥3
ELIA, Litgrid, AS, Elering, MAVIR, Swissgrid, APG, ELES, JSC EMS	1-2
Fingrid, SEPS, Statnett, Svenska Kraftnät	0
CEPS, energinet.dk, ESO EAD, HOPS, IPTO, PSE, REN	No indication

Table 14. Number of coordination events/activities by aspect - Maximum limits on rates of change of active power output

- *Level of advance in coordination completion by aspect*

  Only ELES has reported that they have completed their coordination process while in most of the countries is in progress.

TSOs	Level of coordination completion
ELES	Completed
APG, ELIA, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, JSC EMS, Litgrid, AS, Elering, REN, Swissgrid, TERNA, Transelectrica, REE, MAVIR, RTE	In progress
CEPS, energinet.dk, ESO EAD, Fingrid, HOPS, IPTO, PSE, SEPS, Statnett, Svenska Kraftnät, Tennet NL	No indication

Table 15. Level of coordination completion by aspect - Maximum limits on rates of change of active power output

4.3.1.2.9 Article 21 (2): Synthetic inertia

With regard to implementation of this item, most of the TSOs are in progress and already had one or more physical meetings (for example APG,RTE,CEPS,ELES,TERNA,TENNET and Elia, Amprion, 50 Hz, RTE, EirGrid, Swissgrid). There are also TSOs which are doing internal consultations (ESO, energinet.dk) or have planned so. Consultations with experts from SPD working group are also mentioned. Fingrid, Statnett, TenneT NL and SEPS did not report any activities nor have mentioned that are planning activities in future.

4.3.2 NC DCC

4.3.2.1 TSO coordination for implementation explicitly required

This section covers requirements, for which coordination is explicitly specified by NC DCC.

4.3.2.1.1 Articles 29 (2)d, 29 (e), 29 (2)g: Demand Response – System frequency control

For Demand Response – System frequency control (DR-SFC) most of the TSOs report an ongoing process of coordination. Inter TSO meetings, WG CNC workshops and NCLP meetings are mentioned.

4.3.2.2 TSO collaboration for implementation reasonably required

This section covers requirements, for which coordination is not explicitly requested by NC DCC but would reasonably make sense from a system engineering perspective.

4.3.2.2.1 Article 12 (1): Frequency Ranges

With regard to frequency ranges, new transmission connected demand facilities/distribution networks shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in NC DCC. Coordination at synchronous area level of time period for operation for certain frequency ranges under specification by each TSO is reasonably expected.

- *Number of coordination events/activities by aspect*

  Most of the TSOs from CE have organized 1 or more events in order to set the frequency ranges. No answers have been received from the Nordic synchronous area. WG CNC meetings are also reported as coordination events with regard to this item.

TSOs	*Number of coordination events/activities*
Elering AS, energinet.dk, Transelectrica, JSC EMS, RTE, ELES, CEPS, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, PSE, REE, TERNA, Tennet (NL), ELIA	≥5
Litgrid, HOPS	*3-4*
Swissgrid	*1-2*
Fingrid, Statnett, APG, EOS EAD, MAVIR, IPTO, REN, SEPS, Svenska Kraftnät	*0 / No indication*

Table 16. Number of coordination events/activities by aspect - Frequency Ranges

- *Level of advance in coordination completion by aspect*

  For a few TSOs coordination is pending. The majority reports work in progress. TSOs from the Nordic synchronous area have not provided any information.

TSOs	Level of coordination completion
JSC EMS, REE, RTE	Completed
APG, ELES, EOS EAD, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, CEPS, ELIA, PSE, REN, Swissgrid, TERNA, Transelectrica	In progress
MAVIR, Litgrid, AS, Elering	Pending

Table 17. Level of coordination completion by aspect - Frequency Ranges

4.3.2.2.2 Article 19 (1)(a): Demand disconnection trigger

The relevant TSO may specify a disconnection trigger based on a combination of low frequency and rate-of-change-of-frequency. Collaboration is not explicitly required by NC DCC, and does not prevent from defining different values if needed to ensure safety of the system in case of system splits or islanding.

- *Number of coordination events/activities by aspect*

  The following table shows the number of coordination events/activities that have been reported by each TSO.

TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH	≥5
ELES, Fingrid Swissgrid, Transelectrica JSC EMS, REE	1-4
Fingrid, CEPS, Litgrid, AS, Elering, MAVIR, Statnett, Tennet (NL), ELES, Svenska Kraftnät	0
REN, RTE, SEPS, , APG, ELIA, energinet.dk, EOS EAD, ELIA*	No indication
HOPS, Terna	Further analysis needed

(*) the same requirement as for the RfG, this collaboration has been performed in the scope of the RfG.

Table 18. Number of coordination events/activities by aspect - Demand disconnection trigger

- *Level of advance in coordination completion by aspect*

German TSOs consider the coordination as completed. For most of the other TSOs coordination is either work in progress or still pending. A number of TSOs have not provided any information.

TSOs	Level of coordination completion
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH	Completed
JSC EMS, REN, Swissgrid, Transelectrica, APG, ELES, EOS EAD, ELIA, REE	In progress
CEPS, MAVIR, Litgrid, AS, Elering	Pending
Fingrid, HOPS, RTE, SEPS, Statnett, Tennet (NL), TERNA, energinet.dk, Svenska Kraftnät	No indication

Table 19. Level of coordination completion by aspect - Demand disconnection trigger

4.3.2.2.3 Article 28 (2)(k): RoCoF withstand capability

Minimum RoCoF withstand capability is to be defined at synchronous level without the prejudice to define by each TSO a higher withstand capability on national level if needed to ensure safety of the system in case of system splits or islanding.

- *Number of coordination events/activities by aspect*

  The following table shows the number of coordination events/activities that have been reported by each TSO. WG CNC meetings have been considered as coordination events for most of the TSOs.

TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, TERNA, Tennet (NL), energinet.dk, ELIA, Elering AS, JSC EMS, ELES, CEPS, Transelectrica, RTE	≥5
Swissgrid, HOPS, Litgrid	1-4
Fingrid, Statnett, IPTO, Svenska Kraftnät	0
APG, EOS EAD, MAVIR, REN, SEPS	No indication

Table 20. Number of coordination events/activities by aspect - RoCoF withstand capability

- *Level of advance in coordination completion by aspect*

  None of the TSOs has reported the coordination as completed. Almost half of the TSOs report work in progress.

TSOs	Level of coordination completion
APG, CEPS, ELES, EOS EAD, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REN, Swissgrid, TERNA, REE, Transelectrica, ELIA, Svenska Kraftnät, RTE	*In progress*
CEPS, JSC EMS, Litgrid, AS, Elering	*Pending*
Fingrid, MAVIR, SEPS, Statnett, Svenska Kraftnät, energinet.dk, HOPS, IPTO	*No indication*

Table 21. Level of coordination completion by aspect - RoCoF withstand capability

4.3.2.2.4 Article 30 (2)(b): Demand response – very fast active power control

According to NC DCC, the network operator may agree with a demand facility owner or a CDSO on a contract for the delivery of demand response very fast active power control. Therefore this requirement is qualified as non-mandatory.

Only TSOs, which intend to apply this optional requirement may seek for collaboration.

- *Number of coordination events/activities*

  Most of the TSOs expect WG CNC and/or NCLP to provide collaboration process (by IGDs, WS, WG meetings, call conference and webinars). First outcomes were presented in Public Workshop on Frequency Stability Parameters for Connection Network Code Implementation on July, 20th 2017.

  Additionally, 3 TSOs have indicated a kind of inter-TSO expert meeting outside ENTSO-E.

TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, TERNA	≥5
ELES	*3*
SWISSGRID, TRANSELECTRICA	*2*
ESO EAD, JSC EMS,	*1*
FINGRID, LITGRID, AS, ELERING, MAVIR, SVENSKA Kraftnät, STATNETT, TENNET	*0*
APG, CEPS, ELIA, energienet.dk, HOPS, IPTO, REN, RTE, SEPS, PSE*	*No indication*

(*) the same requirement as for the RfG, this collaboration has been performed in the scope of the RfG.

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Table 22. Number of coordination events/activities by aspect - DSR – very fast APC

- *Level of advance in coordination completion by aspect*

  None of the TSOs has reported the coordination as completed. Almost half of the TSOs have answered that they are in progress.

TSOs	Level of coordination completion
APG, ELES, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, JSC EMS, REE, REN, SWISSGRID, TERNA, TRANSELECTRICA, RTE	In progress
LITGRID, AS, ELERING, MAVIR	Pending
CEPS, ELIA, energinet.dk, ESO EAD, FINGRID, HOPS, IPTO, SVENSKA Kraftnät , SEPS, STATNETT, TENNET, PSE	No indication

Table 23. Level of coordination completion by aspect - DSR – very fast APC

4.3.3 NC HVDC

4.3.3.1 TSO coordination for implementation explicitly required

This section covers requirements, for which coordination is explicitly specified by NC HVDC.

4.3.3.1.1 Article 18 (5): Voltage ranges and time periods

Article 18 (5) of NC HVDC addresses exclusively to TSOs of the Baltic synchronous area. The Baltic TSOs cooperate closely in the CNC implementation. The coordination on Article 18 (5) is pending. Baltic TSOs will establish ad-hoc physical meetings of experts (outside ENTSO-E) on the matter.

4.4 Statistics regarding Adjacent TSOs coordination/collaboration

4.4.1 NC RfG

4.4.1.1 TSO coordination for implementation explicitly required

4.4.1.1.1 Article 5 (3): Capacity thresholds for generators

In forming proposals for maximum capacity thresholds for types B, C and D power-generating modules, the relevant TSO shall coordinate with adjacent TSOs and DSOs.

- *Number of coordination events/activities*

  The following table shows the number of coordination events/activities that have been reported by each TSO, having reach a total number of 63 accounted actions at the date of collection of the replies to the survey.

TSOs	Number of coordination events/activities
CEPS, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, Eles, energinet.dk, HOPS, Elia, TenneT TSO, Terna, JSC EMS, Transelectrica, PSE, RTE, Elering AS, Litgrid, REN	≥4
Fingrid, Statnett SF, Svenska Kraftnät, APG, Swissgrid, Creos Luxembourg	1-3
ESO EAD, IPTO, MAVIR, SEPS	0

Table 24. Number of coordination events/activities by aspect - Capacity thresholds for generators

- *Level of advance in coordination completion*

Coordination on this item is considerably advanced, with almost half of the TSOs having completed it while it is still work in progress for the others.

TSOs	Level of coordination completion
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, AS, Transelectrica, Elering, energinet.dk, Fingrid, Litgrid AB, REN, RTE, Statnett SF, Svenska Kraftnät	Completed
APG, CEPS, Creos Luxembourg, Eles, Elia, ESO EAD, HOPS, IPTO, JSC EMS, MAVIR, PSE S.A., REE, SEPS, Swissgrid, TenneT NL, Terna	In progress

Table 25. Number of coordination events/activities by aspect - Capacity thresholds for generators

4.4.2 NC DCC

4.4.2.1 TSO coordination for implementation explicitly required

4.4.2.1.1 Article 20: Power Quality

Accordingly with the NC DCC, TSOs shall coordinate their power quality requirements with the requirements of adjacent TSOs.

- *Number of coordination events/activities by aspect*

The following table shows the number of coordination events/activities reported by each TSO. Some TSOs have started coordination. Others have not provided further indication or report that will follow previously agreed standards,

TSOs	Number of coordination events/activities
REN, REE, JSC EMS	≥3
Energinet, Fringrid, Statnett, Svenska Kraftnät, Swissgrid, APG, CEPS, ELES, Litgrid, AS, Elering, Transelectrica, TERNA	1-2
Tennet NL, ESO EAD, ELIA, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, HOPS, IPTO, MAVIR, PSE, RTE, SEPS	No indication

Table 26. Number of coordination events/activities by aspect - Power Quality

- *Level of advance in coordination completion by aspect*

Within the Nordic synchronous area coordination has been completed while in most of the TSOs from Continental Europe report, that it is in progress. Transelectrica and JSC EMS have also reported that they have completed their coordination process.

TSOs	Level of coordination completion
Fingrid, JSC EMS, Statnett, Svenska Kraftnät, Transelectrica	Completed
APG, TERNA, Litgrid, AS, Elering, REE, REN, Swissgrid, ELES	In progress
CEPS, ELIA, energinet.dk, ESO EAD, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, HOPS, IPTO, MAVIR, PSE, RTE, SEPS, Tennet NL	No indication

Table 27. Level of coordination completion by aspect - Power Quality

4.4.3 NC HVDC

4.4.3.1 TSO coordination for implementation explicitly required

4.4.3.1.1 Article 13 (3): Automatic remedial actions

According to NC HVDC, if specified by a relevant TSO,in coordination with adjacent TSOs, the control functions of an HVDC system shall be capable of taking automatic remedial actions including, but not limited to, stopping the ramping and blocking FSM, LFSM-O, LFSM-U and frequency control. The triggering and blocking criteria shall be specified by relevant TSO and subject to notification to the regulatory authority. The modalities of that notification shall be determined in accordance with the applicable national regulatory framework.

- *Number of coordination events/activities by aspect*

The following table shows the number of coordination events/activities reported by each TSO. German, Nordic and Iberian TSOs have reported certain number of coordination experiences. Swissgrid has also reported events. WG CNC meetings are also reported as coordination events providing implementation guidance on this item.

The collaboration needs to be performed on a case-by-case basis for each specific HVDC project.

TSOs	Number of coordination events/activities
REE, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REN, Fingrid, Statnett, Svenska Kraftnät, Swissgrid, RTE	≥2
JSC EMS, Litgrid, AS, Elering, Tennet NL	0
ESO EAD, APG, CEPS, ELES, ELIA, energinet.dk, HOPS, IPTO, MAVIR, PSE, SEPS, TERNA, Transelectrica	No indication

Table 28. Number of coordination events/activities by aspect - Automatic remedial actions

- *Percentage of coordination completion by aspect*

Within the Nordic synchronous area coordination seems to be completed while in most of the countries of Continental Europe it is in progress or pending. The majority of the events which have been reported were ad-hoc expert meetings out of WG CNC / NCLP works.

TSOs	Level of coordination completion
Fingrid, Statnett, Svenska Kraftnät	Completed
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, Swissgrid, TERNA, REN, RTE	In progress
JSC EMS, Litgrid, AS, Elering	Pending
APG, CEPS, ELES, ELIA, energinet.dk, ESO EAD, HOPS, IPTO, MAVIR, PSE, SEPS, Tennet NL, Transelectrica	No indication

Table 29. Level of coordination completion by aspect - Automatic remedial actions

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4.4.3.1.2 Article 17 (2): Loss of active power in two or more control areas

Where an HVDC system connects two or more control areas, the relevant TSOs shall consult each other in order to set a coordinated value of the maximum loss of active power injection, taking into account common mode failures.

- *Number of coordination events/activities by aspect*

The following table shows the number of coordination events/activities reported by each TSO. German and Iberian TSOs have reported certain number of coordination experiences. Swissgrid has also reported events. WG CNC meetings are also reported as coordination events providing implementation guidance on this item.

The collaboration needs to be performed on a case-by-case basis for each specific HVDC project.

TSOs	Number of coordination events/activities
Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, REN, Swissgrid	≥2
Tennet NL, Satnett, FINGRID, SVENSKA Kraftnät, JSC EMS, Litgrid, AS, Elering, APG, CEPS, ELES, energinet.dk, ESO EAD, ELIA, IPTO, Transelectrica, HOPS, MAVIR, RTE, SEPS, TERNA, PSE	0 / no indication

Table 30. Number of coordination events/activities by aspect - Loss of active power in two or more control areas

- *Level of coordination by aspect*

None of the TSOs has reported the completion of the coordination. Most of the TSOs are still working on implementation of this requirement due to its project-specific nature.

The majority of the events that have been reported was ad-hoc expert meetings.

TSOs	Level of coordination completion
Swissgrid, TERNA, Amprion GmbH, 50Hertz Transmission GmbH, TenneT TSO GmbH, TransnetBW GmbH, REE, RTE	In progress
Litgrid, AS, Elering, REN, JSC EMS	Pending
APG, CEPS, ELES, energinet.dk, ESO EAD, ELIA, IPTO, Transelectrica, HOPS, MAVIR, SEPS, PSE, Tennet NL, Statnett, FINGRID, Svenska Kraftnät	No indication

Table 31. Level of coordination completion by aspect - Loss of active power in two or more control areas

4.4.3.1.3 Article 18 (1): Reference 1 pu voltage

Without prejudice to Article 25 on NC HVDC, an HVDC converter station shall be capable of staying connected to the network and capable of operating at HVDC system maximum current, within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to reference 1 pu voltage, and the time periods specified in other parts of this NC. The establishment of the reference 1 pu voltage shall be subject to coordination between the adjacent relevant system operators.

A number of TSOs considers this requirement as project-specific or does not consider it as a coordination item, because voltage levels and reference voltage are fixed. Consequently, the majority of the TSOs has not replied to this aspect in the survey.

The majority of TSOs are still working on implementation of NC HVDC and no one has confirmed the finalization of the coordination.

5 Conclusions

TSOs' coordination when implementing the CNCs consists in working closely together in specifications for national implementation, to ensure that the objectives of the NCs RfG, DCC and HVDC are achieved. In the frame of CNCs the objective of coordination has not be considered as an obligation to agree on common requirements, differently from operational and market network codes (NCs) and guidelines (GLs) which explicitly require all TSOs to elaborate together joint proposals of requirements. This coordination/collaboration shall guide the national implementation but not impair the decision making prerogatives of the relevant entities at the national level.

It is important to recall, that coordination is not an issue for the synchronous Areas of GB and Ireland, because single TSOs are responsible for the CNC implementation there.

From the survey to the TSOs, it can be noticed that coordination on implementating NC RfG is significantly more advanced than for NCs DCC and HVDC.

Concerning NC RfG, the aspects with higher level of advance in terms of coordination for implementation are:

- Determination of capacity thresholds
- LFSM-O, LFSM-U parameters
- Frequency ranges
- RoCoF withstand capability
- FSM parameters

The Nordic and Baltic synchronous areas seem to be in a more advanced state of coordination for many requirements compared to Continental Europe, which sounds logical due to the smaller size of these areas and less involved TSOs.

With regards to NC DCC, both explicitly and reasonably required coordination items are progressing, with particular focus on:

- Frequency ranges
- Demand Disconnection Trigger features
- Power Quality
- Automatic remedial actions

The implementation of NC HVDC is slower than for the other CNCs mainly because depends considerably on the HVDC experiences and future relevance for each TSO.

Hence most of the TSOs without experience/expertise on HVDC systems are waiting for specific implementation guidance by ENTSO-E in order to set specifications of non-exhaustive requirements.

It is important to note that TSOs outside the EU (non-member states) are also in the CNC implementation and the corresponding coordination/collaboration. Due to the different status of implementation of the EU legislation in the non-EU member states, the CNCs implementation may encounter delays as regard the EU timelines. For example, for non-EU members of the Energy Community, the CNCs need first to be transposed in their primary legislation in order to become applicable there.

Regarding synchronous area level coordination, most of the inter-TSO coordination is governed by existing ENTSO-E groups, for example:

- *WG CNC and its network of network code link persons (NCLPs)*
- *Regional Group System Protection and Dynamics (SPD) for Continental Europe*
- *Regional Group Nordic Analysis Group (NAG) for Nordic*

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Inter-adjacent TSOs coordination mainly carried out both by e-mail/telcos and particular physical inter-adjacent TSOs meetings, such as:

- *1 meeting in Brussels (ELIA, RTE, TenneT NL, TenneT TSO GmbH, Amprion, Creos)*
- *1 meeting in Bucharest (TEL, ESO, EMS)*
- *1 meeting in Belgrade (EMS, TEL, ESO, IPTO)*
- *1 meeting in Vienna (APG, TenneT TSO GmbH (representing alle German TSOs), TERNA, ELES, CEPS and RTE)*
- *2 meetings in Madrid (RTE,REN and REE)*
- *5 meetings within Nordic coordination task force (NCCI)*
- *5 meetings of Baltic CNC working group (Lithuanian, Latvian and Estonian TSOs)*
- *A number of other expert meetings*

The majority of the TSOs have reported that no major problems have been encountered during the coordination processes.

Five TSOs have underlined the need to consider the national system characteristics (different structure of grid, differences in the penetration level of renewables and in general different structure of generation mix) for the national CNC implementation, and the different degree of development of connection requirements. Some countries have already experienced am advanced development of renewable energy sources and consequently have already defined and updated a set of connection requirements on the light of this development, which has already demonstrated its need and benefits through operational experience in normal and emergency network situations.

The importance of the implementation guidance provided by ENTSO-E to the national processes through the series of Implementation Guidelines Documents (IGDs) for national specifications of non-exhaustive requirements and coordination/collaboration between TSOs was emphasized frequently.

Annex I: Identification of the aspects in each code subject to coordination (both necessary coordination as it is mandated by the codes and desirable by means of its nature)

NC RfG – TSO coordination for implementation explicitly required

Article	Requirement	Text
Preamble (23)	Voltage Ranges	**Voltage ranges should be coordinated between interconnected systems** because they are crucial to secure planning and operation of a power system within a synchronous area. Disconnections because of voltage disturbances have an impact on neighbouring systems. Failure to specify voltage ranges could lead to widespread uncertainty in planning and operation of the system with respect to operation beyond normal operating conditions. *Remark: Articles 15 (3), 16(2) and 25 cover the definition of voltage ranges, no further coordination is required beyond these specifications.*
5 (3)	Capacity thresholds for generators	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.
13 (2)	LFSM-O parameters	With regard to the limited frequency sensitive mode — overfrequency (LFSM-O), the following shall apply, **as determined by the relevant TSO for its control area in coordination with the TSOs of the same synchronous area** to ensure minimal impacts on neighbouring areas: a) the power generating module shall be capable of activating the provision of active power frequency response according to figure 1 at a frequency threshold and droop settings specified by the relevant TSO; b) instead of the capability referred to in paragraph (a), the relevant TSO may choose to allow within its control area automatic disconnection and reconnection of power generating modules of Type A at randomised frequencies, ideally uniformly distributed, above a frequency threshold, as determined by the relevant TSO where it is able to demonstrate to the relevant regulatory authority, and with the cooperation of power generating module owners, that this has a limited cross-border impact and maintains the same level of operational security in all system states; c) the frequency threshold shall be between **50.2** Hz and 50.5 Hz inclusive; d) the droop settings shall be between 2 % and 12 %; e) the power generating module shall be capable of activating a power frequency response with an initial delay that is as short as possible. If that delay is greater than two seconds, the power generating facility owner shall justify the delay, providing technical evidence to the relevant TSO; f) the relevant TSO may require that upon reaching minimum regulating level, the power generating module be capable of either: (i) continuing operation at this level; or (ii) further decreasing active power output; g) the power generating module shall be capable of operating stably during LFSM-O operation. When LFSM-O is active, the LFSM-O setpoint will prevail over any other active power setpoints.
15 (2) (c) (i)	LFSM-U parameters	In addition to paragraph 2 of Article 13, the following requirements shall apply to type C power generating modules with regard to limited frequency sensitive mode – underfrequency (LFSM-U): (i) the power generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and with a droop **specified by the relevant TSO in coordination with the TSOs of the same synchronous area** as follows: – the frequency threshold specified by the TSO shall be between 49.8 Hz and 49.5 Hz inclusive; – the droop settings specified by the TSO shall be in the range 2 – 12 %. This is represented graphically in Figure 4;

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NC RfG – TSO collaboration for implementation reasonably required

Article	Requirement	Recommendation
13 (1) (a)	Frequency Ranges	With regard to frequency ranges: (i) a power generating module shall be capable of remaining connected to the network and operate **within the frequency ranges and time periods specified in Table 2;** *Coordination on synchronous area level of time period for operation for those frequency ranges, where Table 2 requires specifications by each TSO.*
13 (1) (b)	RoCoF withstand capability	With regard to the rate of change of frequency withstand capability, a power generating module shall be capable of staying connected to the network and **operate at rates of change of frequency up to a value specified by the relevant TSO**, unless disconnection was triggered by rate-of-change-of-frequency-type loss of mains protection. The relevant system operator, in coordination with the relevant TSO, shall specify this rate-of-change-of-frequency-type loss of mains protection. *Coordination on synchronous area level on RoCoF value to be withstood. Minimum RoCoF is to be defined on synchronous level without the prejudice to define by each TSO higher RoCoF on national level if needed to ensure safety of the system in case of asynchronous operation or islanding.*
13 (4)	Admissible active power reduction at low frequencies	The relevant TSO shall **specify admissible active power reduction from maximum output with falling frequency in its control area as a rate of reduction falling within the boundaries, illustrated by the full lines in Figure 2:** a) below 49 Hz falling by a reduction rate of 2 % of the maximum capacity at 50 Hz per 1 Hz frequency drop; b) below 49.5 Hz falling by a reduction rate of 10 % of the maximum capacity at 50 Hz per 1 Hz frequency drop. *Coordination on synchronous area level on the frequency-dependent admissible active power reduction taking into account technology limitations.*
13 (7)	Frequency ranges of automatic connection and gradient of active power increase	The relevant TSO shall specify the conditions under which a power generating module is capable of connecting automatically to the network. Those conditions shall include: **a) frequency ranges within which an automatic connection is admissible, and a corresponding delay time; and** **b) maximum admissible gradient of increase in active power output.** Automatic connection is allowed unless specified otherwise by the relevant system operator in coordination with the relevant TSO. *Coordination on synchronous area level of these ranges and gradients*
14 (4) (a)	Automatic reconnection after an incidental disconnection	Type B power generating modules shall fulfil the following requirements relating to system restoration: a) the relevant TSO **shall specify the conditions under which a power generating module is capable of reconnecting to the network after an incidental disconnection caused by a network disturbance;** and *Coordination on synchronous area level of conditions for reconnection*
15 (2) (d)	FSM parameters	In addition to point (c) of paragraph (2), the following shall apply cumulatively when frequency sensitive mode ('FSM') is operating: **(i)** the power generating module shall be capable of providing active power frequency response in accordance **with the parameters specified by each relevant TSO within the ranges shown in Table 4.** (ii) … (iii) in the event of a frequency step change, the power generating module shall be capable of activating full active power frequency response, at or above the full line shown in Figure 6 **in accordance with the parameters specified by each TSO (which shall aim at avoiding active power oscillations for the power generating module) within the ranges given in Table 5.** The combination of choice of the parameters specified by the TSO shall take possible technology-dependent limitations into account; (iv) … (v) the power generating module shall be capable of **providing full active power frequency response for a period of between 15 and 30 minutes as specified by the relevant TSO.** In specifying the period, the TSO shall have regard to active power headroom and primary energy source of the power generating module; (vi) … (vii) … *Coordination on synchronous area level of parameters of Tables 5, and of duration of active power frequency response provision. The methodology of selecting of static parameters specified in Table 4 for FSM will be proposed through this coordination to ensure proper overall Control Block active power frequency response*
15 (5) (c) (iii)	Quick re-synchronisation	Power generating modules shall be capable of continuing operation following tripping to house load, irrespective of any auxiliary connection to the external network. **The minimum operation time shall be specified by the relevant system** operator in coordination with the relevant TSO, taking into consideration the specific characteristics of prime mover technology *Coordination on synchronous area level of minimum operation time*

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Article	Requirement	Recommendation
15 (6) (e)	Maximum limits on rates of change of active power output	The relevant system operator shall specify, in coordination with the relevant TSO, **minimum and maximum limits on rates of change of active power output (ramping limits) in both an up and down direction of change of active power output for a power generating module**, taking into consideration the specific characteristics of prime mover technology; *Coordination on synchronous area level of rate of change of active power output Ramp rate ranges need to be defined taking into account technology constraints (within these ranges TSOs will specify the needed ramp rates during the implementation process)*
21 (2)	Synthetic inertia	Type C power park modules shall fulfil the following additional requirements in relation to frequency stability: (a) the relevant TSO shall have the right to specify that power park modules **be capable of providing synthetic inertia** during very fast frequency deviations; *Coordination on synchronous area level of provision of synthetic inertia. Minimum inertia is to be defined on synchronous level without the prejudice to define higher inertia on national level by each TSO if needed to ensure safety of the system in case of asynchronous operation or islanding.*

NC DCC – TSO coordination for implementation explicitly required

Article	Requirement	Text
20	Power Quality	**TSOs shall coordinate their power quality requirements with the requirements of adjacent TSOs.**
29 (2)d	DSR- SFC	…be equipped with a control system that is insensitive within a dead band around the nominal system frequency of 50.00 Hz, of a **width to be specified by the relevant TSO in consultation with the TSOs in the synchronous area**
29 (2)e	DSR- SFC	**The maximum frequency deviation** from nominal value of 50.00 Hz to respond to shall be specified by the relevant TSO **in coordination with the TSOs in the synchronous area**
29 (2)g	DSR- SFC	The demand unit shall be capable of a rapid detection and response to changes in system frequency**, to be specified by the relevant TSO in coordination with the TSOs in the synchronous area**

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NC DCC – TSO collaboration for implementation reasonably required

Article	Requirement	Text
19 (1) a	Demand disconnection trigger	The **relevant TSO may specify a disconnection trigger** based on a combination of low frequency and rate-of-change-of-frequency; Collaboration does not prevent from defining different values *if needed to ensure safety of the system in case of asynchronous operation or islanding*
28 (2) k	RoCoF withstand capability	have the capability to not disconnect from the system due to the rate-of-change-of-frequency up to **a value specified by the relevant TSO**. The value of rate-of-change-of-frequency shall be calculated as the average of a 500 ms time frame. *Collaboration on synchronous area level on RoCoF value to be withstood. Minimum RoCoF is to be defined on synchronous level without the prejudice to define by each TSO higher RoCoF on national level if needed to ensure safety of the system in case of asynchronous operation or islanding*
30 (2) b	DSR – very fast APC	The contract …. shall specify … **the operating principle of this control system and the associated performance parameters;**

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NC HVDC – TSO coordination for implementation explicitly required

Article	Requirement	Text
13 (3)	Automatic remedial actions	If specified by **a relevant TSO, in coordination with adjacent TSOs**, the control functions of an HVDC system shall be capable of taking automatic remedial actions including, but not limited to, stopping the ramping and blocking FSM, LFSM-O, LFSM-U and frequency control. The triggering and blocking criteria shall be specified by relevant TSO and subject to notification to the regulatory authority. The modalities of that notification shall be determined in accordance with the applicable national regulatory framework. The collaboration is performed for each specific HVDC
17 (2)	Loss of active power in two or more control areas	Where an HVDC system connects two or more control areas, the **relevant TSOs shall consult each other** in order to set a coordinated value of the maximum loss of active power injection as referred to in paragraph 1, taking into account common mode failures. The collaboration is performed for each specific HVDC
18 (1)	Reference 1 pu voltage	Without prejudice to Article 25, an HVDC converter station shall be capable of staying connected to the network and capable of operating at HVDC system maximum current, within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to reference 1 pu voltage, and the time periods specified in Tables 4 and 5, Annex III. The establishment of the **reference 1 pu voltage shall be subject to coordination between the adjacent relevant system operators**.
18 (5)	Voltage ranges and time periods	Notwithstanding the provisions of paragraph 1, the **relevant TSOs in the Baltic synchronous area may, following consultation with relevant neighbouring TSOs**, require HVDC converter stations to remain connected to the 400 kV network in the voltage ranges and for time periods that apply in the Continental Europe synchronous area.

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