European Connection Network Code Requirements 2.0 (EU CNC 2.0)

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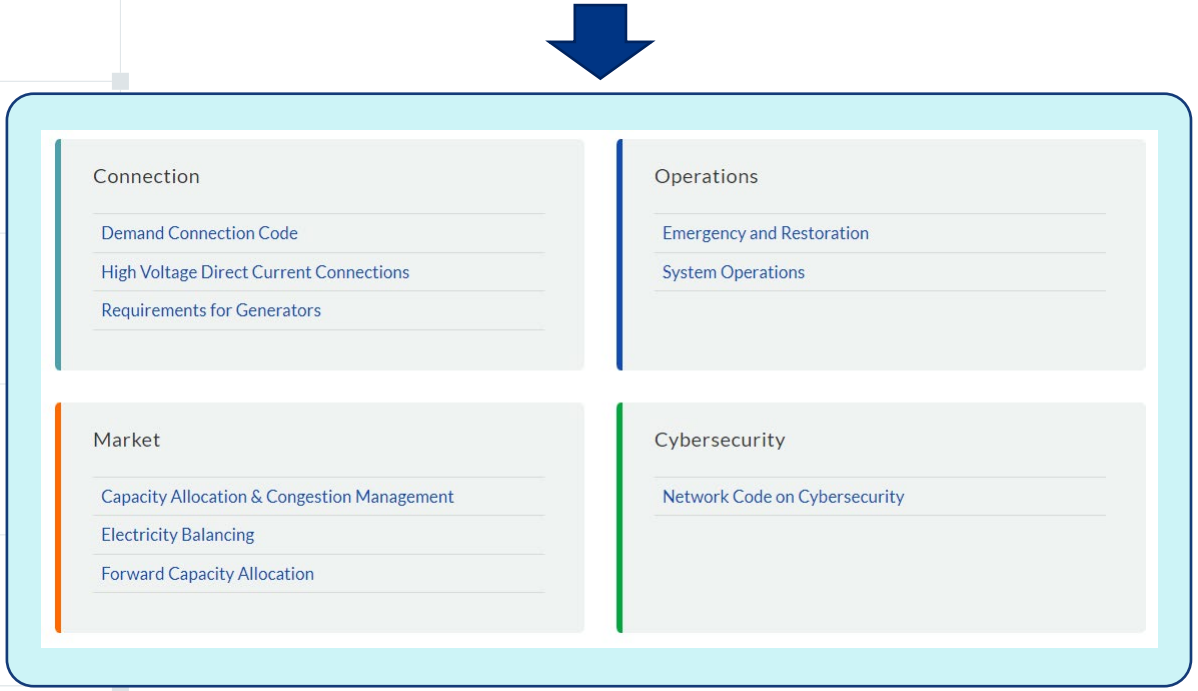
Content

- Introduction on EU connection network codes (EU CNC)
- Amendment process key changes in NC RfG, NC DC and NC HVDC

Introduction

EU Network Codes (NC)



Connection Network Codes (CNC):

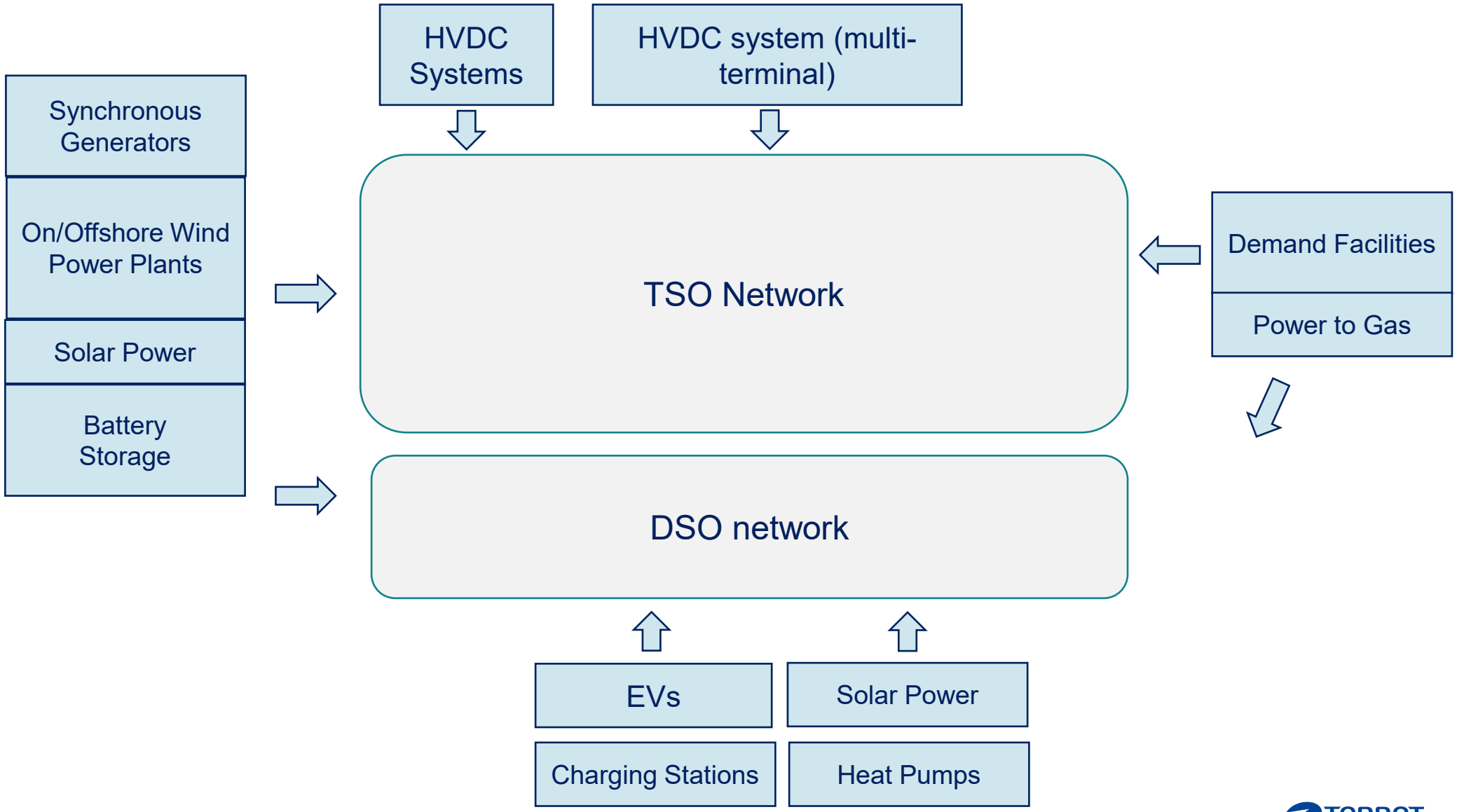
CNC is the **regulatory platform** at European level which define the necessary **technical capabilities** of power generating modules, distribution systems connected to transmission systems, demand facilities, and HVDC systems during normal and disturbed system operating conditions. It is split into following three:

- NC RfG
- NC DC
- NC HVDC

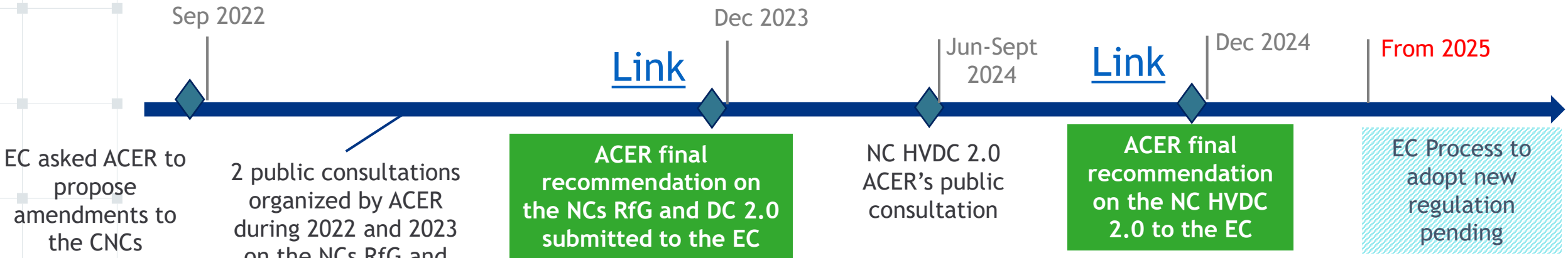
National regulation on connection codes

Detailed project specification and connection agreements

CNC Impact on the Power System



NC RfG 2.0, NC DC 2.0 and NC HVDC 2.0



NC RfG 2.0 – Core Amendments

Background: Core Capabilities of PGMs todate

NC RfG safeguards an energy transition under high penetration of RES while ensuring stable and reliable power system.

- Frequency ranges
- Voltage ranges
- Reactive power capability of PGM
- FRT capability
- Fast Fault current injection

- Frequency Sensitive Mode (FSM)
- Limited Frequency Sensitive Mode (LFSM-O/U)
- Voltage control – steady state
- Voltage control – dynamics
- Power Oscillations Damping

Background: Power Generating Modules – Types

Limits for thresholds for type B, C and D power-generating modules

Synchronous areas	Limit for maximum capacity threshold from which a power-generating module is of type B	Limit for maximum capacity threshold from which a power-generating module is of type C	Limit for maximum capacity threshold from which a power-generating module is of type D
Continental Europe	1 MW	50 MW	75 MW
Great Britain	1 MW	50 MW	75 MW
Nordic	1,5 MW	10 MW	30 MW
Ireland and Northern Ireland	0,1 MW	5 MW	10 MW
Baltic	0,5 MW	10 MW	15 MW

National Implementation of the Art.5 NC RfG

Country	A/B threshold	B/C threshold	C/D threshold
AT	250 kW	35 MW	50 MW
BE	1 MW	25 MW	75 MW*
BG	1 MW	5 MW	20 MW
CZ	100 kW	30 MW	75 MW
DE	135 kW	36 MW	45 MW
DK	125 kW	3 MW	25 MW
EE	0.5 MW	5 MW	15 MW
ES	100 kW	5 MW	50 MW
FI	1 MW	10 MW	30 MW
FR	1 MW	18 MW	75 MW**
GB	1 MW	10 MW	50 MW
GR	1 MW	20 MW	75 MW
HR	500 kW	5 MW	10 MW
HU	200 kW	5 MW	25 MW
IE&NI	100kW	5MW	10MW
IT	11,08 kW	6 MW	10MW
LT	250 kW	5 MW	15 MW
LU	135 kW	36 MW	45 MW
LV	0,5 MW	5 MW	15 MW
NL	1 MW	50 MW	60 MW
PL	200kW	10MW	75MW
PT	1 MW	10 MW	45 MW
RO	1 MW	5 MW	20 MW
SE	1,5 MW	10 MW	30 MW
SI	10 kW	5 MW	20 MW
SK	100 kW	5 MW	20 MW

Changes in Connection Network Codes

Network Code RfG 2.0

Storage requirements and bidirectional electric vehicles requirements

- Currently, the three European Connection Network Codes (RfG, HVDC and DCC) explicitly exclude storage technologies other than in respect of Pumped Storage although its fleet is increasing in the EU level.

Requirements for all SPGMs

OR

Requirements for all PPMs
(incl. grid forming)

Additional requirements for ESM

- LFSM-O and LFSM-U response (adjusting injection or consumption)
- Modulation of active power input (or output) following the instruction
- ESM provides capabilities based on their maximum energy content
- Switching between injecting and consuming

Changes in Connection Network Codes

Network Code RfG 2.0

Bidirectional electric vehicles (V2G) and associated bidirectional electric vehicle charging points or installations

0,8 kW < capacity < 2,4 kW
V2G type EV1

2,4 kW ≤ capacity ≤ 50 kW
V2G type EV2

New Article in NC RfG 2.0 (exhaustive requirements for both EV1 and EV2). Mainly:

- Frequency ranges, RoCoF withstand capability
- Voltage robustness/FRT
- LFSM-U EV and LFSM-O EV

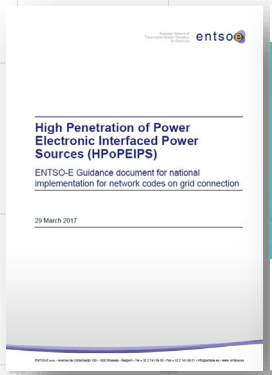
50 kW ≤ capacity < 1 MW
V2G type EV3

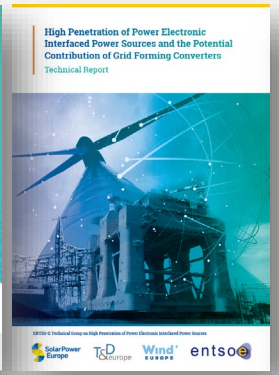
Apply all the requirements applicable to type EV1 and EV2. In addition, applies:

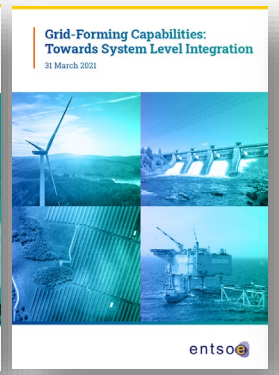
- voltage ranges for MV/HV/EHV
- system management
- reactive power capabilities
- post-fault active power recovery

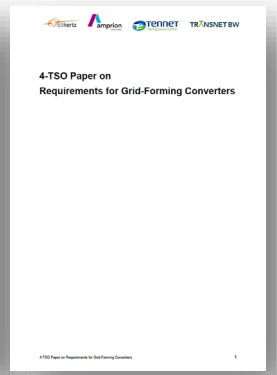
EU Connection Network Codes on Generators (NC RfG) – Key Points

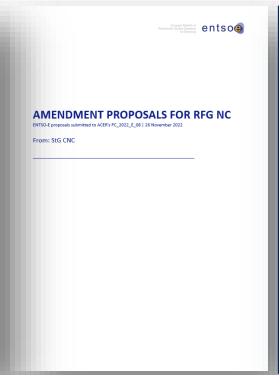
Network Code RfG 2.0 → Grid Forming Capability for Power Plant Modules











IGD HPoPEIPS 29.03.2017 → MIGRATE 14.01.2020 → Technical Report HPoPEIPS 28.01.2020 → ENTSO-E Position Paper 31.03.2021 → 4TSO Position paper 10.05.2022 → ENTSO-E Amendments 26.09.2022 → EG ACPPM June 2023 → NC RfG 2.0 2024 → 2025

EU Connection Network Codes on Generators (NC RfG) – Key Points

Network Code RfG 2.0	Grid Forming Capability for Power Plant Modules
Type A and B PPMs (Pmax <10 MW)	Non-mandatory requirement to be decided on national level if applicable.
Type B and C PPMs with Pmax >10 MW	The power park module **shall** have the capability of grid-forming (mandatory) within the energy, voltage and current limits of the PPM. No additional energy storage mandated.
All PPMs	The relevant system operator in coordination with the TSO shall specify the temporal parameters of the dynamic performance regarding grid forming

Changes in Connection Network Codes

Network Code RfG 2.0 → **RoCoF-withstand capability**

Type A, B, C and D PPM	**Type A, B, C and D SPGM** with Pmax < 140 MW	**Type D SPGMs** with Pmax ≥ 140 MW
1) Staying connected to the network and operating at: • ±4,0 Hz/s over a period of 0,25 s, • ±2,0 Hz/s over a period of 0,5 s, • ±1,5 Hz/s over a period of 1 s, and • ±1,25 Hz/s over a period of 2 s; 2) Staying connected to the network and operating at the sequence defined by the frequency against time profiles	Staying connected to the network and operating at: • ±2,0 Hz/s over a period of 0,5 s, • ±1,5 Hz/s over a period of 1 s, • ±1,25 Hz/s over a period of 2 s;	Staying connected to the network and operating at: ±1,0 Hz/s over a period of 0,5 s

Changes in Connection Network Codes

Network Code RfG 2.0

Extension of frequency ranges

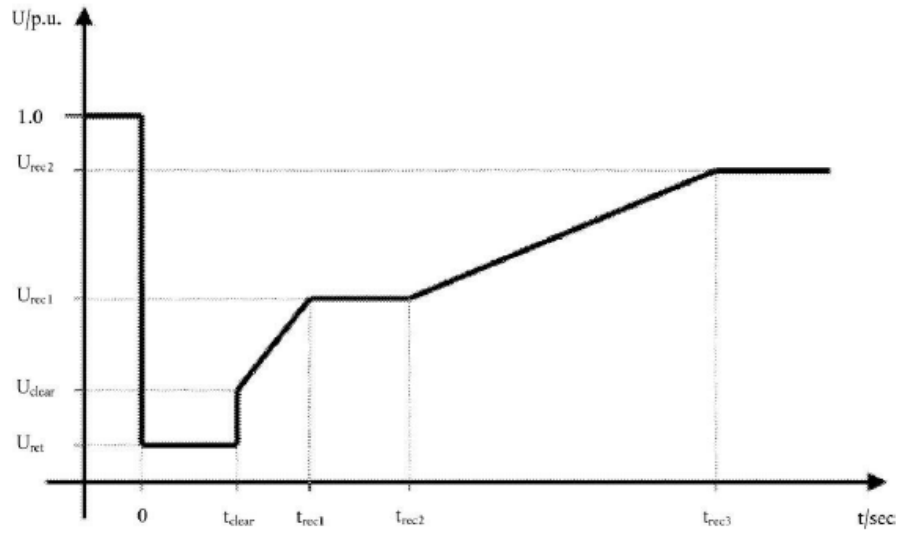
- Large imbalances during system splits would result at high frequency variations due to system dynamics

- **For CE SA:** the power-generating module shall be capable of remaining connected to the network and operate at the frequency between 51.5 Hz – 52.5 Hz for 10 seconds.

Changes in Connection Network Codes

Network Code RfG 2.0

FRT capability and post fault active power recovery for type-A power park modules (11kW<Pmax< 1MW):



Time parameters (seconds)	
t_{clear}:	0,15
t_{rec1}:	t_{clear}
t_{rec2}	t_{rec1}
t_{rec3}	3,0

Voltage parameters (pu)	
U_{ret}:	0,05
U_{clear}:	U_{ret}
U_{rec1}:	U_{clear}
U_{rec2}:	0,85

Justification

- Seeing the expected growth of Type A generating modules it is perceived that robustness to fault on transmission networks is crucial.

NC DC 2.0 – Core Amendments

EU Connection Network Code on Demand Connection (NC DC 2.0)

Unidirectional electric vehicles (V1G) and other demand units will be included in NC DC

V1G EVs and associated one-way EV charging point or installation

> 0,8 kW capacity
at all voltage levels

New Article in NC DC – **exhaustive requirements**:

- Frequency and voltage ranges
- RoCoF withstand capability
- LFSM-UC

Heat pumps,

power-to-gas demand units

New Article in NC DC – **exhaustive requirements**:

- Dedicated LFSM-UC Function for heat pumps to provide active power reduction during underfrequency

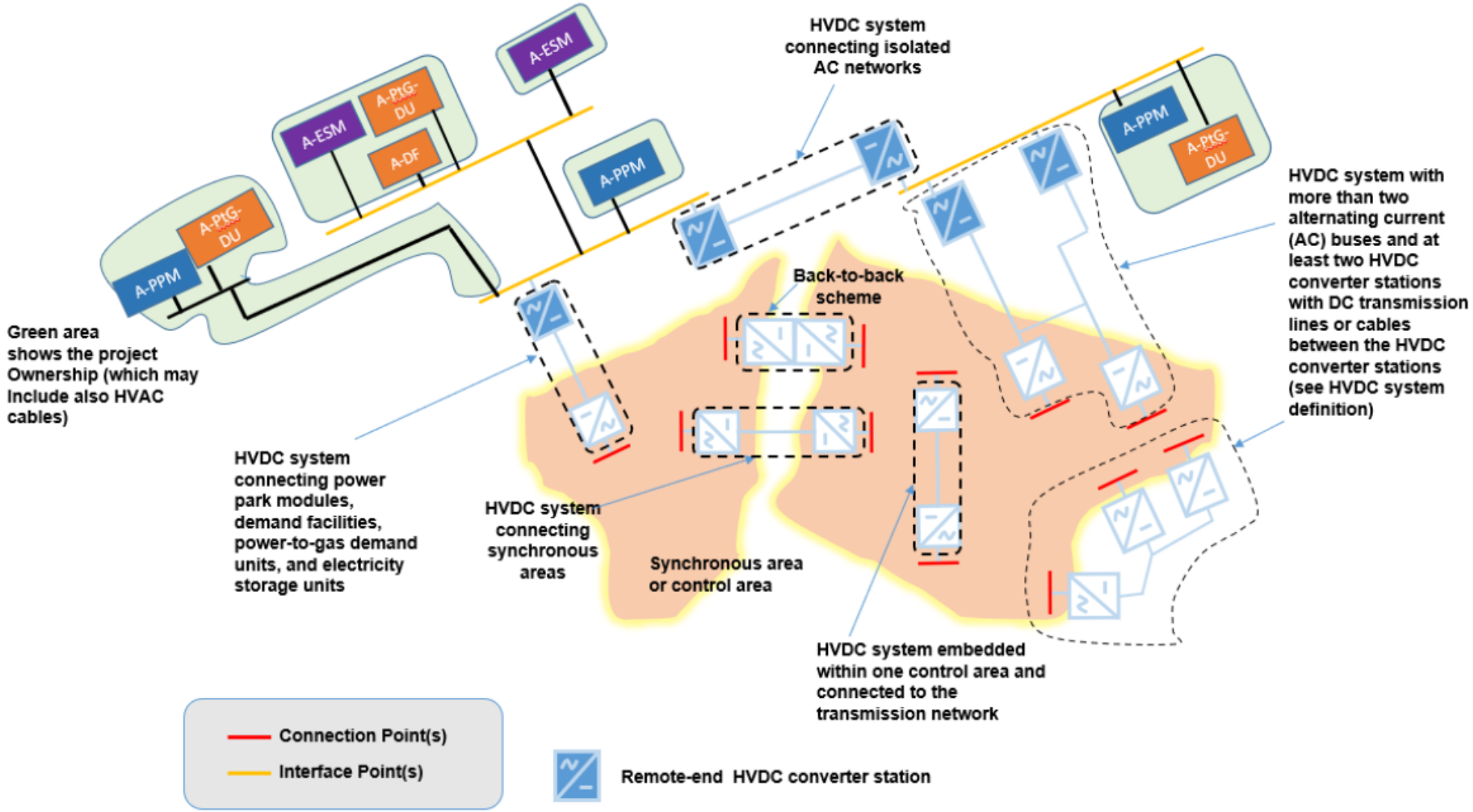
EU Connection Network Code on Demand Connection (NC DC 2.0)

Key Amendments

- Includes **new requirements** for PtG units and Heat pumps
  - RoCof
  - L/H FRT
  - LFSM-UC)
- New requirements for low frequency demand disconnection (LFDD)

NC HVDC 2.0 – Core Amendments

NC HVDC 2.0 – Scope Extension



NC HVDC 2.0 ACER submission to the EC – main changes (1/2)

Summary of the **proposed changes** 1/2

- **Application to existing HVDC system**, Art. 4.
- New proposed requirement for **voltage angle jump withstand capability**. TSOs see this as new capability in order to ensure system robustness in the CE SA, as in Art. 12b.
- **Grid forming capability**, Art. 14.
- New proposal for **over-voltage ride through** of HVDC systems, Art. 25. This is a requirement aligned with NC RfG.
- New requirement for **HVDC system robustness**, Art. 33.

NC HVDC 2.0 ACER submission to the EC – main changes (1/2)

Summary of the **proposed changes by ENTSO-**E provided during the consultation 2/2

- **Improved** requirement for **LFSM** of **power to gas demand units** connected to offshore HVDC links.
- Proposed **over-voltage ride through for power to gas demand units** connected to offshore HVDC links.
- **Compliance tests** requirement for **LFSM-UC of power to gas demand units**, which was missing from ACER proposal.
- **Compliance simulation** requirement for **grid forming and RoCoF immunity**, Art. 72, which was missing from ACER proposal.
- **Compliance simulation** requirements for **FRT of power to gas demand units**, Art. 74, which was missing from ACER proposal.
- Updated on **tables of voltage ranges**, Annex V - VIII.

Thank you for your attention

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