Network Code on Requirements for Generators

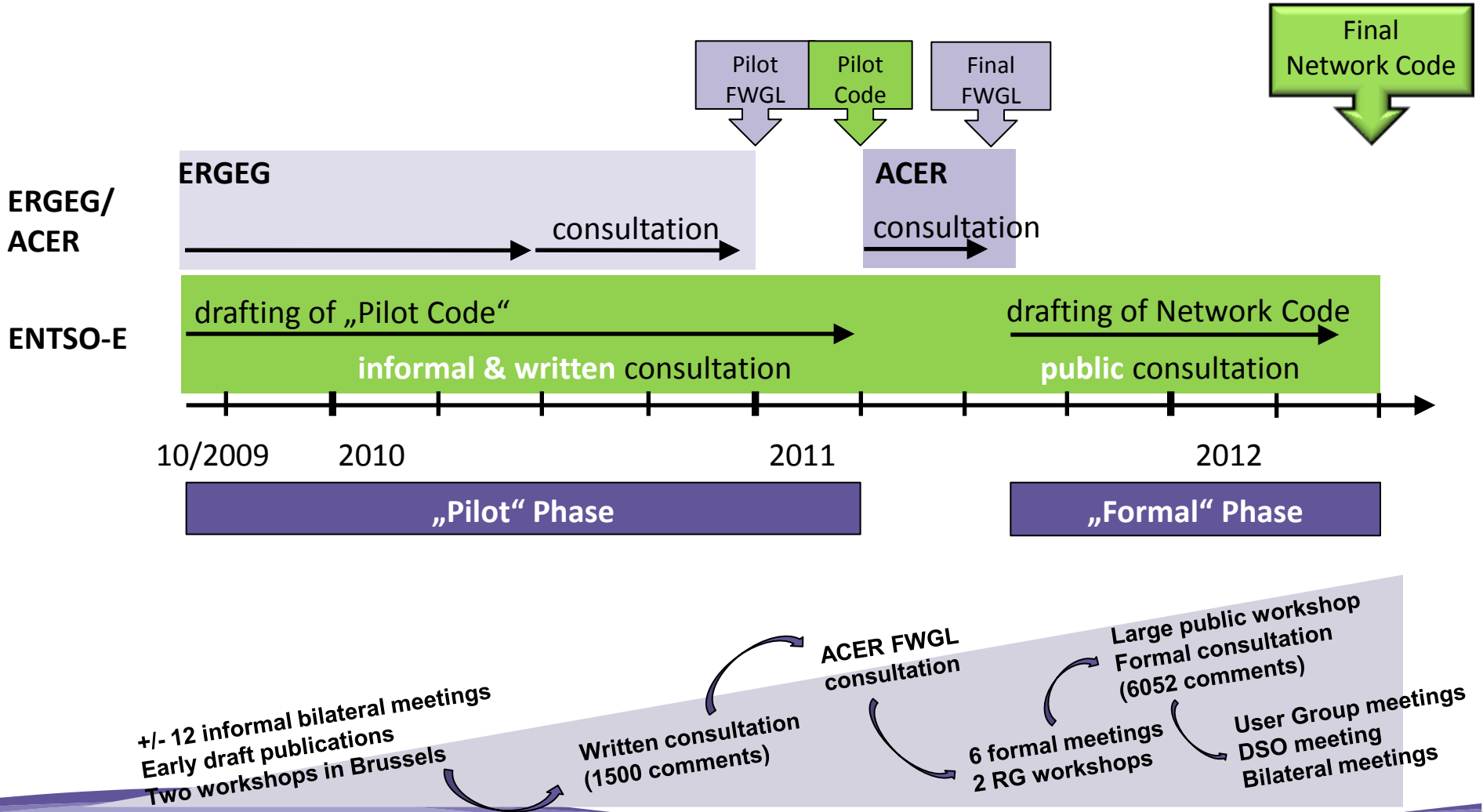
3rd RfG User Group meeting

28 June 2012, Brussels

entsoe

Reliable Sustainable Connected

NC RfG process over the past 3 years



28 June 2012 - Agenda

10:30	*Welcome*
10:30	Status - Final ENTSO-E code - Overview NC RfG 'package' (supporting documentation)
10:45	Network Code "Requirements for Generators" in view of the future European electricity system and the Third Package network codes
11:15	Follow-up to topics adressed in the past RfG User Group meetings - Recent changes in the code - ENTSO-E assessment of key stakeholder issues - How does NC RfG relate to present practices in Europe ?
12:30	*Lunch*
13:30	Round table of User Group participants - Reflection on changes in the code since consultation - Supporting documentation : specific questions
15:45	Conclusions
16:00	*End of Meeting*

NC RfG 'package'

Comments received and discussions undertaken resulted in a better code

- Clarifications in the code and supporting documentation
- Shifts of requirements between types
- Simplifications, improvements and corrections
- Clearer language

ENTSO-E publishes end of June a complete NC RfG package

Final Network Code *(proposal published, updates tbd)*

"Network Code "Requirements for Generators" in view of the future European electricity system and the Third Package network codes" *(draft published)*

Evaluation of Comments *(draft sent to the User Group)*

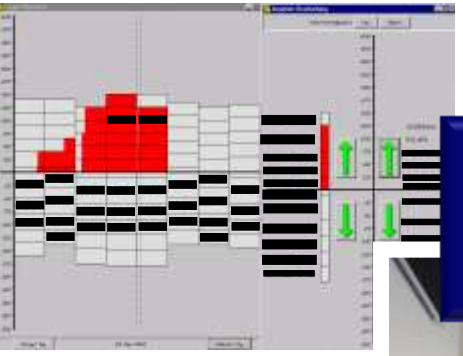
NC RfG Frequently Asked Questions *(draft sent to the User Group)*

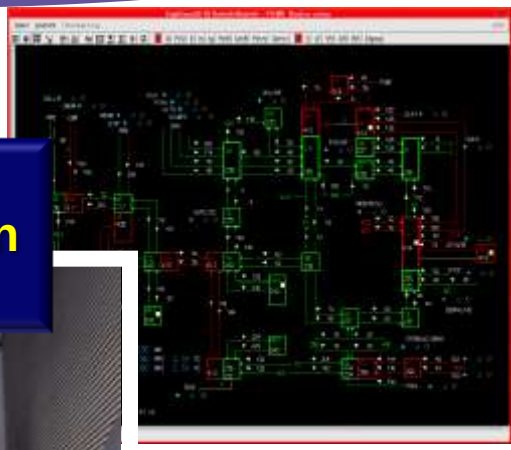
NC RfG Justification outlines

NC RfG Requirements in the context of present practices

“Network Code “Requirements for Generators” in view of the future European electricity system and the Third Package network codes”

Efficiently operating the power system – it's getting harder!



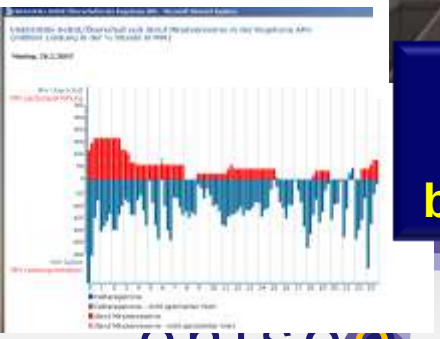


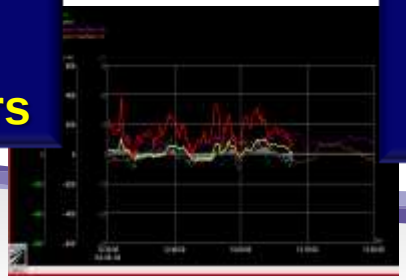
Large wind & solar volumes

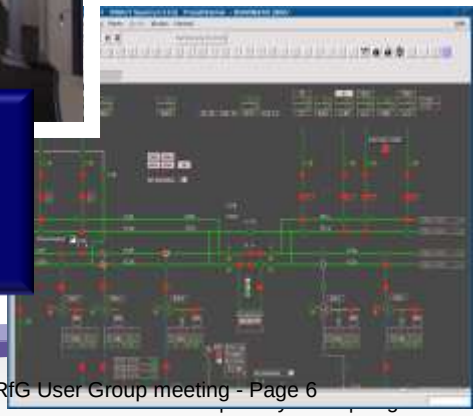
Geographic concentration of RES

Increasing Levels of Market driven Flows

Delays in building infrastructure







Frequency Deviations between hours

Rules on Priority Dispatch

What are the crucial aspects of system security

Build and maintain transmission network for bulk power flows

Design market mechanisms for facilitating trading at all time horizons

Continuous evolution of operational and coordination measures

Generators should be *able to* provide ancillary services requested by system conditions

~€104 bn investments, to be compared with

≈ 2% of the bulk power prices and

less than 1% increase of end-users' E-bills

+1.3% per year grid length to match

a major shift in generation mix and

+3% p.a. of generation capacity growth

TYNDP 2012

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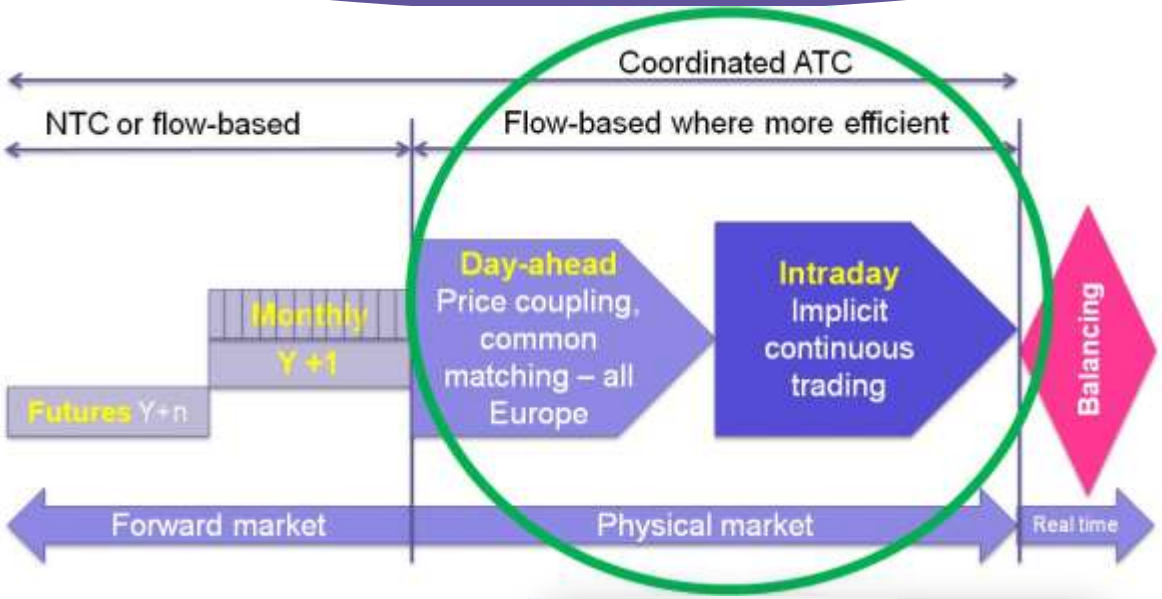
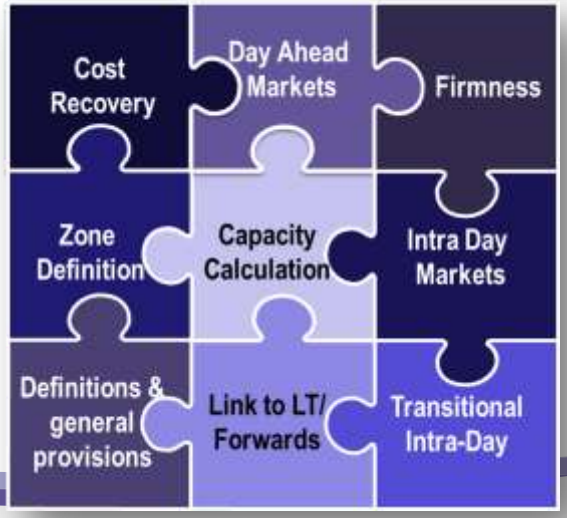


Capacity Allocation and Congestion Management NC



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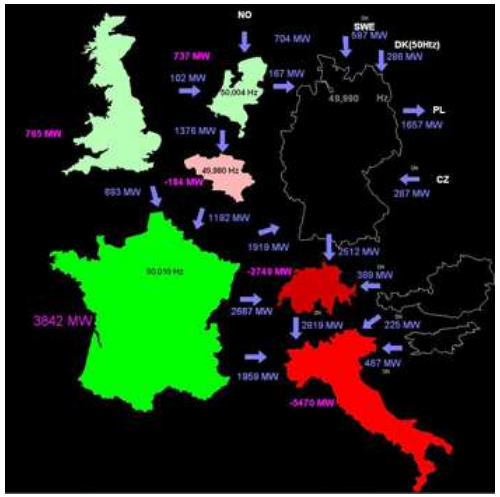

Visualization of Disturbance 4/11/06

Data exchange
(e.g. DACF process, on line measurements)

ENTSO-E Awareness System

Coordinated remedial actions
(eg. PSEO-50Hertz, or the rescheduling of HVDC links over the Baltic Sea)

CWE Phase-Shift Transformer management

Inter-TSO cooperation
(eg CORESO, TSC, SSC)

NC Operational Security (03/2013)

NC Operational Planning and Scheduling (04/2013)

What are the crucial aspects of system security

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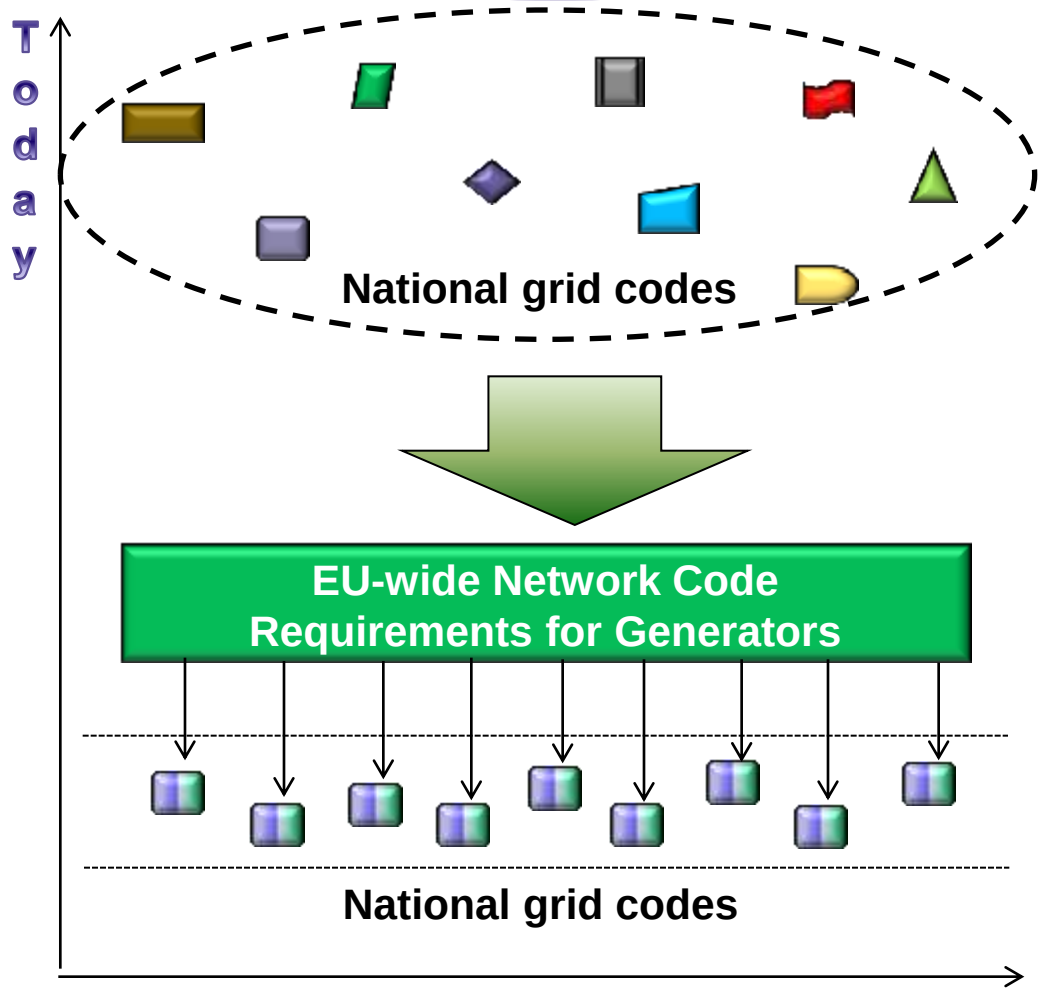
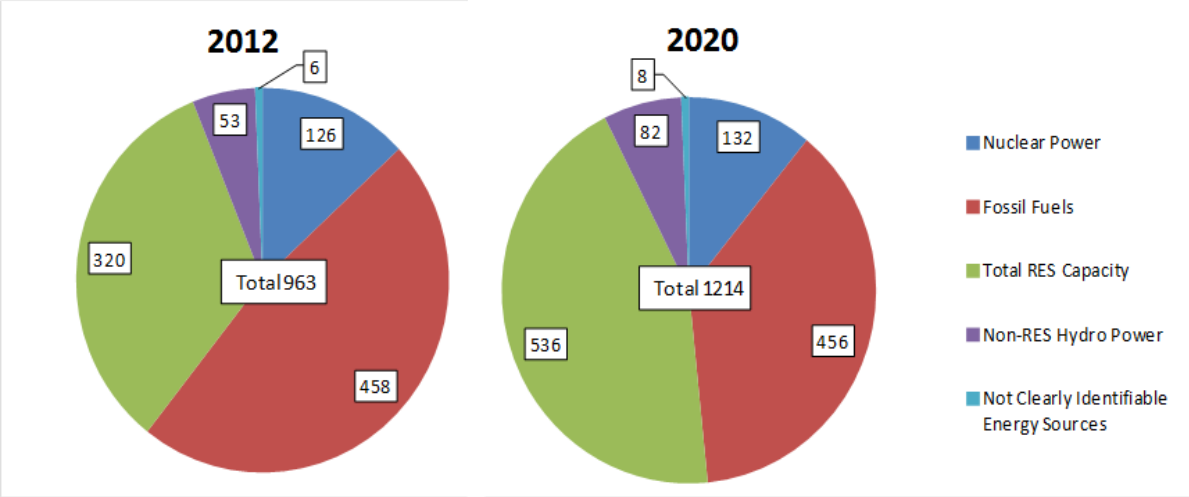
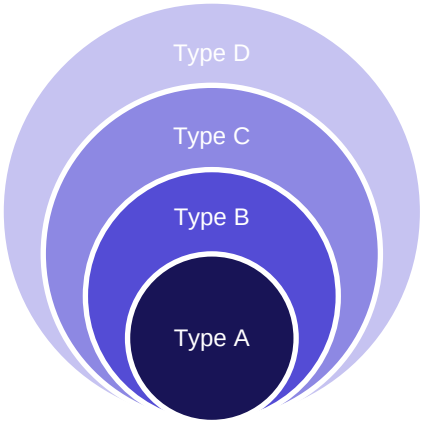


Why a Network Code on grid connection / EU-law is needed today



In a proportional, non-discriminatory and technology-independent manner – "significant grid users"



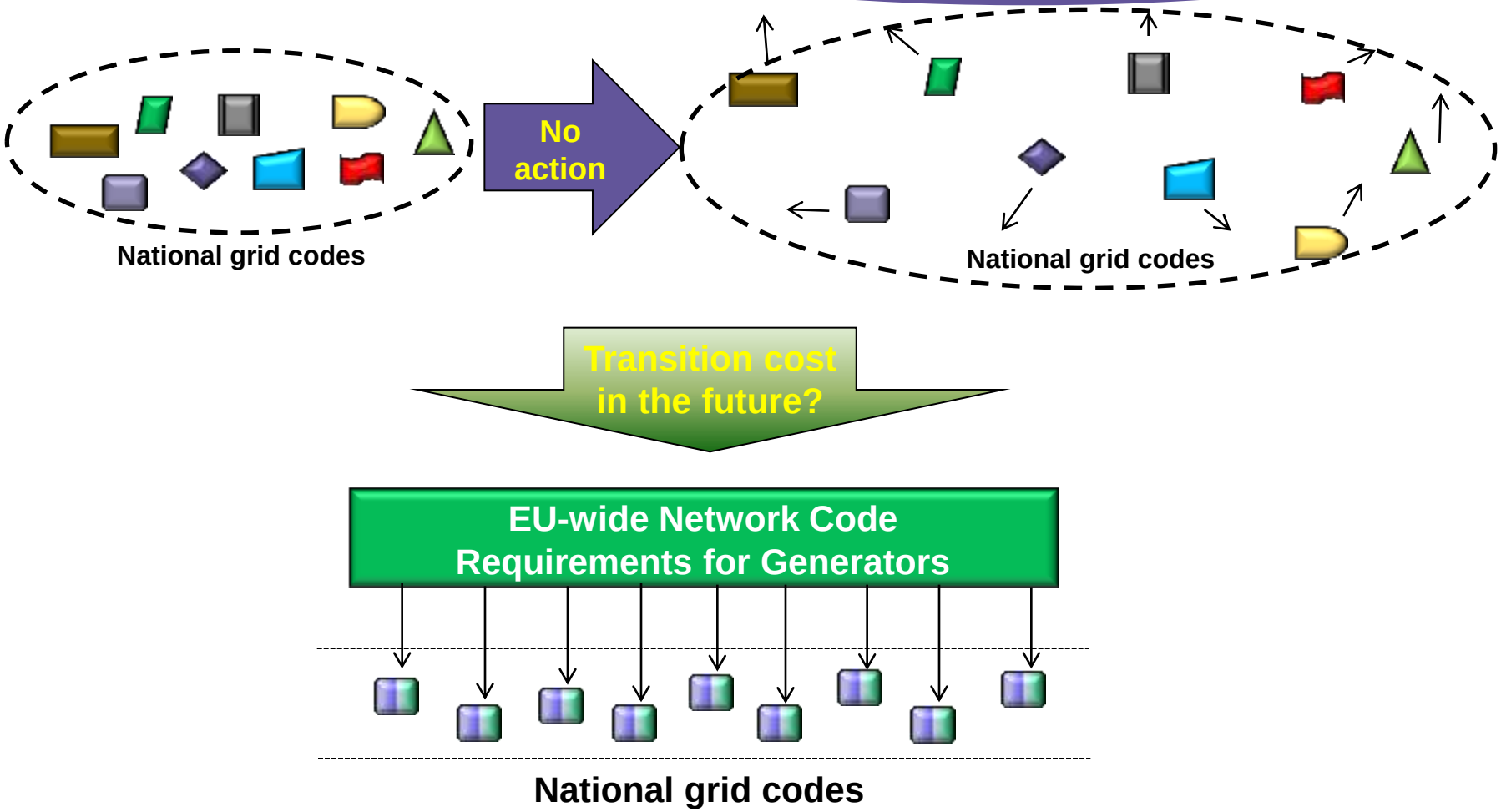
Wide-scale network operation and stability including EU-wide balancing services

Stable and controllable dynamic response capabilities covering all operational network states

Automated dynamic response and resilience to operational events including system operator control

Basic capabilities to withstand wide-scale critical events; limited automated response/operator control

Why a Network Code on grid connection / EU-law is needed today



How to ensure that support for system security is there when needed

DIRECTIVE 2009/72/EC "Each transmission system operator shall be responsible for […] ensuring the availability of all necessary ancillary services, including those provided by demand response […]"

- The NC Requirements for Generators defines the *necessary ability* of generating facilities to contribute to the secure operation of the system
  - The procurement and remuneration of ancillary services should in general be market based and is outside the scope of the code; they should be defined based on the connection requirements
  - Could ancillary services markets be developed to drive this ability? Prices high enough? Risks covered? What certainty of payments? Free riders? Market distortions? Time and cost to deliver?
- A *limited* number of the NC requirements crucial to system security are mandatory
  - if no action is taken today the risk for the system tomorrow is high
- **The NC does not apply to existing users** unless at national level a cost-benefit analysis demonstrates the contrary under NRA approval

ENTSO-E Network Codes – how do they fit together?

TYNDP scenarios and other TSO forecasts
Past and present experience

Background information for the anticipated challenges

NC Requirements for Generators

12 requirements apply directly at EU level	41 requirements to be specified at MS level	9 requirements are not mandatory
e.g. frequency voltage	e.g. remote switch data exchange fault-ride-through	e.g. black start synthetic inertia

ENTSO-E Network Codes – how do they fit together?

NC Requirements for Generators

requirements that apply directly

requirements that must be specified at national level

requirements that are not mandatory

Independent of operational and market conditions

Minimum generation contribution to system security on which the Operational Security and Balancing NCs should build upon

Guidance on how to implement provisions at national level for detailing requirements

NC Operations

- Build upon the capabilities of generators and demand
- Define security principles
- Elaborate coordination of operations

NC Balancing

- Build upon the capabilities of generators and demand as well as security requirements
- Design balancing markets to maximize social welfare, efficiency and security

Example – Frequency stability

Addressing the Issue

Network Operators

- **Monitor System States including state estimation applications;**
- **Means for controlling of switching;**
- **Communication between control centers of TSOs - DSOs, Generating Facilities and Demand Facilities, for balancing, ancillary services, system defense and restoration and for the delivery and coordination of real-time operational data;**
- **Tools for security analysis.**

Generators

- **New installations adapt design to ensure operation within ranges**
- **Existing installations subject to NRA decision on retrospective application (based on CBA)**
- **Thus ensure that Network Operators have adequate time to respond to emergencies in a system operating closer and closer to its limits**

Harmonized requirements that would lead to cost savings (standardization)

Most prominent improvements in the code since the 2nd User Group meeting

Definitions (I)

- Definition of „Equipment Certificate“ improved

Equipment Certificate - is a document issued by an Authorised Certifier for equipment used in Power Generating Modules confirming performance in respect of the requirements of this Network Code. In relation to those parameters, for which this Network Code defines ranges rather than definite values, the Equipment Certificate shall define the extent of its validity. This will identify its validity at a national or other level at which a specific value is selected from the range allowed at a European level. The Equipment Certificate can additionally include models confirmed against test results for the purpose of replacing specific parts of the compliance process for Type B, C and D Power Generating Modules. The Equipment Certificate will have a unique number allowing simple reference to it in the Installation Document or the Power Generating Module Document.

- Motivation:
  - „Manufacturer‘s Data and Performance Type Certificate“ removed and merged with the „Equipment Certificate“

Definitions (II)

- Definition of „Minimum Stable Operating Level“ introduced

Minimum Regulating Level - is the minimum Active Power as defined in the Connection Agreement or as agreed between the Relevant Network Operator and the Power Generating Facility Owner, that the Power Generating Module can regulate down to and can provide Active Power control.

Minimum Stable Operating Level - is the minimum Active Power as defined in the Connection Agreement or as agreed between the Relevant Network Operator and the Power Generating Facility Owner, at which the Power Generating Module can be operated stably for unlimited time.

- Motivation:
  - Distinction needed between the minimum levels, at which Active Power Frequency Response can be delivered, and at which continuous stable operation shall be possible (without Active Power Frequency Response capability)

Definitions (III)

- Definition of „New Power Generating module“ improved

New Power Generating Module - is a Power Generating Module for which

- with regard to the provisions of the initial version of this Network code, a final and binding contract of purchase of the main plant has been signed after the day, which is two years after the day of the entry into force of this Network Code, or,
- with regard to the provisions of the initial version of this Network code, no confirmation is provided by the Power Generating Facility Owner, with a delay not exceeding thirty months as from the day of entry into force of this Network Code, that a final and binding contract of purchase of the main plant exists prior to the day, which is two years after the day of the entry into force of this Network Code, or,
- with regard to the provisions of any subsequent amendment to this Network Code and/or after any change of thresholds pursuant to the re-assessment procedure of Article 3(6), a final and binding contract of purchase of the main plant has been signed after the day, which is two years after the entry into force of any subsequent amendment to this Network Code and/or after the entry into force of any change of thresholds pursuant to the re-assessment procedure of Article 3(6).

- Motivation:
  - ➢ Removal of a „legal gap“ with regard to amendments/changes to the code

Article 4 – Regulatory Aspects

- Improving terms and conditions for national implementations and respecting the TSOs responsibility on system security

3. Where reference is made to this paragraph, the determination of the terms and conditions for connection and access to networks or the methodologies to establish them shall be set in accordance with the rules of national law implementing Article 37 (6) (a), (7) and (10) of Directive 2009/72/EC, and with the principles of transparency, proportionality and non-discrimination.

The establishment of these terms and conditions or their methodologies shall be performed by entities and based on the legal framework indicated in this Network Code where reference is made to this paragraph, unless the rules of national law at the date of the entry into force of this Network Code assign this establishment to a different entity and according to a different legal framework.

4. Any decision by a Network Operator other than the Relevant TSO and any agreement between a Network Operator other than the Relevant TSO and a Power Generating Facility Owner shall be exercised in compliance with and respecting the Relevant TSO's responsibility to ensure system security according to national legislation. Further details to ensure this principle may be specified either by national legislation or by agreements between the Relevant TSO and the Network Operators in its Control Area, as the case may be.

- Motivation:
  - National implementations shall consider existing national legislation at the day of entry into force of the Network Code
  - Overall system security is assigned to TSOs and shall be respected by other Network Operators appropriately

Article 5 – Cost Recovery

- Update of recovery of costs incurred by regulated Network Operators

1. The costs related to the obligations referred to in this network code which have to be borne by regulated Network Operators shall be assessed by National Regulatory Authorities.

2. Costs assessed as reasonable and proportionate shall be recovered in a timely manner via network tariffs or appropriate mechanisms as determined by National Regulatory Authorities.

3. If requested to do so by National Regulatory Authorities, regulated Network Operators shall, within three months of such a request, use best endeavours to provide such additional information as reasonably requested by National Regulatory Authorities to facilitate the assessment of the costs incurred.

- Motivation:
  - Result of dicsussions with ACER

Article 8 – General requirements Type A (et al.)

- Improvements to emphasize capabilities of Generating Units

1. Type A Power Generating Modules shall fulfil the following requirements referring to Frequency stability:

a) With regard to Frequency ranges:

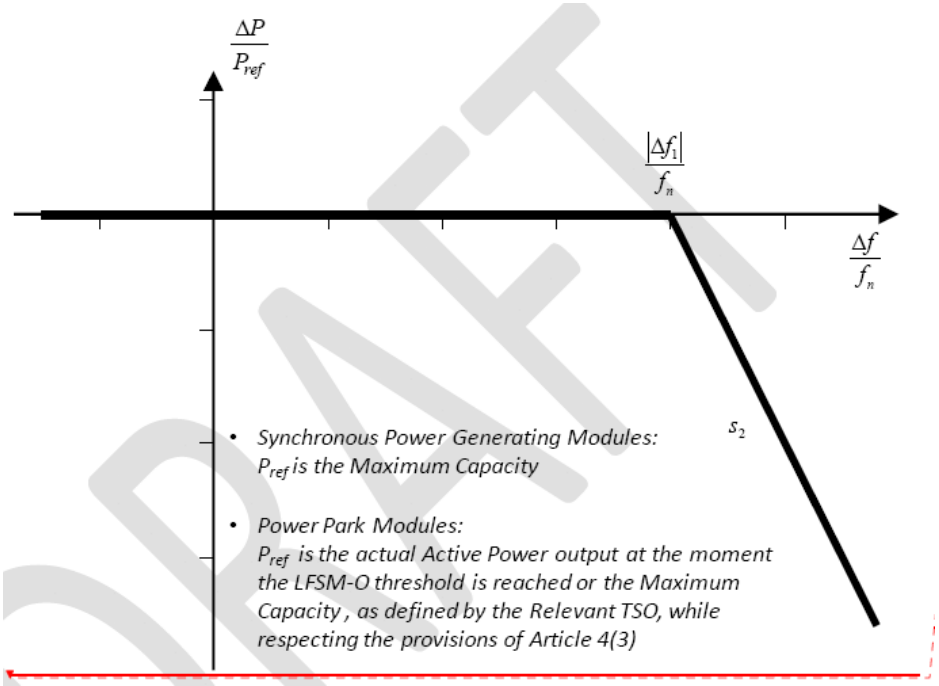
1) A Power Generating Module shall be capable of staying connected to the Network and operating within the Frequency ranges and time periods specified by table 2.

b) 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 operating at rates of change of Frequency up to a value defined by the Relevant TSO while respecting the provisions of Article 4(3) other than triggered by rate-of-change-of-Frequency-type of loss of mains protection. This rate-of-change-of-Frequency-type of loss of mains protection will be defined by the Relevant Network Operator in coordination with the Relevant TSO.

- Motivation:
  - Capabilities of Generating Units are the objective of this Network Code
  - Better distinction from operational issues

Article 8 – General requirements Type A

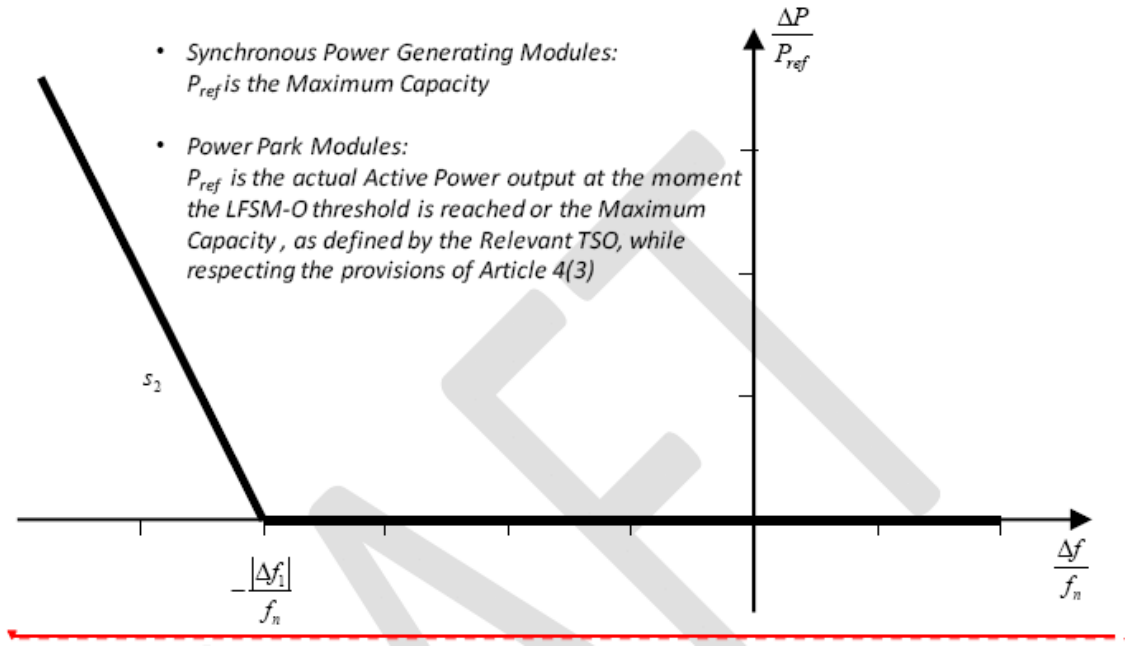
- Improvement of LFSM-O requirement for Power Park Modules by allowing for the actual Active Power Output as reference value for Active Power reduction at high frequencies



- Motivation:
  - Coherent system response at high frequencies, in particular in systems with high RES penetration running at partial load

Article 10 – General requirements Type C

- Improvement of LFSM-U requirement for Power Park Modules by allowing for the actual Active Power Output as reference value for Active Power increase at lowfrequencies



- Motivation:
  - Coherent system response at low frequencies, in particular in systems with high RES penetration running at partial load

Article 11 – General requirements Type D

- Changes to Voltage Ranges

Synchronous Area	Voltage Range	Time period for operation
	0,85 pu – 0,90 pu	60 minutes
	0.90 pu – 1,118 pu	Unlimited
	1,118 pu – 1,15 pu	To be decided by each TSO while respecting the provisions of Article 4(3), but not less than 20 minutes

2) While respecting the provisions of Article 4(3), wider Voltage ranges or longer minimum times for operation can be agreed between the Relevant Network Operator in coordination with the Relevant TSO and the Power Generating Facility Owner to ensure the best use of the technical capabilities of a Power Generating Module if needed to preserve or to restore system security. If wider Voltage ranges or longer minimum times for operation are economically and technically feasible, the consent of the Power Generating Facility Owner shall not be unreasonably withheld.

- Motivation:
  - No general requirement for very low voltages anymore, but option for agreements
  - Reduced operating times for very high voltages in line with CIGRE investigations

Article 15 – Requirements Type B Power Park Modules

- Improvements to Reactive Current Injection during fault

b) The Relevant Network Operator in coordination with the Relevant TSO shall have the right to require while respecting the provisions of Article 4(3) fast acting additional reactive Current injection at the Connection Point to the pre-fault reactive Current injection in case of symmetrical (3-phase) faults:

1) The Power Park Module shall be capable of activating this additional reactive Current injection during the period of faults. The Power Park Module shall be capable of either:

- ensuring the supply of the additional reactive Current at the Connection Point according to further specifications by Relevant Network Operator in coordination with the Relevant TSO of the magnitude of this Current, depending on the deviation of the Voltage at the Connection point from its nominal value; or

- alternatively, measuring Voltage deviations at the terminals of the individual units of the Power Park Module and providing an additional reactive Current at the terminals of these units according to further specifications by Relevant Network Operator in coordination with the Relevant TSO of the magnitude of this Current, depending on the deviation of the Voltage at units' terminals from its nominal value.

- Motivation:
  - Introducing more flexibility to consider regional network characteristics
  - Better consideration of state-of-the-art of generation/converter technology

Article 16 – Requirements Type C Power Park Modules

- Improvements to Reactive Power Capabilities below Maximum Active Power

c) With regard to Reactive Power capability below Maximum Capacity:

1) The Relevant Network Operator in coordination with the Relevant TSO shall define while respecting the provisions of Article 4(3) the Reactive Power provision capability requirements. For doing so, it shall define a P-Q/P_{max}-profile that shall take any shape within the boundaries of which the Power Park Module shall be capable of providing Reactive Power below Maximum Capacity.

2) The P-Q/P_{max}-profile is defined by each Relevant Network Operator in coordination with the Relevant TSO while respecting the provisions of Article 4(3), in conformity with the following principles:

- the P-Q/P_{max}-profile shall not exceed the P-Q/P_{max}-profile envelope, represented by the inner envelope in figure 9;
- the Q/P_{max} range of the P-Q/P_{max}-profile envelope is defined for each Synchronous Area in table 9;
- the Active Power range of the P-Q/P_{max}-profile envelope at zero Reactive Power shall be 1 pu;
- the P-Q/P_{max}-profile can be of any shape and shall include conditions for Reactive Power capability at zero Active Power; and
- the position of the P-Q/P_{max}-profile envelope within the limits of the fixed outer envelope in figure 9.

- Motivation:
  - Allowing for more flexibility to define P-Q/P_{max}-profiles
  - Better consideration of state-of-the-art of generation/converter technology

Removals

- Torsional stress requirement
  - *No cross-border issue*

- Voltage quality requirement
  - *No cross-border issue*

- Specifications of control mode and Reactive Power exchange parameters for Power Park Modules
  - *Operational issue*

- DC-connected offshore generation
  - *Requirements not sufficiently mature, to be covered by the forthcoming HVDC – connection Network Code*

Overall assessment of key issues

Positive evolutions and reasons for proposals not accepted in the code

DSOs

- Type testing of smaller units by accredited certifiers
- Appropriate classification of users/requirements
- Stronger involvement in NC development by means of Expert Groups

- 'Legal gap' on private lines and closed distribution systems
- Concern on a gap if there is no European standard for type testing against NC RfG requirements

Manufacturers

- Many improvements in technical details and clarifications
- Offshore DC connections postponed and to be combined with HVDC code
- Exemption to CHPs on some requirements covering controllability

- Low level of harmonization, no design manual
- No exemptions for specific / non-mature technologies in the code

Generators

- Focus of the code is on new units, not existing ones
- Clarifications and streamlining of operational notification, derogation process, …
- Exemptions to industrial customers to ensure sensitive local production processes

- How will Member States implement non-exhaustive requirements, e.g. FRT and reactive power?
- How will network codes interact?
- Absence of CBA for significant deviations

How does NC RfG relate to present practices in Europe ?

NC RfG – justification outlines

Distinction between
- Exhaustive requirements
  - frequency ranges
  - voltage ranges
  - (L)FSM capabilities
- Non-exhaustive requirements
  - mainly referred to as *"The Relevant Network Operator in coordination with the Relevant TSO shall define while respecting the provisions of Article 4(3) …"*

Requirement formulated in terms of
- Principle/methodology
- Numerical values

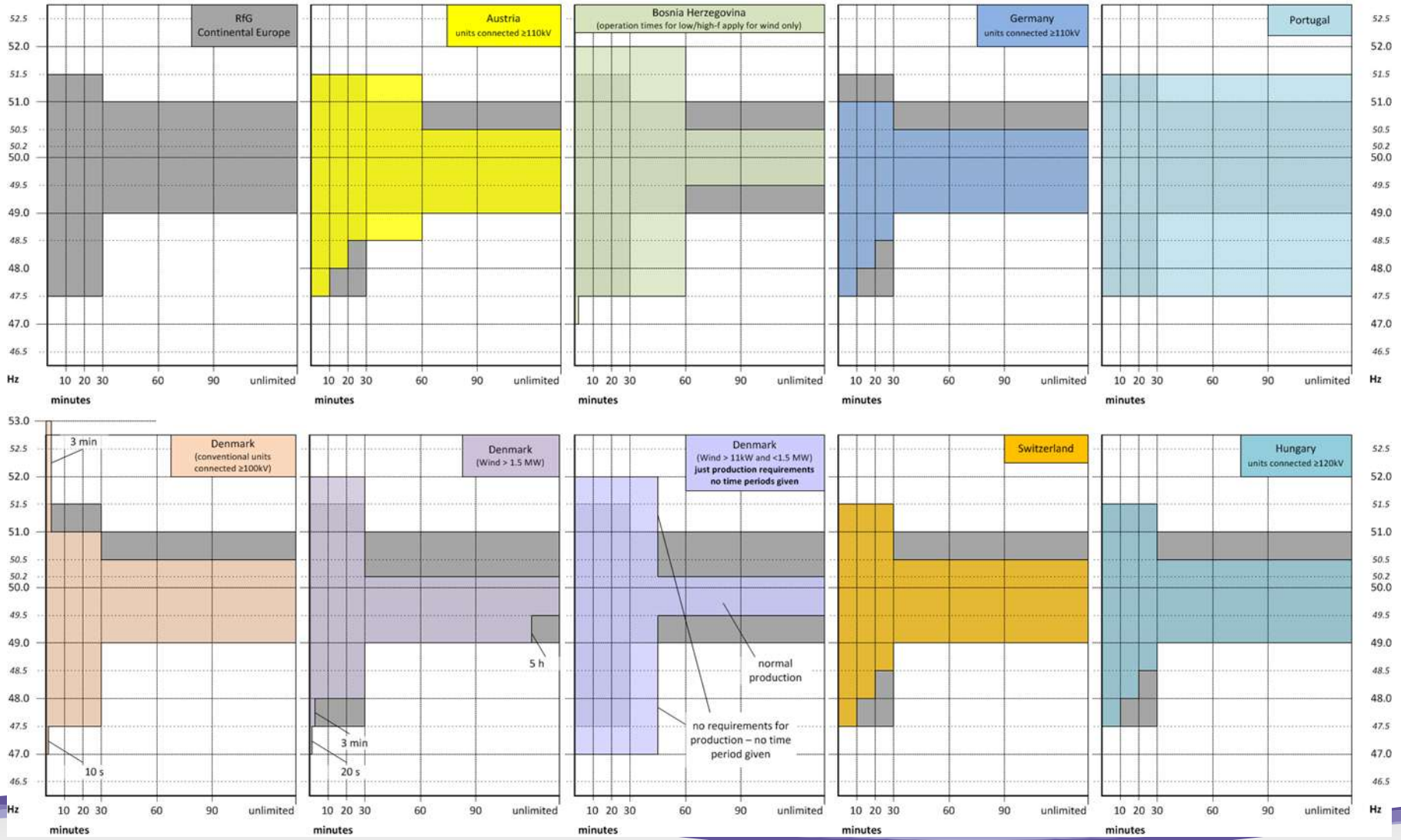
Requirement:	Frequency Ranges			
Reference to NC RfG:	Article 8(1) (a)			
Cross-border impact:	Frequency without any doubt is the parameter of an interconnected electricity transmission and distribution system, which has the largest cross-border impact. Frequency is the same across a synchronous area and across all voltage levels. Deviations of frequency from its nominal value due to load imbalances therefore occur everywhere at the same time and affect all Power Generating Modules immediately in a common way regardless of their size and voltage level of connection.			
Exhaustive requirement:	X	**Non-exhaustive requirement:**		
Justification:	• Due to their immediate cross-border impact, frequency requirements need to be harmonised as much as possible at least on the level of a synchronous area. In particular, the range for unlimited operation needs to be identical to share the burdens of deviations equally. • The ranges and time periods where time-limited operation of Power Generating Modules is requested however may vary and shall take into account regional characteristics and the network operators' operational requirements, because these ranges are primarily needed for management of system disturbances and restoration. • Inherent inertia of the electricity supply system will decrease due to less synchronous generators connected in future, consequently larger sudden frequency deviations occur in case of load imbalances.			
Principle/Methodology only:		**(Ranges of) values/parameters given:**	X	
Justification:	• Frequency is the same across a synchronous area and across all voltage levels. • Deviations of frequency from its nominal occur everywhere at the same time and affect all Power Generating Modules immediately in a common way regardless of their size and voltage level of connection.			
Alternative solutions:	• Limitations on penetration of (RES) generation without inherent inertia, however this will jeopardize achieving EU energy policy targets.			
Link to FWGL:	• paragraph 2.1: *"… Furthermore, the network code(s)shall define the requirements on significant grid users in relation to the relevant system parameters contributing to secure system operation, including … Frequency and voltage parameters; …"* • paragraph 2.1.3: *"… the detail of possible deviations of significant parameters (e.g. voltage, frequency) that generation units must withstand …"*			

NC RfG – justification outlines (cont'd)

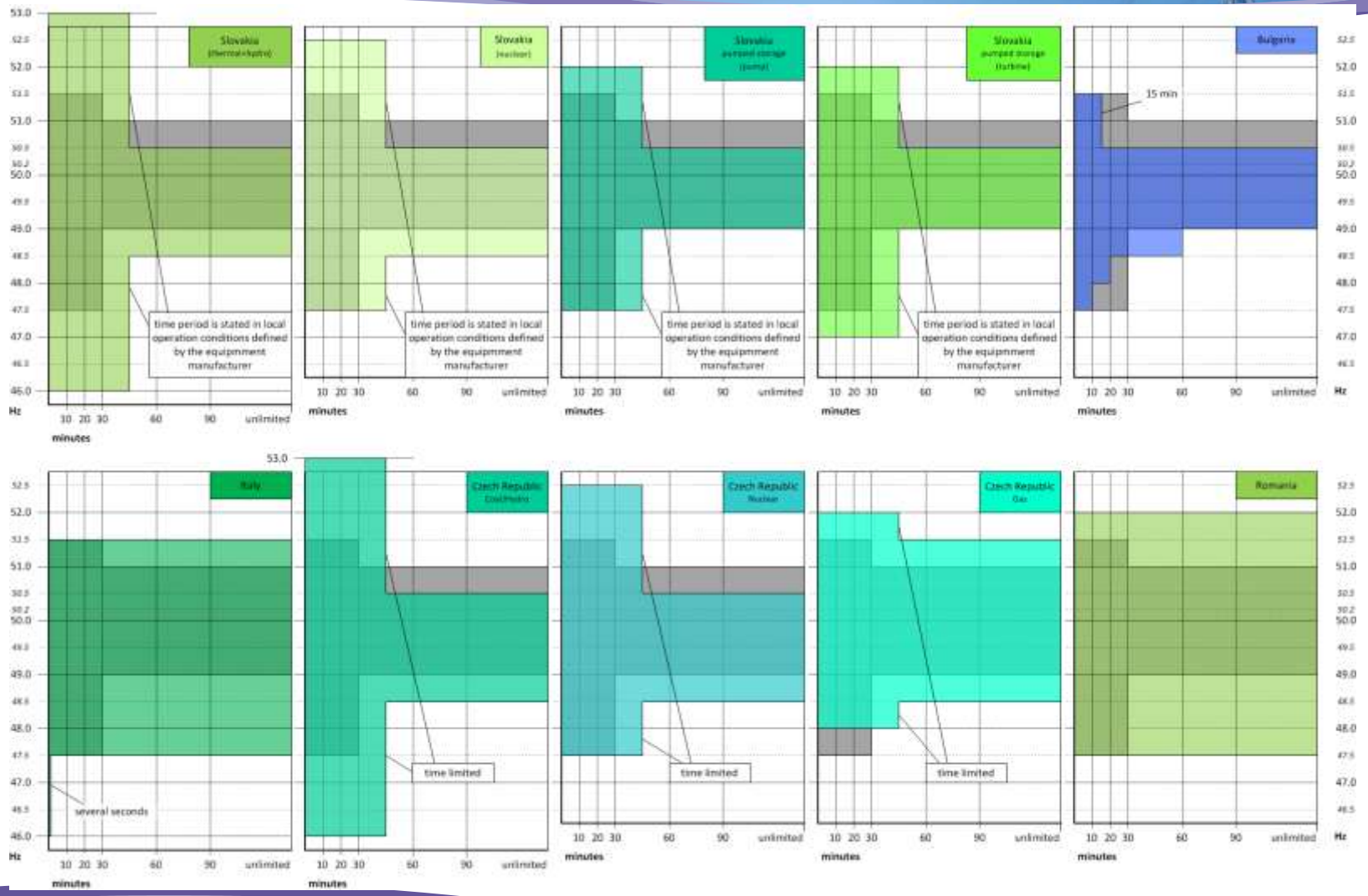
Requirement:	Information Exchange				
Reference to NC RfG:	Article 9(5) (d)				
Cross-border impact:	Adequate information exchange between network operators and Power Generating Module operators is a prerequisite for network operators to maintain system stability and security. Network operators continuously need to have an overview over the state of the system, which includes information on the operating conditions of Power Generating Modules as well as the possibility to communicate with them in order to direct operational instructions.				
Exhaustive requirement:			**Non-exhaustive requirement:**	X	
Justification:	The mere capability to exchange information is required. Details on the information to be exchanged (communication infrastructure, protocols) depend on the operational strategies of the Relevant Network Operator and the Relevant TSO.				
Principle/Methodology only:		X	**(Ranges of) values/parameters given:**		
Justification:	Further specifications beside the general principle/methodology depend on operational strategy and communication infrastructure in the responsibility area of each network operator and TSO and can be specified at that level only.				
Alternative solutions:	Have no requirement and leave capability to the market. However, it is unlikely, based on extensive experience, that the required minimum capability will be made available without detailing what is required.				
Link to FWGL:	• paragraph 3.1: *"… The network code(s) shall set out the procedures and requirements to coordinate and ensure information sharing between … System operator and significant grid user …"* • paragraph 3.2: *"… The network code(s) shall set the requirement for every significant grid user to be able and obliged to provide the necessary real-time operational information to the DSO and TSO that their connection has significant impact upon. The network code(s) shall set the requirement for every significant grid user to be able to receive and to execute the instructions sent by the TSO and/or DSO, on a contractual basis or in critical operating state."*				

NC RfG – present frequency range requirements

Continental Europe



NC RfG – present frequency range requirements (cont'd)



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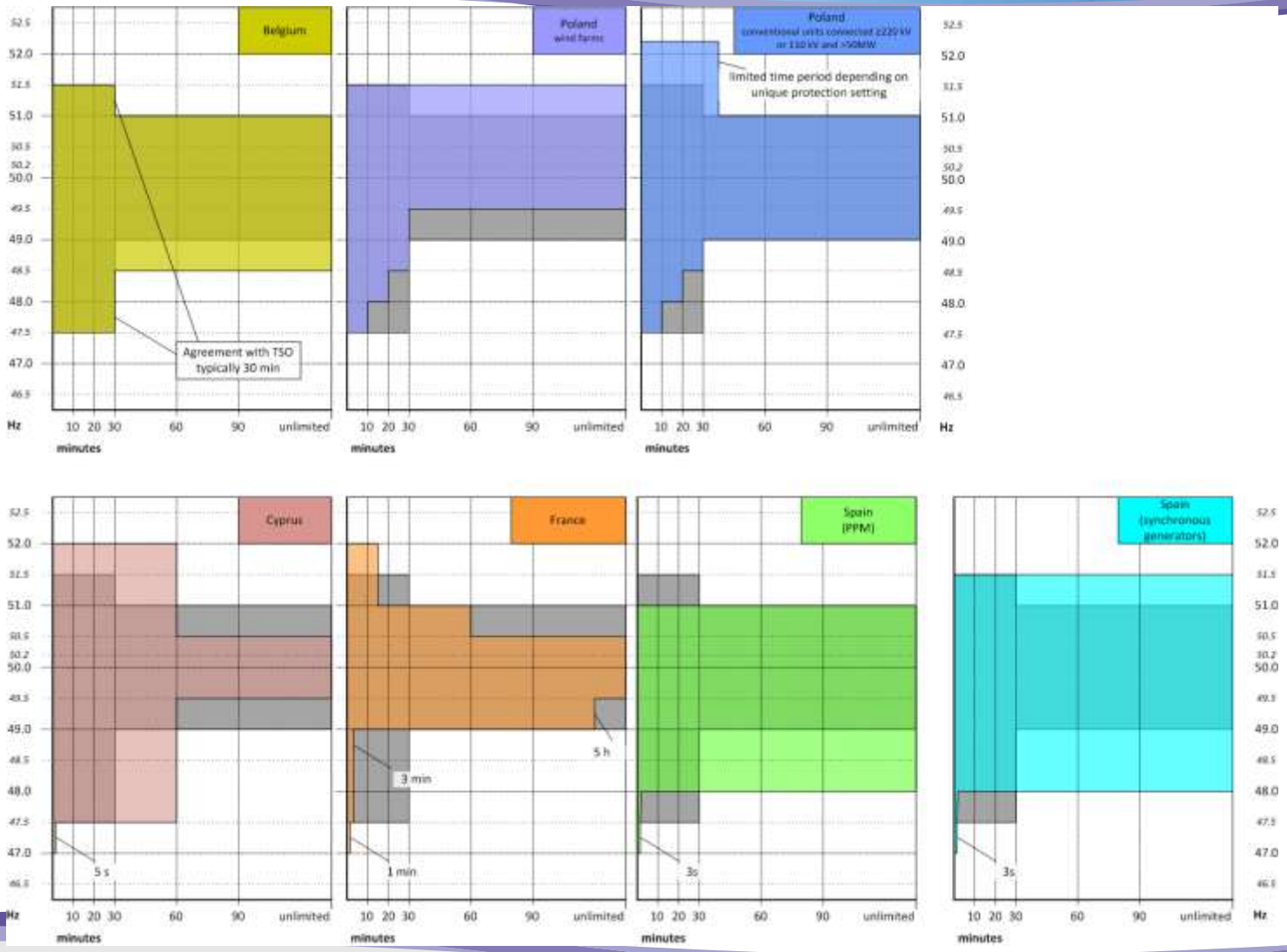
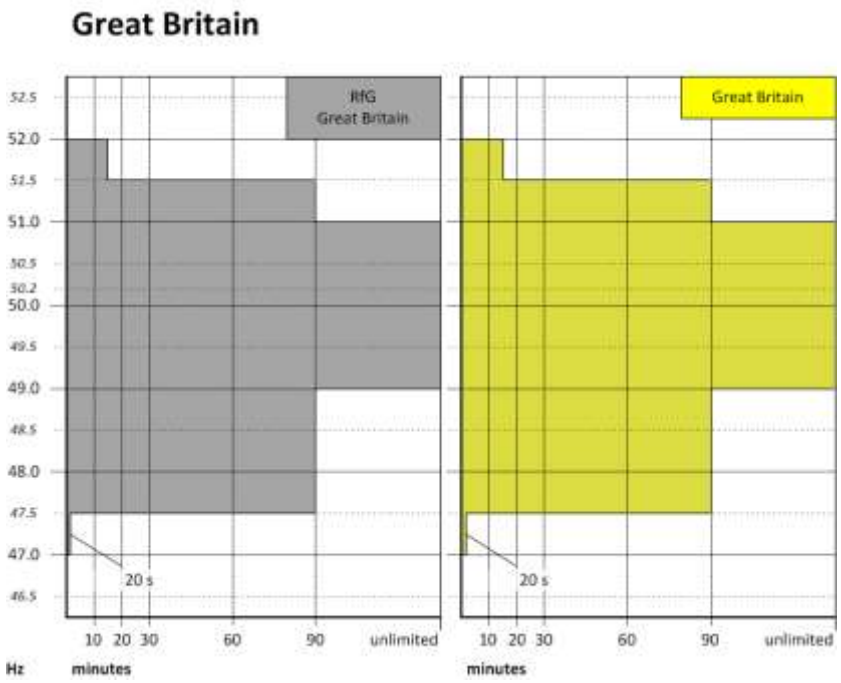


NC RfG – present frequency range requirements (cont'd)



NC RfG – present frequency range requirements (cont'd)

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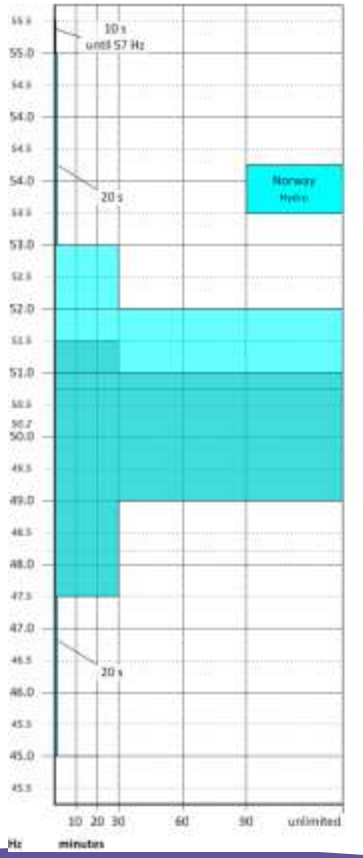
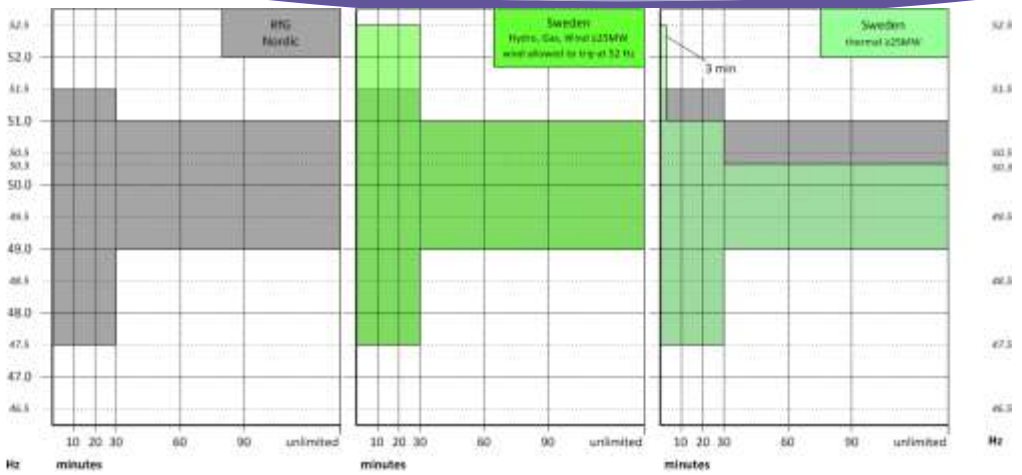
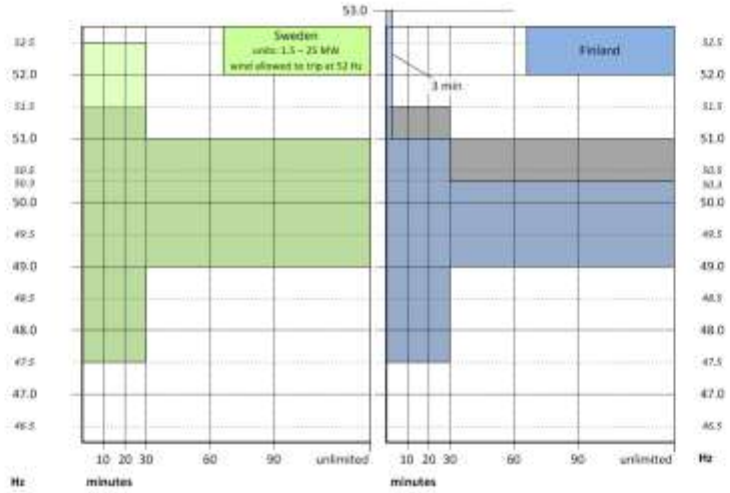






NC RfG – frequency ranges

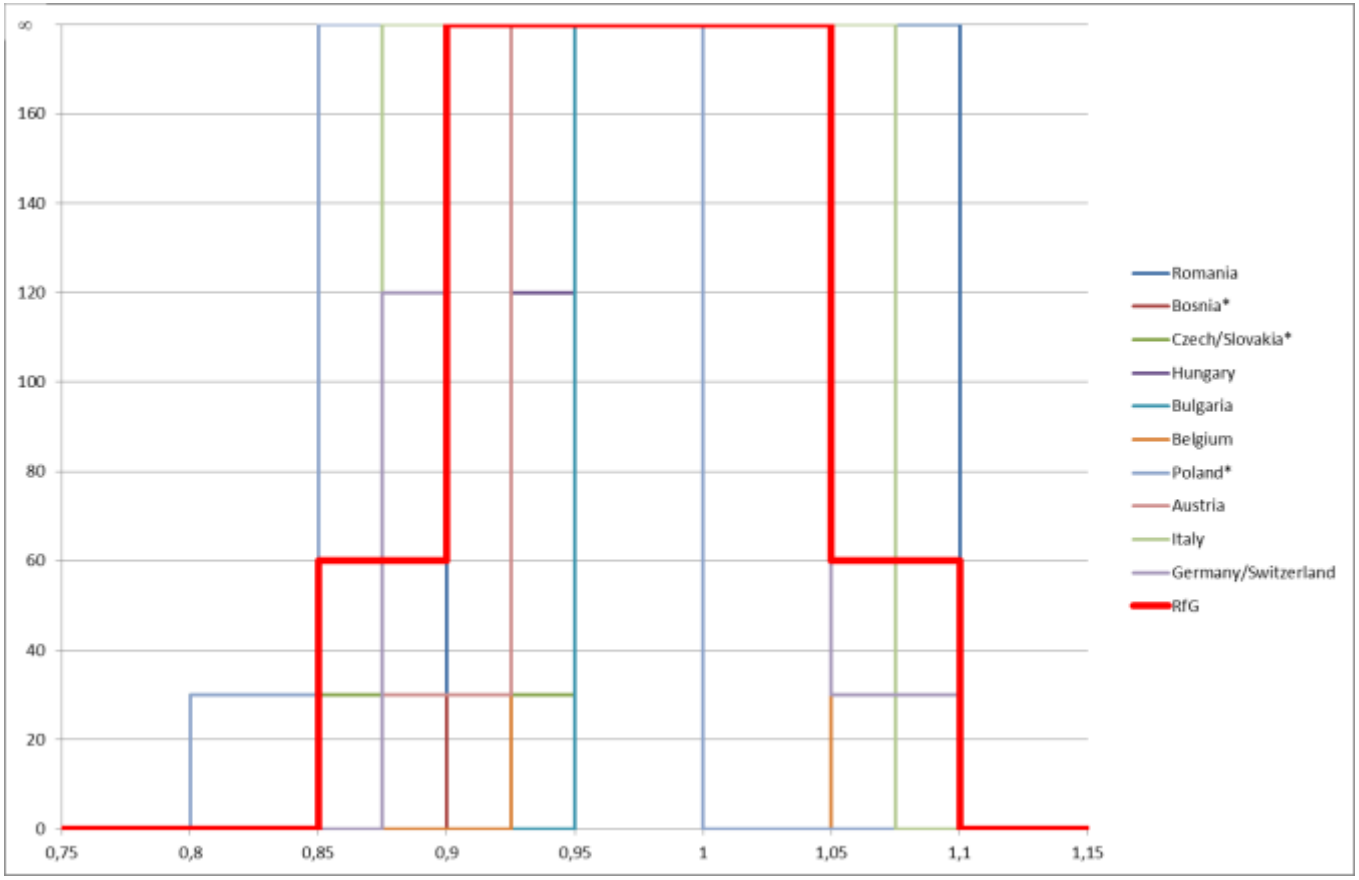
- Compared to present practices across Europe, the NC RfG frequency range requirements are **not the present least onerous requirements, nor across the most onerous ones**.

- The ranges are **compliant with IEC 60034** on rotating electrical machines.

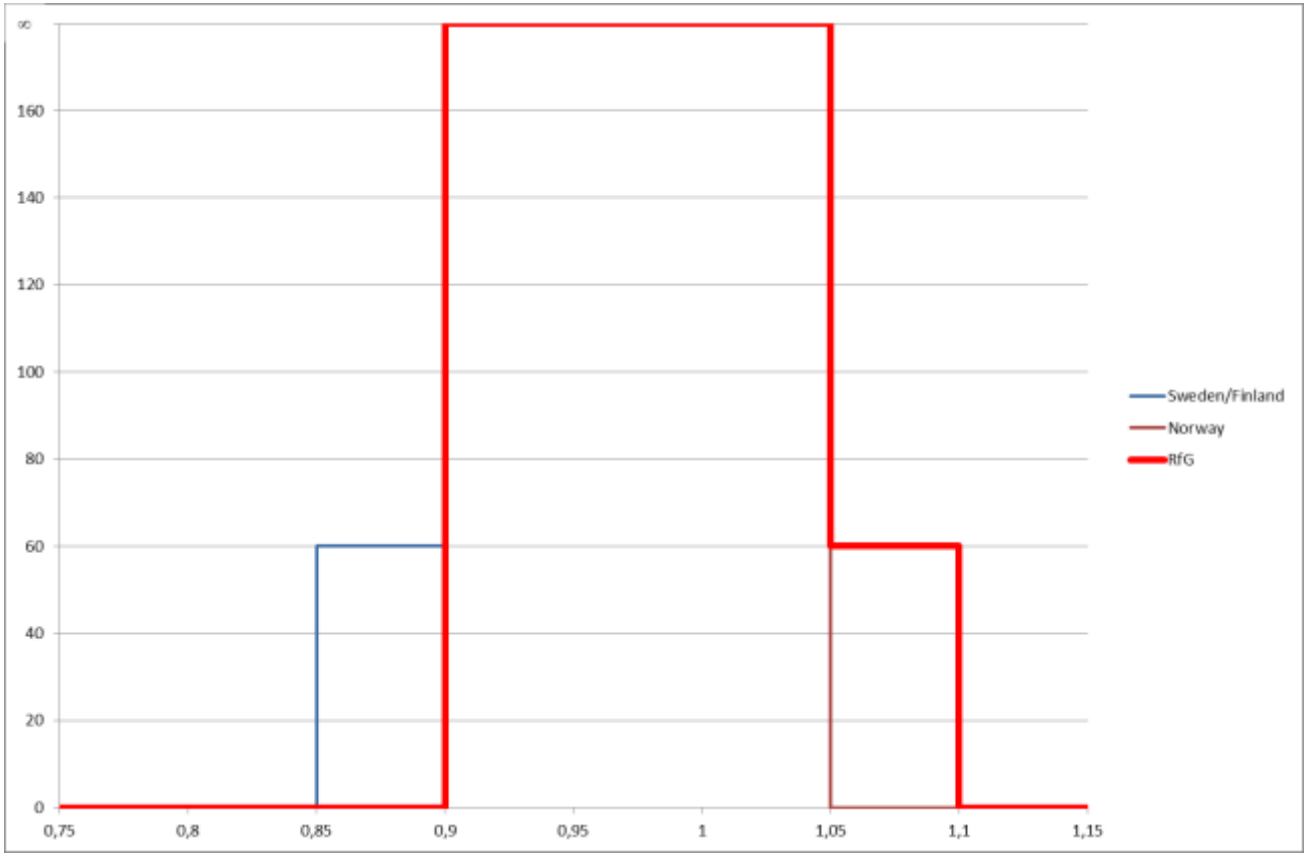
- The periods for **limited time duration** are needed for a network operator to take appropriate measures in case of **severe system events**.

- The proposed ranges are **proportionate** considering present practices and expected changes in the decades ahead, as well as non-discriminatory across Member States within a synchronous area.

NC RfG – present voltage range requirements



NC RfG – present voltage range requirements



NC RfG – voltage ranges

- The voltage ranges in present European grid codes **vary substantially**.
- The NC RfG voltage range requirements are **not the most onerous, nor the present least onerous**.
- The most onerous requirement on high voltage excursions at the connection point (below 300kV) in Continental Europe is supported by studies on testing performed by Cigre and which reflects reality in operational rules nowadays.

WG 33.10, Temporary Overvoltages: Withstand Characteristics of Extra High Voltage Equipment, Electra No.179 August 1998, pp. 39-45

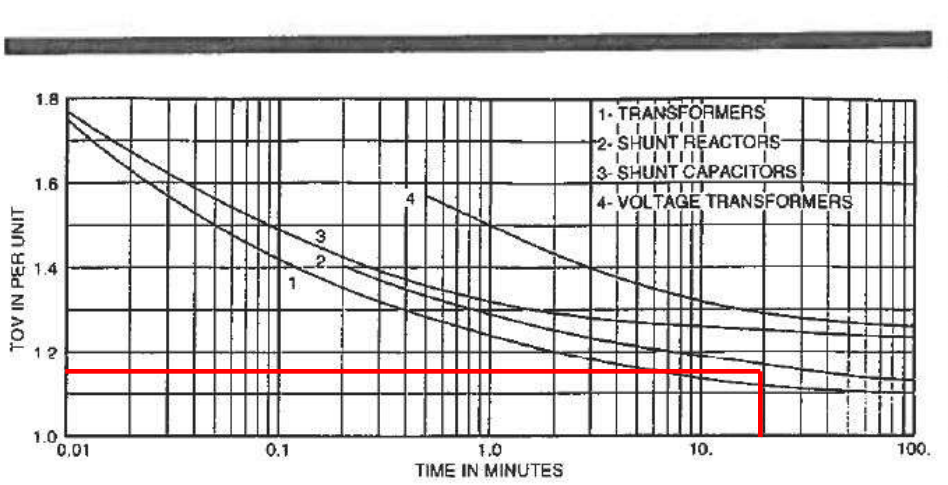


Figure 1. Caractéristiques de tenue aux surtensions temporaires pour les matériels de puissance.

Figure 1. Withstand TOV characteristics for power equipment.

NC RfG – present (L)FSM requirements

- **Frequency Sensitive Mode** is in line with most present practices throughout Europe nowadays, but present practices vary:
  - In some countries the capability is market based.
  - The requirement may be technology specific.
  - Different thresholds may be used for requiring this service.

- **Limited Frequency Sensitive Mode – Overfrequency** is in line with practices in those countries which already require this capability.

- **Limited Frequency Sensitive Mode – Underfrequency** is new to many countries. In terms of capability it provides a relatively low cost solution for aiming at avoiding the first stage of demand disconnection. The capability requirement puts no obligation on the conditions under which to procure this service (e.g. required available headroom or not).

NC RfG - non-exhaustive requirements

The document “NC RfG Requirements in the context of present practices” covers several non-exhaustive requirements in relation to present practices:

- Maximum active power output reduction at underfrequencies
  - Shifted to type A with support in the public consultation (basic frequency related requirement).
  - In line with grid codes which do require this clearly.
  - Ambient conditions need to be addressed at national level.
- FRT
  - Becoming increasingly critical in power systems with increasing amounts of PPMs and dispersed generation.
  - NC RfG requirements on FRT cover presently prescribed FRT requirements across Europe, which are diverse in all aspects (pre-conditions, technology specificities, thresholds).
  - European framework within which many specifications are still to be taken at national level. A combination of all most onerous parameter values is not in line with the principle of principle of optimisation between the highest overall efficiency and lowest total cost for all involved parties.
- Reactive power capabilities
  - A general framework for national implementations, which covers a wide variety of requirements applicable today (either by U-Q/Pmax curves or power factor ranges).
  - The general framework is developed to not restrict future needs in coping with potential changed generation portfolios.
  - The real justification of a reactive power capability implementation needs to be taken at national level while respecting the provisions of Art 4(3).

Break

Round table of User Group participants