5th NC HVDC User Group meeting

Brussels, 10 March 2014

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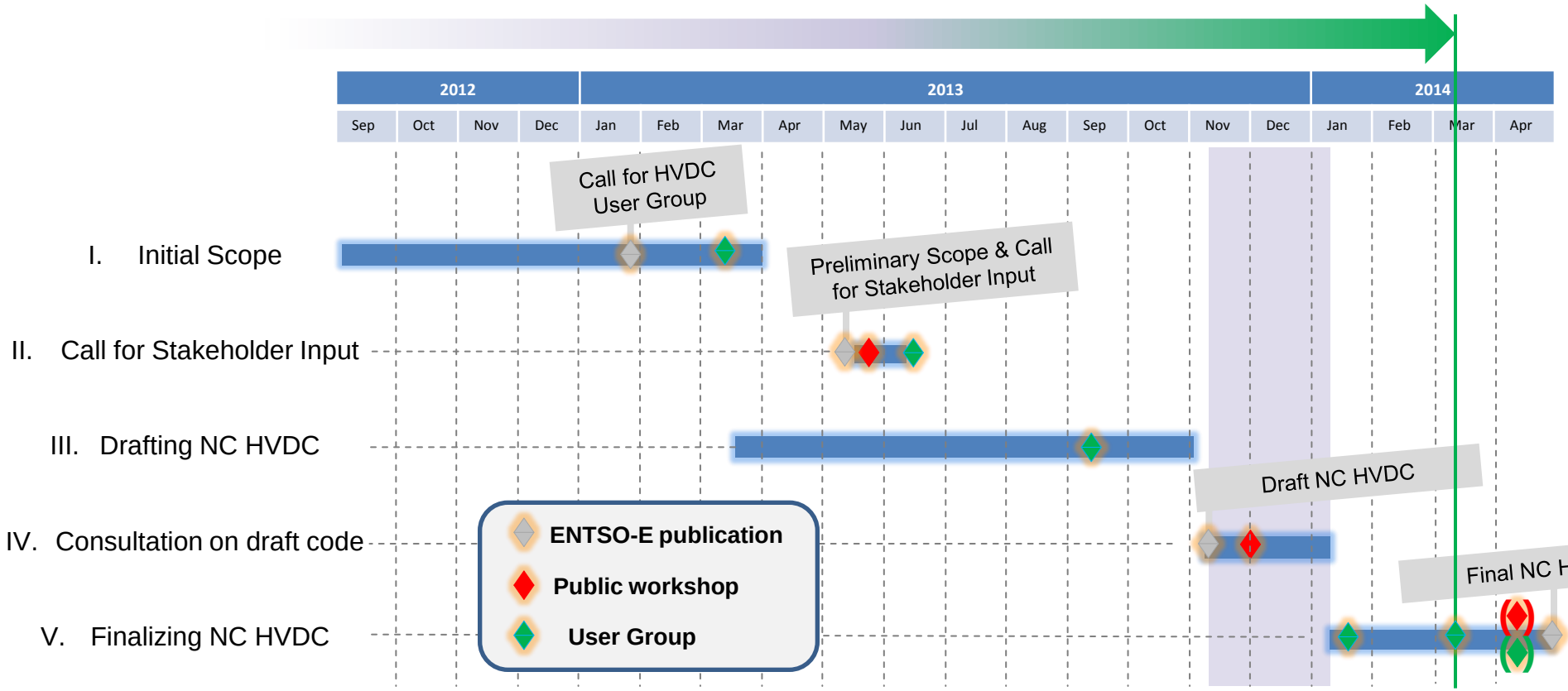
Introduction – Timing of NC development



Today's agenda (proposal)

Time	*Subject*
11h00	Welcome, agenda, introduction
11h05	Status of draft NC HVDC – overview of notable changes
11h45	Key issue I: offshore wind connections
12h30	*Lunch break*
13h30	Key issue II: withstand capabilities – relation with other connection codes
14h00	Key issue III: equitable treatment of HVDC technologies
14h30	Key issue IV: scope – clarity and completeness
14h45	Other items (walkthrough of text)
15h45	Summary and next steps
16h00	*Session closed*

Today's meeting objectives

For discussion today

- Updated NC working draft

Aim

- Common understanding on what has changed / what not, and why
- Identify where text can be clarified still
- Resolve remaining key concerns on which no answer is available yet

After today

- Finalization of text by end of April
- Discussion outcome feeds into supporting documents (being prepared)
- Your views on the present code will guide further steps in the NC adoption process

Code & supporting documents

Network code

- 2500 comments, broken down in +/- 500 issues
- Many improvements to clarify interpretation, specify role of grid users and NRAs
- Alignment with NC RfG / DCC
- Note also that many comments asked for measures that fall out of scope of a HVDC connection code

Supporting documents

- Updates of FAQs, requirement outlines and explanatory note
- Overview of NC HVDC requirements in light of present practices
- HVDC equipment manufacturer survey ongoing to allow for qualitative conclusions to be included on key requirements

Overview of key improvements in text

Terminology

- aligned and completed

Scope

- Clear about exclusion of railway grids
- Clear about inclusion of distribution DC-connected PPMs and rights/responsibilities of the Relevant DSO

Regulatory / procedural aspects

- comments are well noted, but let's be aware of present state of other codes in comitology

Frequency ranges

- stronger link to generation and demand provisions
- option to allow for output reduction
- Flexibility in case of non-50Hz grids

Overview of key improvements in text (II)

Reactive power and voltage control

- Several comments to ensure LCC technology can cope with the requirement

Power Quality

- Process for mitigating impact on the system, including other grid users, aligned with study processes for controller interaction and SSTI

Control

- Restriction on voltage transients reviewed, and aligned with PPMs

Deleted requirements

- Isolated network operation
- Reconnection
- Autoreclosure

Overview of key improvements in text (III)

DC-connected PPMs

- Chapter more clearly split in PPM and converter requirements
- Frequency and voltage requirements aligned with NC RfG envelope
- Provisions for non-50Hz requirements
- Misunderstandings on reactive power capabilities removed

Operational notification and derogation process

- Various clarification

Compliance

- Broadly aligned with reviewed technical requirements

Offshore requirements

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Key question in last User Group meeting: What needs to be achieved?

Need to keep offshore connections within the scope

- Large developments important to markets and security of supply in several countries
- Many developments in planning now covering 10 or more years ahead
- Need to establish certainty ASAP

Cover for radial connection approach as well as a range of integrated approaches

- Early AC connected projects have had mainly radial connections
- Several HVDC connected projects are in progress with an integrated approach using clustering
- Different forms of integration – expected to continue to evolve
- Essential to allow for variety of connection arrangements to cover all European practices

Flexibility to facilitate innovation and cost reductions

- Allow different choices of offshore system frequency, e.g. 16 2/3Hz, with movement of converters to onshore locations
- Allow variable system frequency – simpler WTGs
- Allow use of dc collection networks

➢ **No block on any of these from NC HVDC point of view - some implications in terms of freedom for sharing capacity with neighbours**

Key question in last User Group meeting: By what means can it be achieved?

An appropriately balanced approach

- Freedom for long-term development of the remote end AC network. Facilitate major network benefits.
- Costs minimised for developers through option to
  - defer equipping for full requirements
  - share capabilities between HVDC Converter capability and PPMs
  - capitalise on inherent capabilities

Freedom to chose remote frequency:

- Frequencies other than 50Hz explicitly allowed for (no barrier for 16 2/3Hz design)
- Variable frequency explicitly allowed for
- DC collection possible – by cover at national level (not explicitly in this code)
- Above choices could impact some other users, where clustering is adopted

Key question in last User Group meeting: By what means can it be achieved?

Integration or not? Possible clustering of PPMs

- So far, varied national approaches to clustering
- Reactive power is one key aspect when clustering is chosen
- Greater extent of AC network for clusters - greater need for reactive power to manage the AC voltage
- NC HVDC direct requirement details at national level to be optimised relative to chosen configuration
- NC HVDC encourages optimal sharing of reactive power capability between HVDC link and PPMs

Further integration? Possible interconnection of synchronous areas

- Main system frequency regulation supported from offshore - normally for a single synchronous area
- HVDC Code allows support between synchronous areas - if HVDC connections become a “through” connection.

Frequency Ranges

DC connected PPMs ↓

Frequency Range	Time period for operation
47.0 Hz – 47.5 Hz	20 seconds
47.5Hz – 49.0 Hz	90 minutes
49.0 Hz – 51.0 Hz	Unlimited
51.0 Hz – 51.5 Hz	90 minutes
51.5 Hz – 52.0 Hz	15 minutes

Where a constant nominal Frequency other than 50Hz, or a Frequency variable by design is used, subject to Relevant TSO agreement and Article 4(3), the applicable Frequency ranges and time periods shall be specified by the Relevant TSO taking into account specificities of the system and the principles laid down in this table and respecting the provisions of Article 4(3).

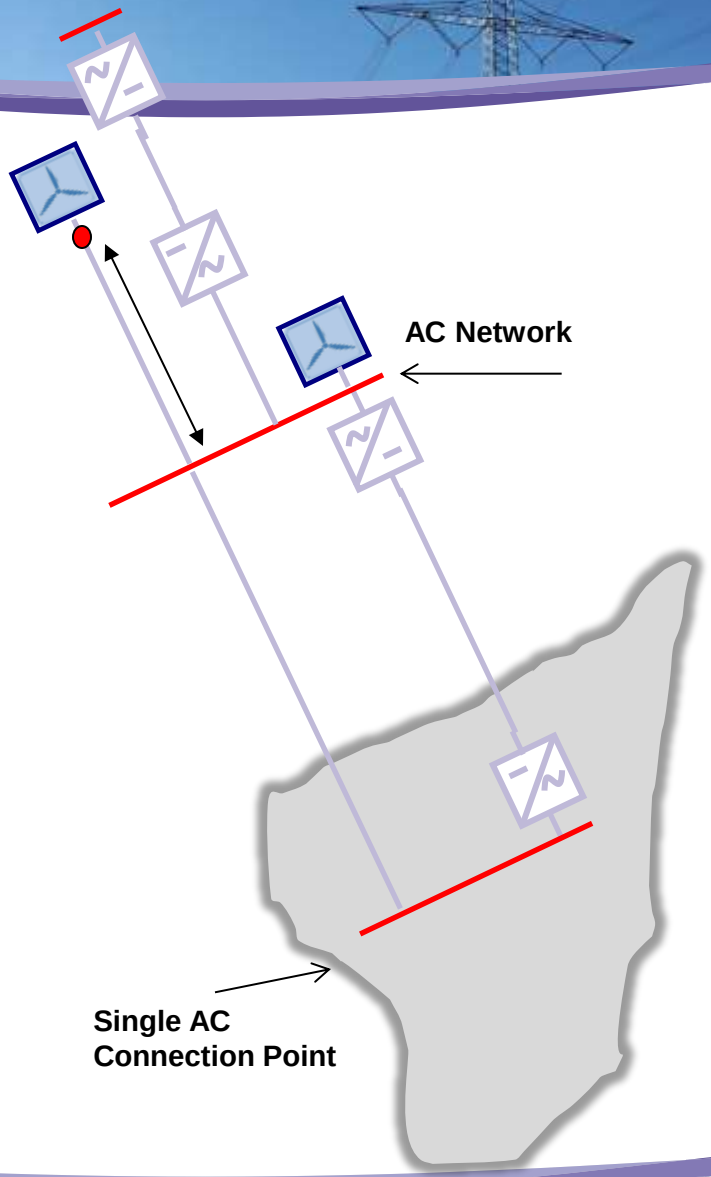
HVDC Converter →

Frequency Range	Time period for operation
47.0 Hz – 47.5 Hz	60 seconds
47.5 Hz – 48.5 Hz	To be defined by each Relevant TSO while respecting the provisions of Article 4(3), but longer than defined times for generation and demand according to [NC RfG] and [DCC], respectively, and longer than for DC-connected PPMs according to Article 37
48.5 Hz – 49.0 Hz	To be defined by each Relevant TSO while respecting the provisions of Article 4(3), but longer than defined times for generation and demand according to [NC RfG] and [DCC], respectively, and longer than for DC-connected PPMs according to Article 37
49.0 Hz – 51.0 Hz	Unlimited
51.0 Hz – 51.5 Hz	To be defined by each Relevant TSO while respecting the provisions of Article 4(3), but longer than defined times for generation and demand according to [NC RfG] and [DCC], respectively, and longer than for DC-connected PPMs according to Article 37
51.5 Hz – 52.0 Hz	To be defined by each Relevant TSO while respecting the provisions of Article 4(3) and longer than for DC-connected PPMs according to Article 37

Reactive Power from DC-connected PPM

bilateral agreement with the owners of the HVDC System(s) connecting the DC-Connected Power Park Module to a single Connection Point on a AC Network:

- **have the Reactive Power capabilities prescribed by the Relevant TSO … already installed as part of the connection of the DC-Connected Power Park Module to the AC Network at the time of initial connection and commissioning**
- **demonstrate to, and then reach agreement with, the Relevant TSO on how the Reactive Power capability prescribed by the TSO will be provided**
- **The Relevant TSO… must account for the development time schedule of retrofitting the Reactive Power capability to the DC-Connected Power Park Module in specifying the point in time by which this Reactive Power capability retrofitting is to take place.**



maximum and minimum range of both Q/Pmax and steady-state Voltage level range for a DC-connected PPM

Range of width of Q/Pmax profile	Range of steady-state Voltage level in pu
0.- 0.95	0.1 - 0.225

Reactive Power from HVDC Converter

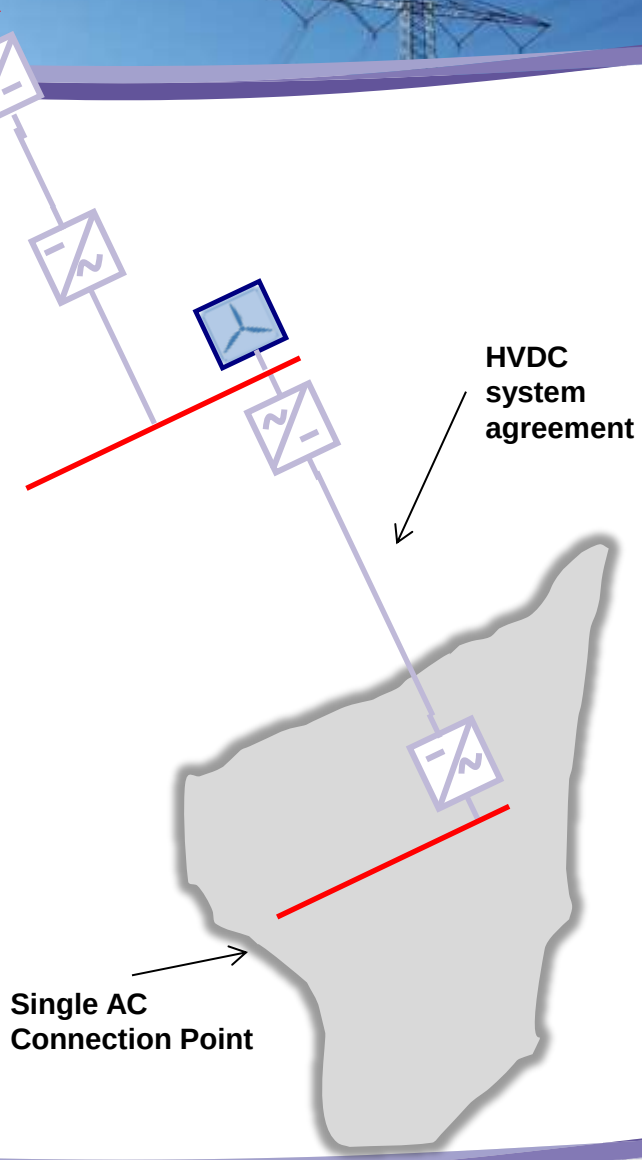
Local HVDC Converter Stations required to:

- **Meet TSO defined reactive power requirements [any shape],**
- **TSO reactive power requirements will be in line with table below**

- **Reactive power can be impacted be local area existing and future network [both local collector network and other connection]**
- **Future network development must be considered to be equitable to all users**
- **NC RfG reactive power requirements for PPMs in meshed and remote nodes sized to provide stabilised nodes – Equitable requirement on converters for same**

Maximum range of Q/Pmax	Maximum range of steady-state Voltage level in PU
0.95	0.225

Maximum range of both Q/Pmax and steady-state Voltage range for a Remote-end HVDC Converter Station



Connection withstand capabilities

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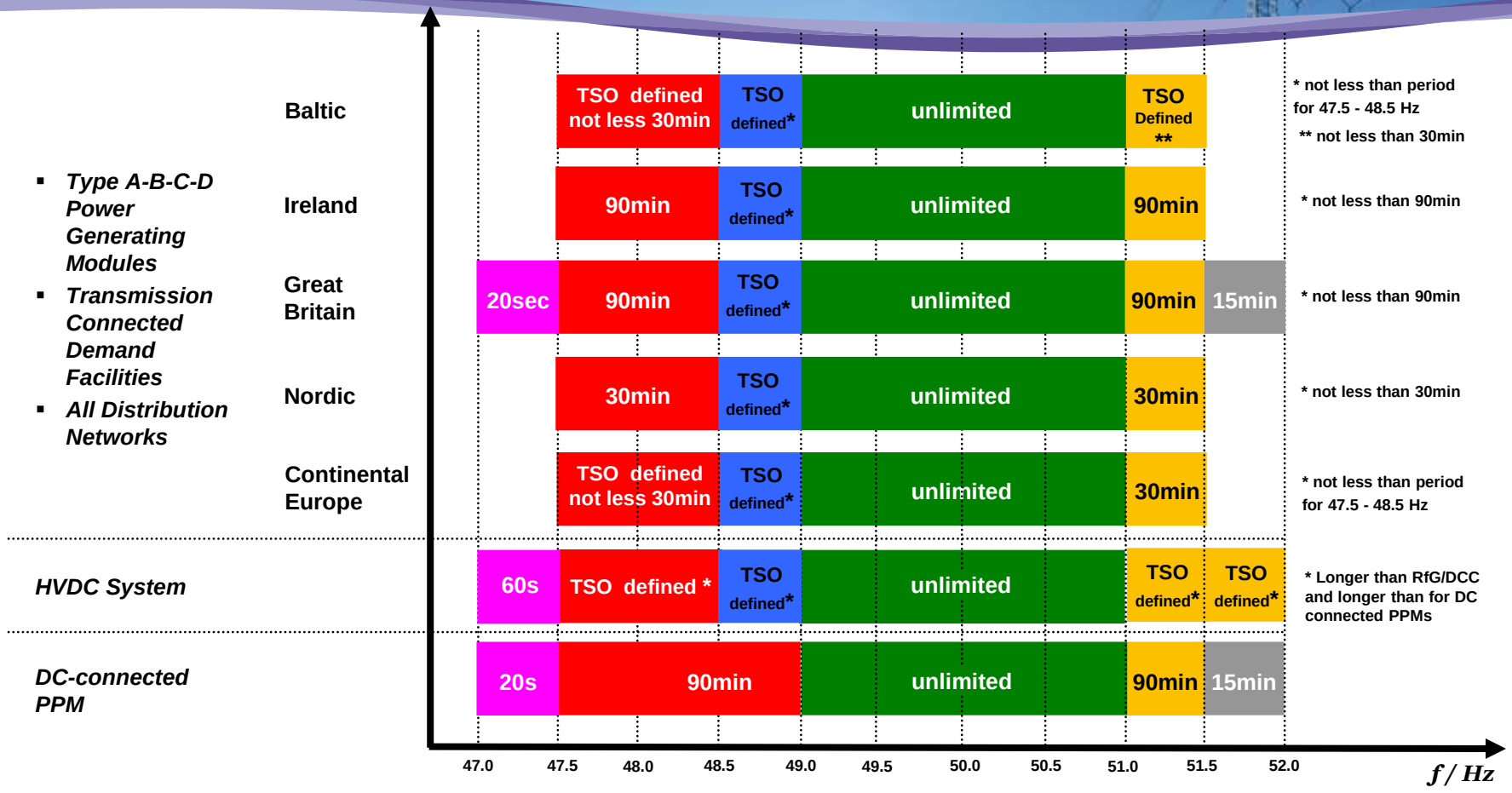
Frequency ranges across three connection codes

- *Type A-B-C-D Power Generating Modules*
- *Transmission Connected Demand Facilities*
- *All Distribution Networks*



➢ **NC HVDC ranges ensures that the network is more resilient to disturbances than generation or demand**

When is Frequency Sensitive Mode used?

HVDC systems connecting synchronous areas

The HVDC system shall be capable of providing Frequency Containment Reserve at each end of the system (for exchanging or sharing FCR between synchronous areas).

- FSM shall be available at each HVDC Converter Station.

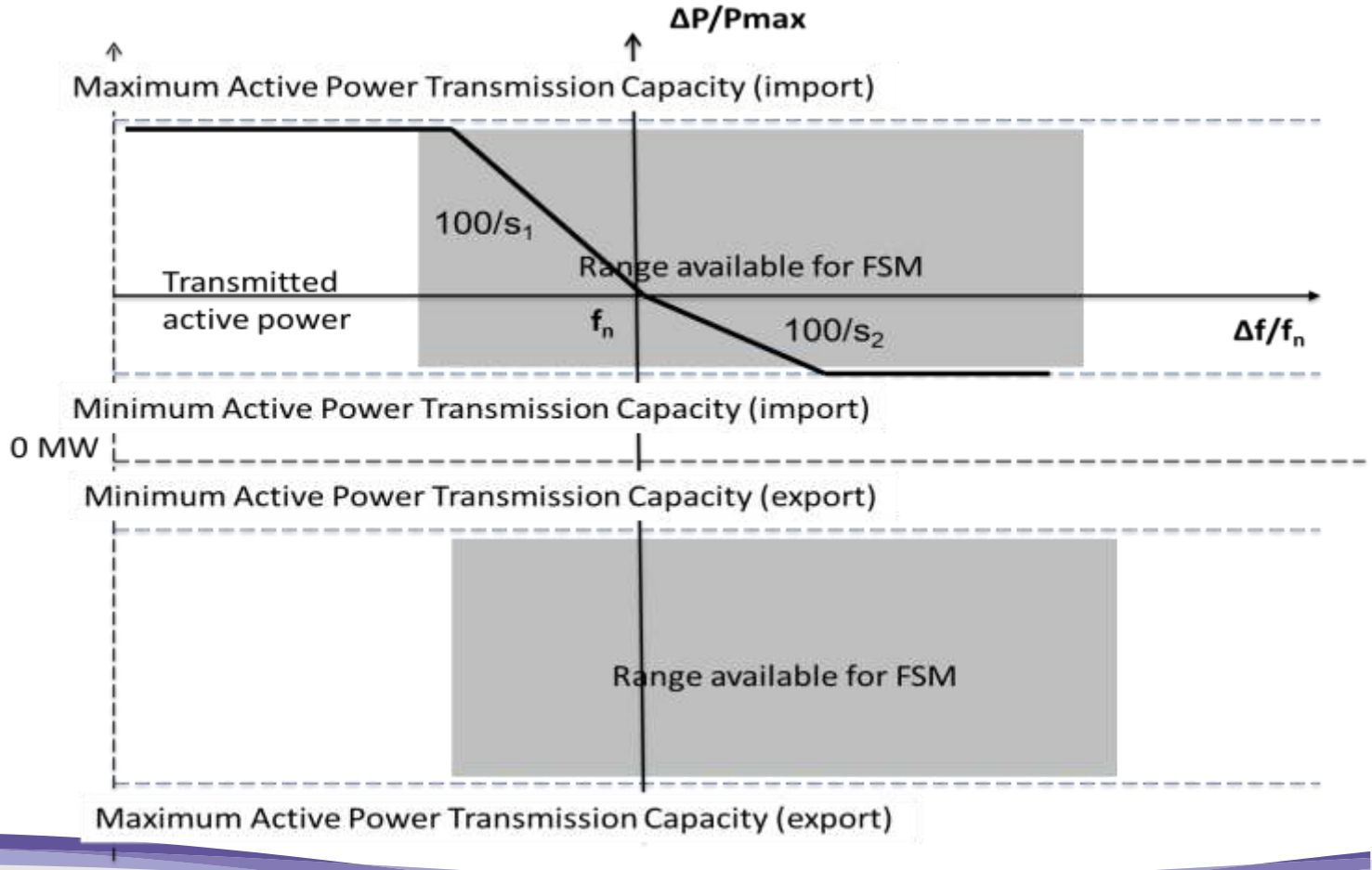
Embedded HVDC systems

HVDC systems shall have the same capability as AC links to supply an islanded system (by radial connection).

- In normal operation to reduce short-circuit power or control flows in the AC system, or in case of disturbances with a network split.
- HVDC systems shall be capable of controlling the frequency of the islanded system by adjusting the active power output in order to maintain stable system frequency inside the island (synthetic frequency).
- could be done by FSM (mandatory mode) using a low droop or by an ad-hoc frequency control mode (non-mandatory mode according to article 14).

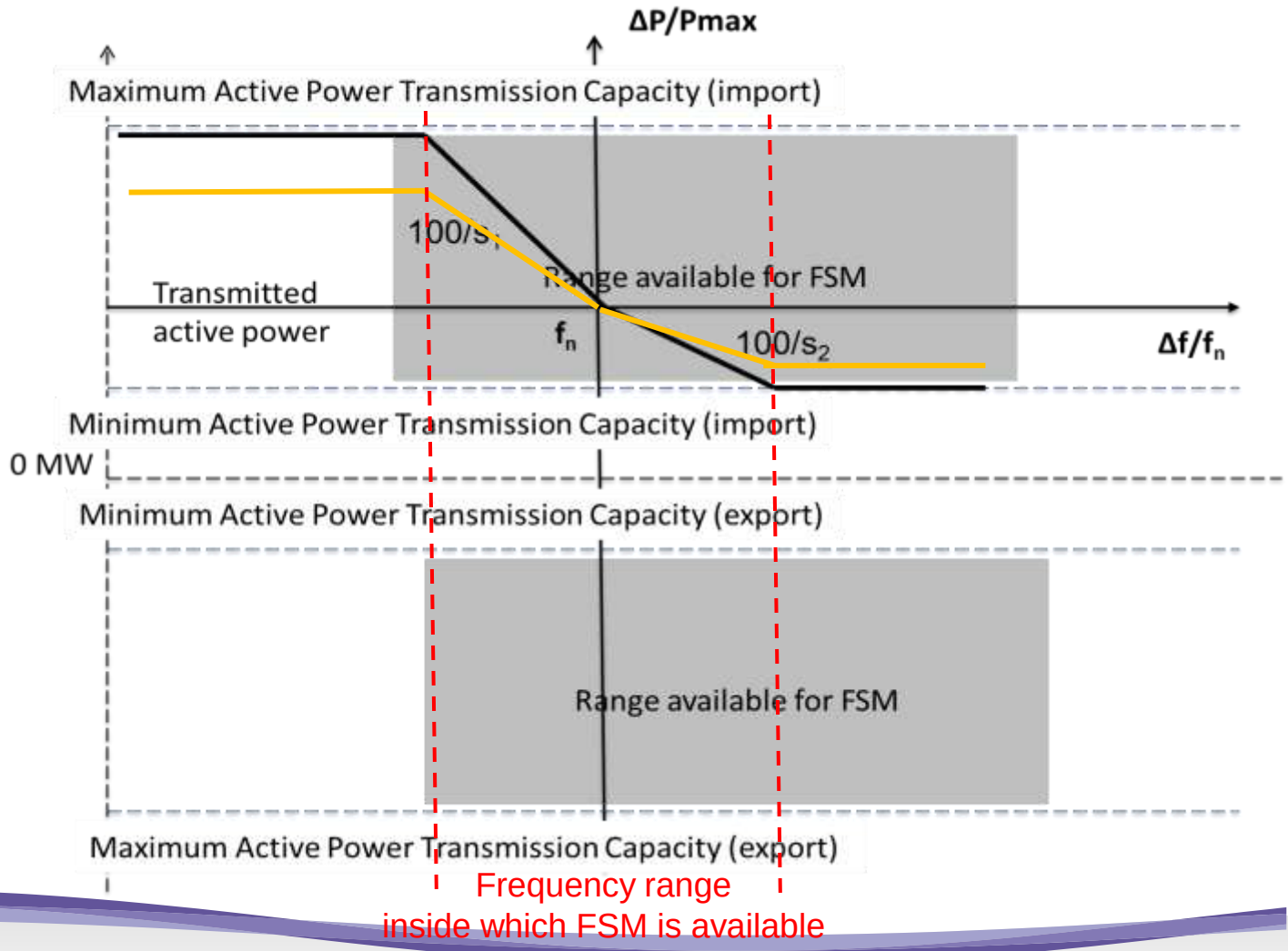
How is Frequency Sensitive Mode applied for HVDC Systems?

Active power range available for FSM (capability)



How is Frequency Sensitive Mode applied for HVDC Systems?

Active power range available for FSM and droops can be adjusted by the TSO (in orange)



Equitable treatment of technologies

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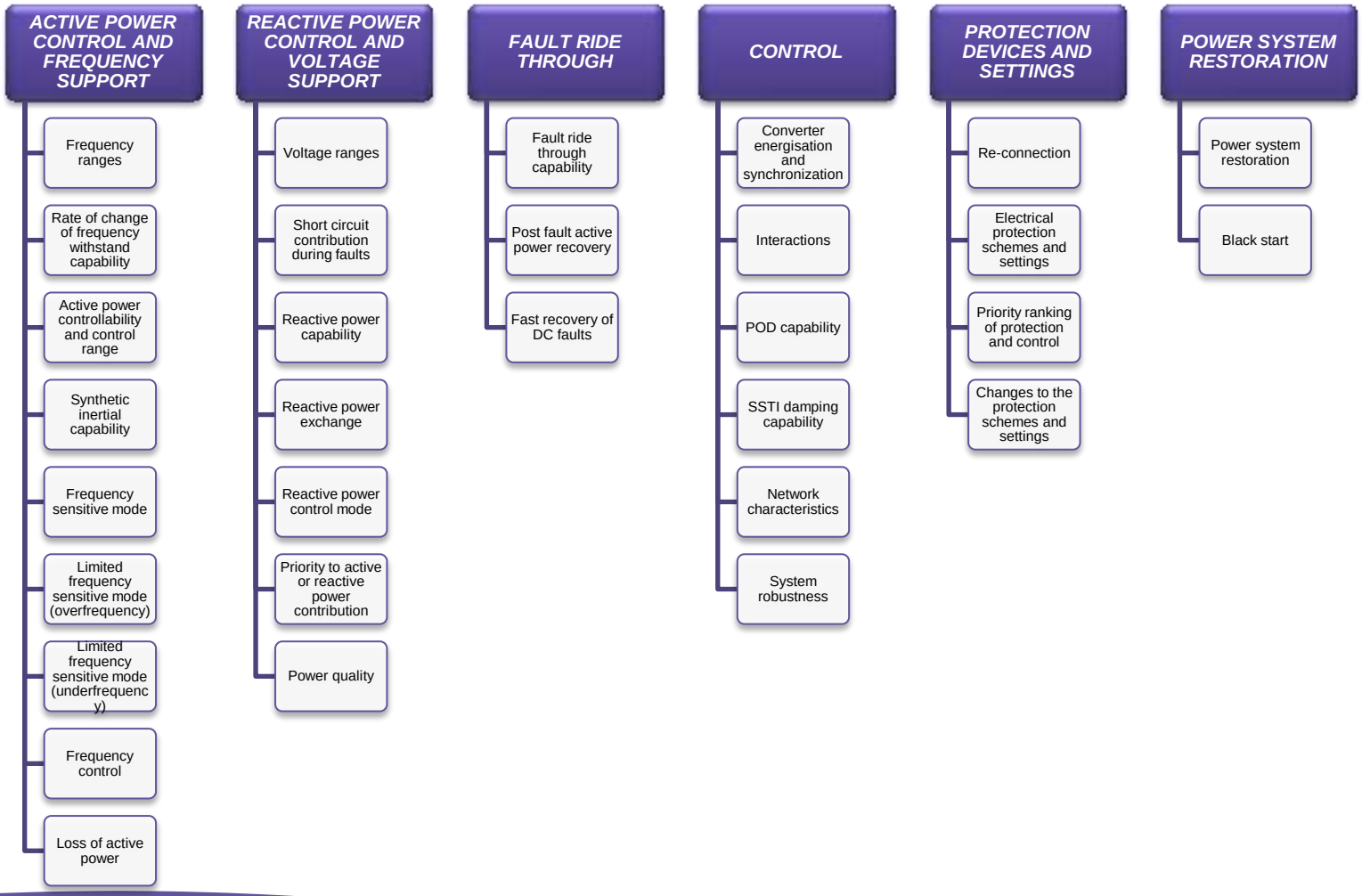
Different HVDC technologies under different conditions

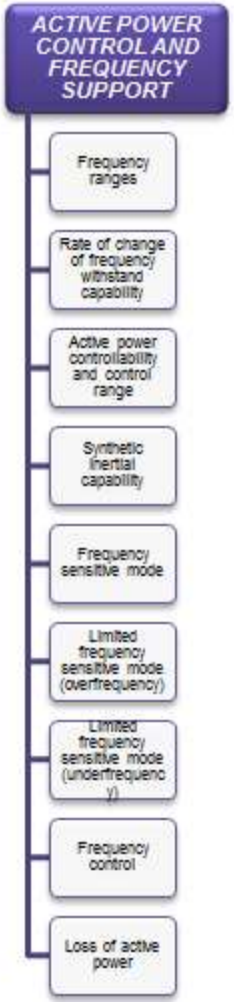
- ***Objective***
  - Allow for grid user to choose preferred approach that satisfies the requirements and to support the specific system needs
  - Define the minimum performance requirements needed to ensure reliable operation of connections
  - Avoid restraining R&D programs, and promote innovative solutions

- ***Approach for NC HVDC requirements***
  - **Technology-neutral** requirements (no LCC or VSC classes)
  - System needs result in **functional capabilities**, instead of design specifications
  - Local conditions and the need for a balanced treatment of all users necessitate a level of **flexibility** to be maintained in the NC HVDC:
    - mandatory and non-mandatory requirements
    - exhaustive and non-exhaustive requirements

General requirements for HVDC Systems



Active Power Control and Frequency Support



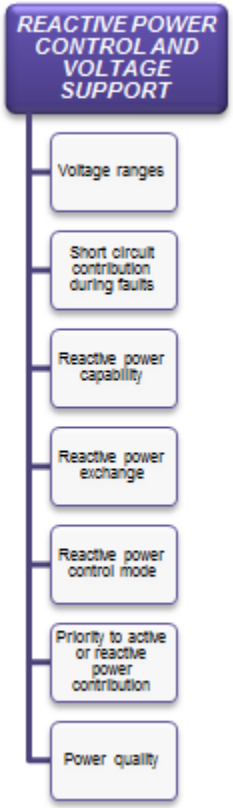
Frequency Ranges: HVDC system remain operable within the Frequency ranges and time periods … for the short circuit power range as specified in Article 30(1)b: The HVDC System shall be capable of operating within the range of short circuit power and network characteristics …

Active Power conrollability: Power reversal Non mandatory: The Relevant TSO(s) shall have the right, while respecting the provisions of Article 4(3) to require the HVDC System to be capable of fast active power reversal

Synthetic Inertia: Non mandatory

Frequency Control: Non mandatory: The Relevant TSO(s) shall have the right to require

Reactive Power Control and Voltage Support
Fault Ride Through Capability

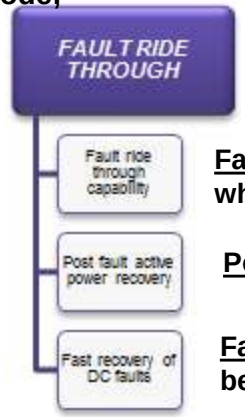


Voltage ranges: HVDC System shall be capable of operating for Voltages deviating from the nominal system value at the Connection Point(s) without disconnecting from the Network … for the short circuit power range as specified in Article 30(1)b: The HVDC System shall be capable of operating within the range of short circuit power and network characteristics …

Short-circuit contribution: Non mandatory

Reactive power: Non exhaustive requirement: to be detailed on national level, different shapes and ranges can be justified with regards to the local system needs

Q control mode: Non exhaustive requirement : … as a minimum be capable of operating in two out of the three following control modes: Voltage Control mode - Reactive-Power Control mode - Power-Factor Control mode;

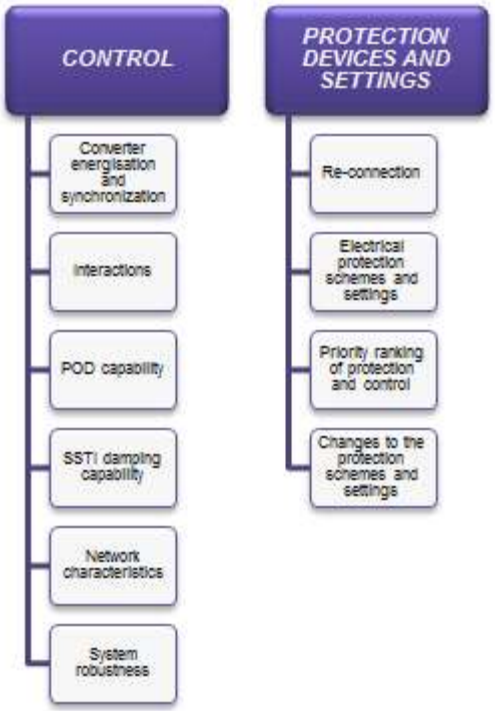


Fault-ride through: Non exhaustive … whereby the HVDC System is allowed to block

Post-fault P recvovery: Non exhaustive … to be specified on national level

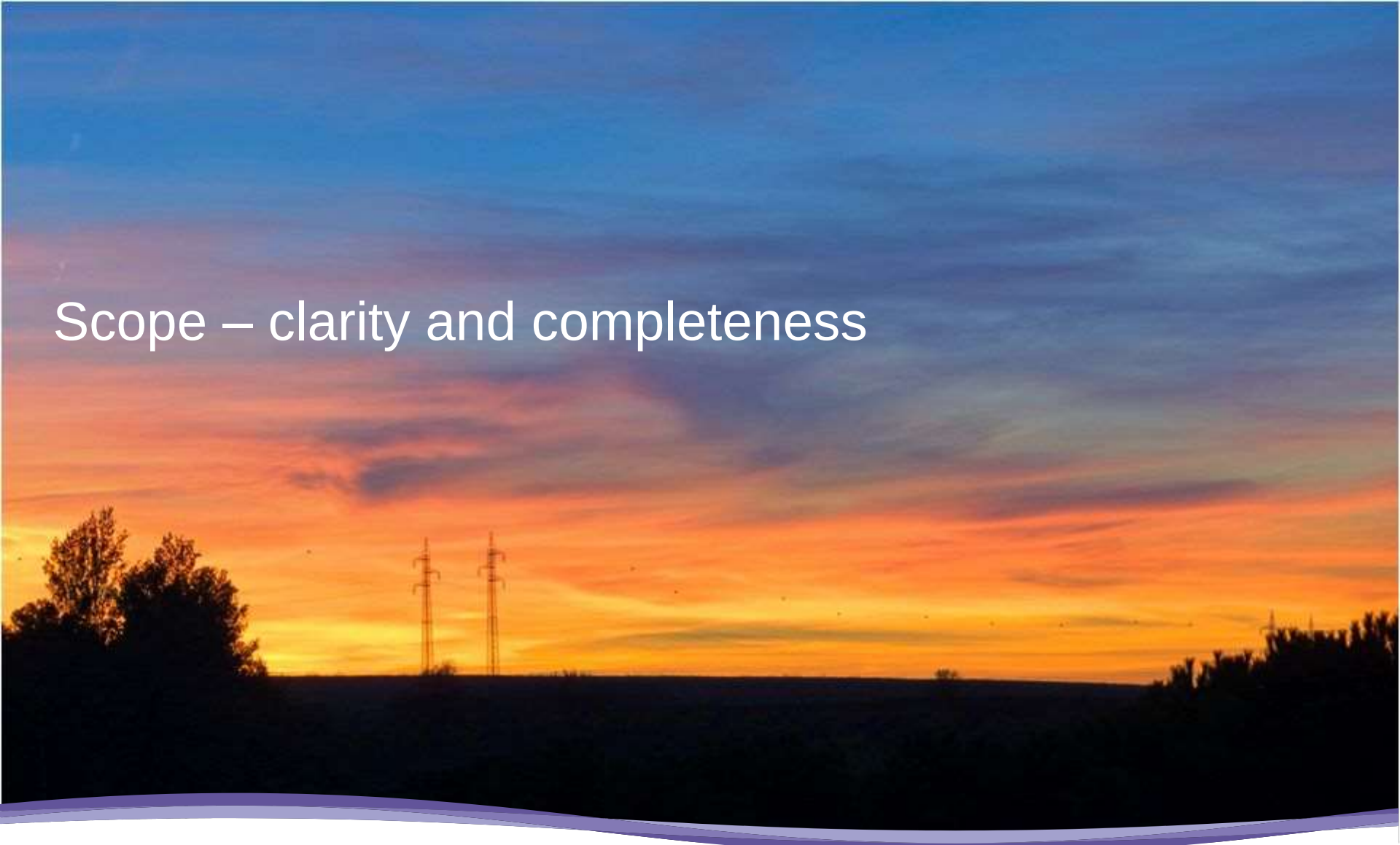
Fast recovery of DC faults: Non exhaustive … to be specified on national level

HVDC Control, Protection & Power System Restoration



Black start: **Non mandatory**

Scope – clarity and completeness



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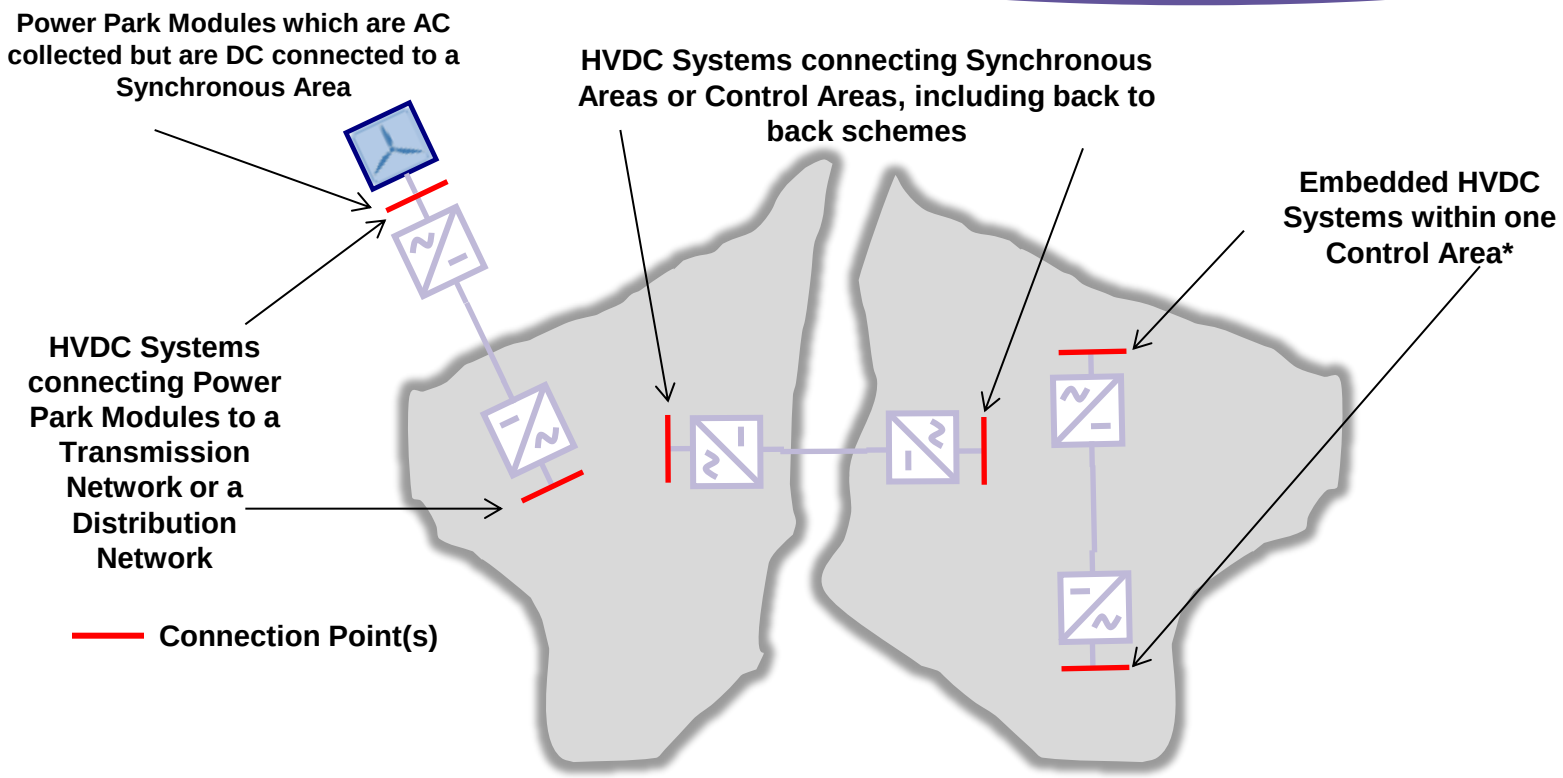
Significant Users in NC HVDC



- **New / Existing: Coherent approach with RfG/DCC**

Comments received

Several comments received and assessed regarding

More clarity on scope of application

More clarity on point of applicability

Non-discrimination between AC and DC-connected PPMs

Distinction of requirements for remote-end converters and PPMs

Clarity on scope of application

Scope of Grid Users

More clarity on new users only (concept not changed, to avoid misunderstandings):
Ref.: Art. 3(5)

More clarity on use of spare parts

Ref.: Art. 3(9)c

Geographical scope

- PPMs on DC-connected islands – national implementation

  Ref.: Art. 3(2)

Threshold of applicability for PPMs

- In line with the principle of non-discrimination, RfG categories apply

  Ref.: Art 36: *"The categorization in Article 3(6) in [NC RfG] shall apply to DC-connected PPMs."*

Note that, as a consequence, DC-connected PPMs are still in scope regardless of the voltage level (transmission / distribution) of connection to the main transmission system.

Clarity on point of applicability

Suggested concept of “Interface point” applied:

“**Interface Point** means an AC point in a Network connecting equipment owned by two or more parties (which can be the owner of a Power Generating Module, Demand Facility, Distribution Network or HVDC System) at which technical specifications affecting the performance of the equipment of one or more parties can be prescribed”

Ref.: Article 1(4)

Applicability of requirements at the AC connection point made more clear in wording.

Ref.: Article 1(3), Recital 4

Non-discrimination between AC and DC-connected PPMs

Non-discrimination of connection type:

"The requirements of [NC RfG], as applicable to offshore PPMs with the exception of Articles 24 to 63, shall apply to DC-connected Power Park Modules, with the modifications expressed in Article 37 to Article 43 this Network Code. The categorization in Article 3(6) in [NC RfG] shall apply to DC-connected PPMs."

Ref.: Art. 36

All modifications expressed in Article 37 to 43 stem from specific system needs of the "remote" collection networks.

Non-discrimination of technology:

"Where a nominal Frequency other than 50Hz, or a Frequency variable by design is used […], the applicable Frequency ranges and time periods shall be specified by the Relevant TSO taking into account specificities of the system…"

Ref.: Art. 37(2)

Distinction of requirements for remote-end converters and PPMs

Chapter 3 divided into 2 sections:

Section 1 – applicable to DC-connected PPM

Basis of requirements is NC RfG, with the modifications expressed in NC HVDC

Section 2 – applicable to Remote-end HVDC Converter Stations

Basis of requirements is Chapter 2, with the modifications expressed in Chapter 3 – Section 2

Ref.: Articles 36 and 44

All modifications expressed in Chapter 3 stem from specific system needs of the “remote” collection networks and apply the general principle of transmission assets being the most resilient elements of the system.

5th NC HVDC User Group meeting

10 October 2012

Brussels, 10 March 2014

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