Expert Group: Identification of Connection Requirements for Offshore Grids (EG CROS) – Phase I

- A summary of main outcome of Phase I

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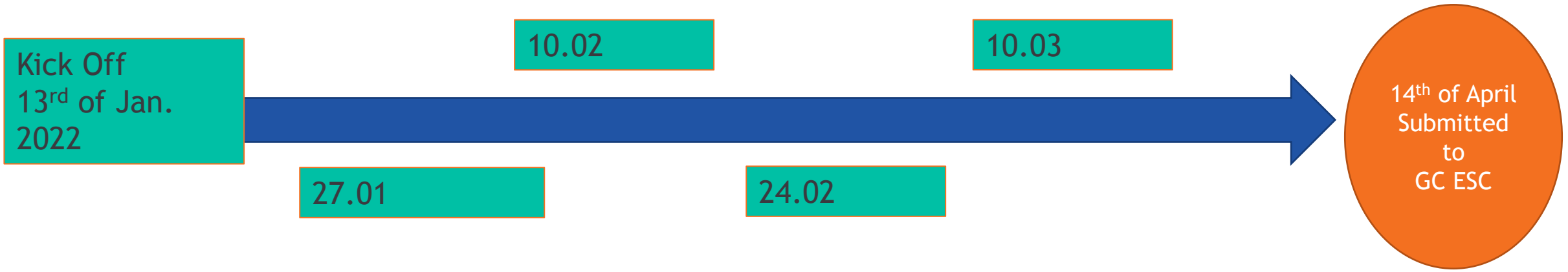
ToR of the EG CROS

Timeline of the EG CROS Phase I



ToR of the EG CROS

Deliverables of phase 1:

1. Provide the ToR for the subsequent phase 2 of the follow up work to be done under the GC ESC
2. Provide a short paper with main points and observations from phase 1 (Annex to the ToR of EG Offshore – phase 2)
3. Provide a mapping of currently existing transmission topologies for the integration of offshore technologies
4. Provide a list of standards, including adoptable for offshore purpose (list to be completed in phase 2)
5. Identify relevant stakeholders for the identified issues to take part in Phase 2

Duration of the EG:

- 4 months from January till April 2022.

Estimated workload

- biweekly webinars
- commitment of total 8 days per member (aprx. 40hours).

Observations of EG CROS - Phase I key discussion points

Observations of EG CROS - Phase I key discussion points (1/3)

- Moving from the classical point-to-point HVDC system, towards complex HVDC topologies (including multi-terminal HVDC) would require a new set of technical capabilities and operation experience.
- DC connection point technical requirements are not yet covered in the NC HVDC and would only be required if the same HVDC infrastructure is developed by different manufacturers in different timeframes (multi-vendor HVDC systems).
- Drafting connection requirements of complex multi-terminal HVDC structures should be done after gaining operation experience from industrial scale projects.
- The topic of interoperability of DC connected PPMs when different OEMs are connected to the HVDC interface point needs to be addressed.

Observations of EG CROS - Phase I key discussion points (2/3)

- The control chain should be assessed starting from the onshore connection point of the HVDC station down to the remote-end HVDC station and the DC connected PPMs.
- The definition of grid forming technical requirements that should be given to PPMs and to HVDC system should be assessed. The focus should be placed on the technical capabilities offered.
- Communication is also an important part for the coordination of the whole control chain from the onshore to the offshore converter and PPMs. Technical requirements of communication links should be set.
- Coordinated operation of onshore and offshore (remote-End) HVDC converter stations with PPMs without communication should be also explored.
- Phase II of the EG CROS should also discuss existing NC HVDC definitions. One example could be synthetic inertia. Its definition is important for setting requirements on future functionalities and capabilities.
- Black start capability is a technical requirement which is not mandatory and is imposed based on the generator type, the individual member state needs and the philosophy of system restoration.

Observations of EG CROS - Phase I key discussion points (3/3)

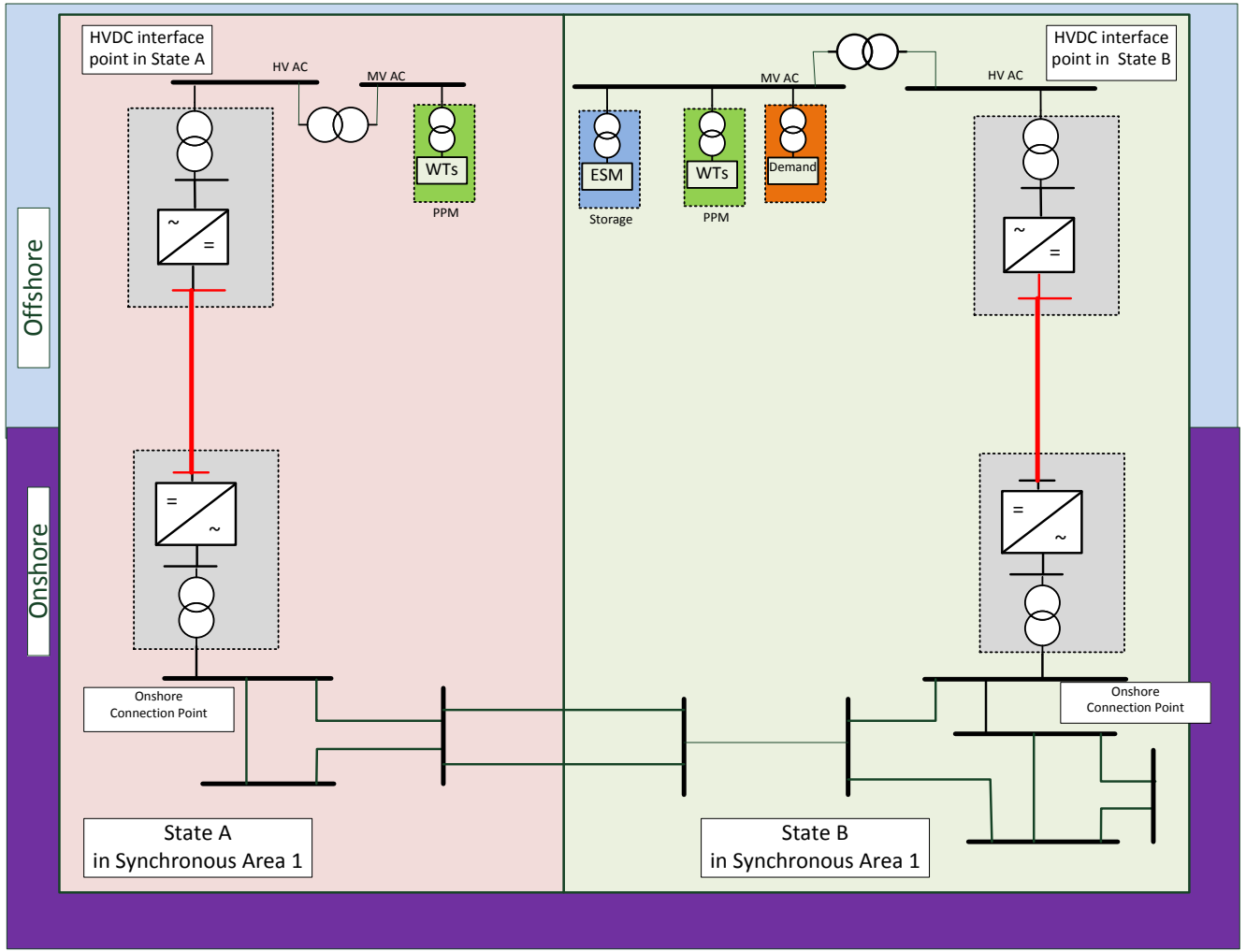
- Today most TSOs or where applicable RSOs require the simulation models in the used software specific programming language (Fortran, DSL etc.).

- The Phase II of EG CROS should discuss the current state of the play in the way EMT models could be exchanged in the form of DLL based models. The expert group should pick up the recommendations made in the expert group interaction studies and simulation models, chapter 5.7.

- Another important topic to be covered is power quality. DC connected PPM requirements may deviate from the IEC harmonic standards or the onshore code requirements and specifications in the actual region. In such cases the details of the possible deviations from the requirements shall be agreed and documented between the involved parties.

Offshore Topologies and applicability of Connection Network Codes

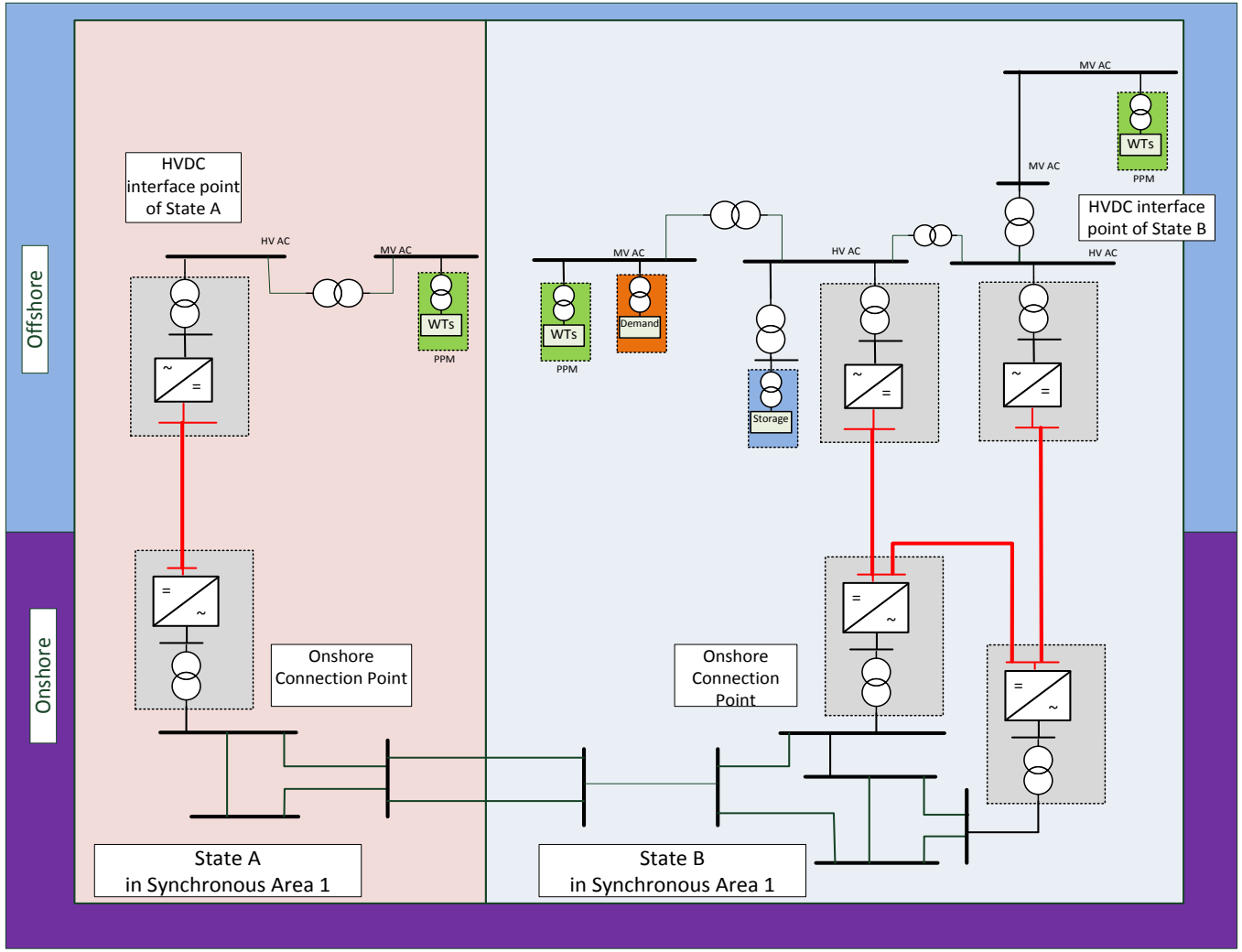
Case 1: DC connected PPMs and Demand Facilities



- The presence of both a DC connected demand facility and energy storage which are connected at the same HVDC interface point is not covered within the frame of NC HVDC.
- Moreover, for any DC connected demand facility, Network Code Demand Connection (NC DC) does not apply (cf. NC DC article 3 (2) (a)).
- DC connected PPMs and if applicable DC connected storage facilities should be able in future to contribute to voltage/frequency formation of the HVDC interface point (grid forming capability).

Offshore Topologies and applicability of Connection Network Codes

Case 1b: DC connected PPMs and Demand Facilities



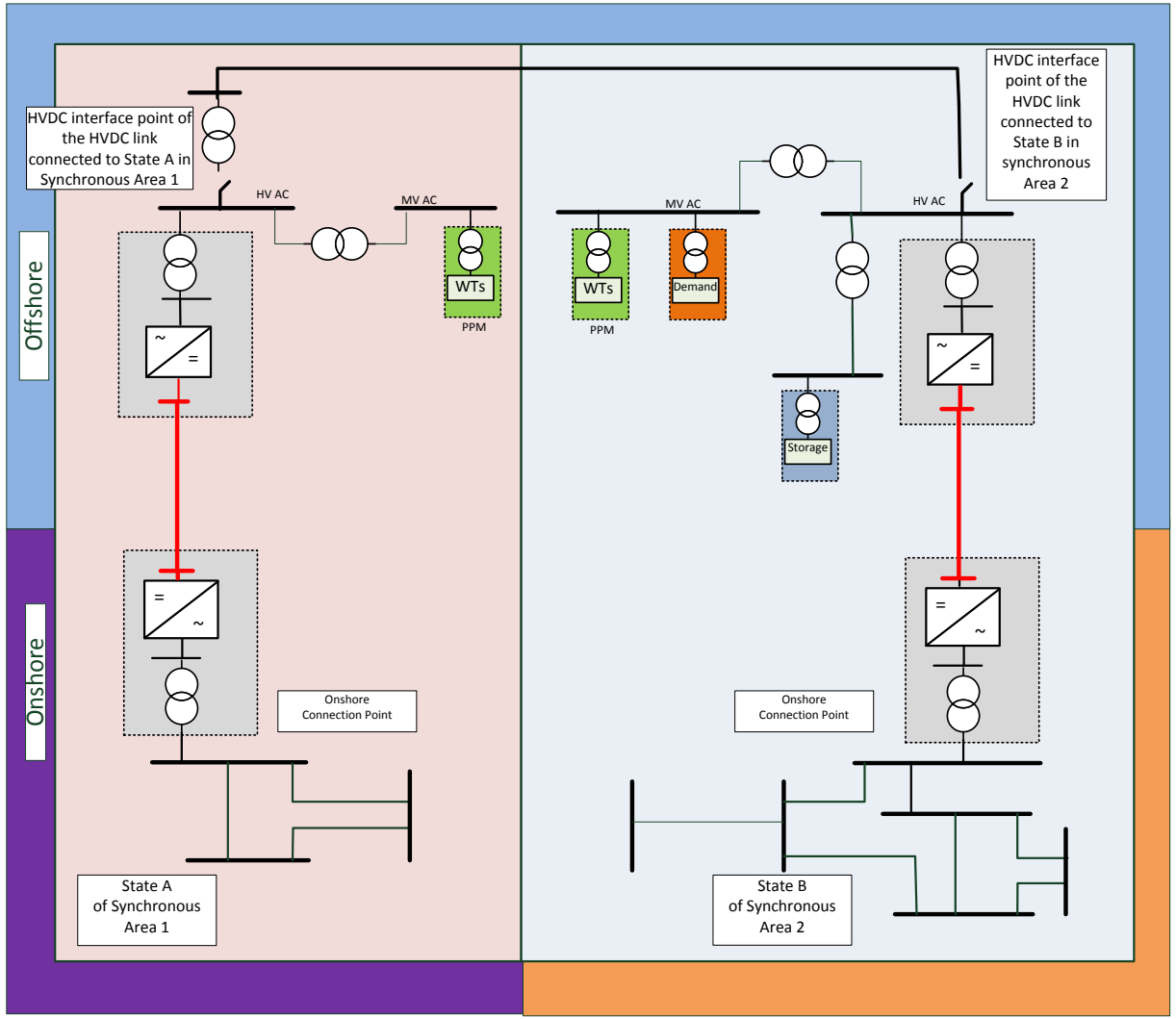
The Phase II of the EG CROS should:

The NC HVDC should be extended to be applicable for DC connected demand facilities and DC connected electricity storage modules.

1. propose such provisions and expand the applicability of the NC HVDC toward energy storage and demand facilities.
2. elaborate potential harmonization of voltage and frequency ranges in combined DC connected- PPMs, demand facilities as well electricity storage units to allow for future expandability.
3. propose and define minimum requirements for grid forming capabilities offered by DC connected PPMs and HVDC systems.

Offshore Topologies and applicability of Connection Network Codes

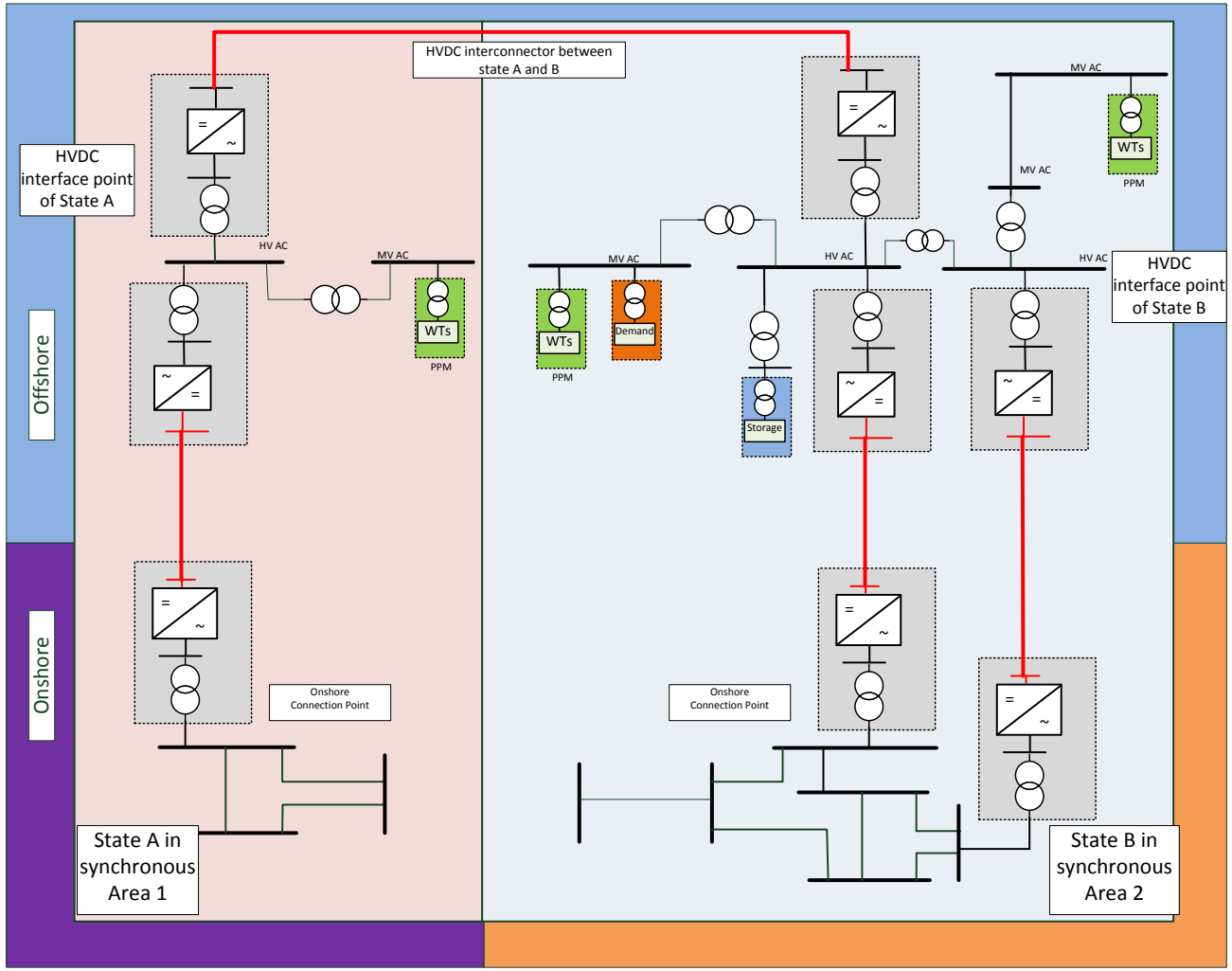
Case 2a: AC connected HVDC interfaced points belonging to different synchronous areas



- Case 2a presents a variation of a typical point-to-point topology, assuming that the offshore HVDC interface points are AC coupled.
- The presence of different technical specifications and CNC requirements in states A and B (being part of different synchronous area) at the HVDC interface points could be a blocking point of such architecture to grow in different timeframes and project phases.
- The technical requirements shall be system supportive and shall ensure robust operation of the integrated AC-DC system.

Offshore Topologies and applicability of Connection Network Codes

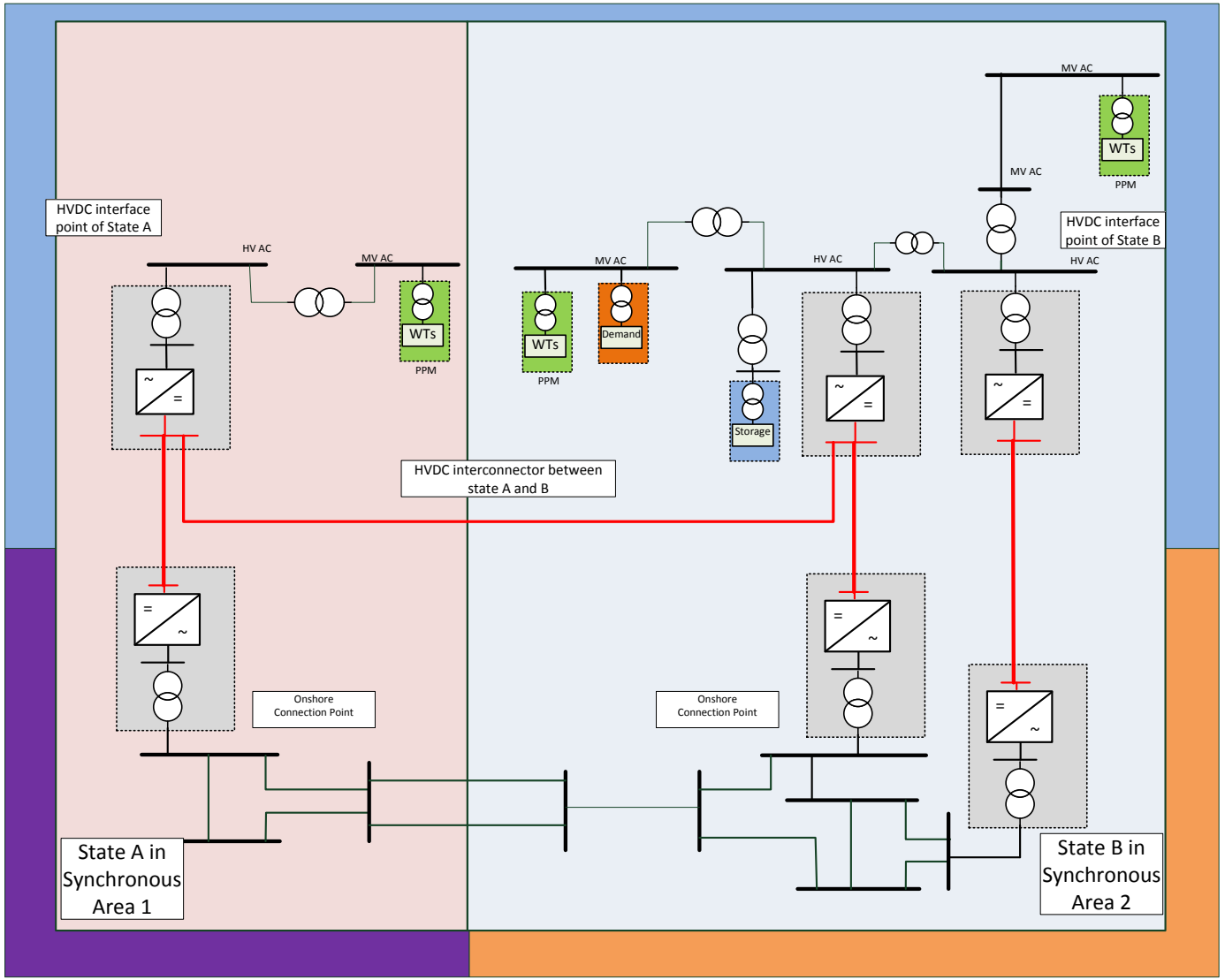
Case 2b: DC coupled HVDC interface points belonging to different synchronous areas



- Case 2b illustrates a situation where an HVDC interconnector is built between two offshore HVDC interface points.
- This specific offshore configuration would require a completely different set of technical requirements and parameters.
- The share of data and models for planning and design studies is a significant issue for the case when the owners as well as the original equipment manufacturers of PPMs, HVDC and demand facilities and energy storage modules are different entities.

Offshore Topologies and applicability of Connection Network Codes

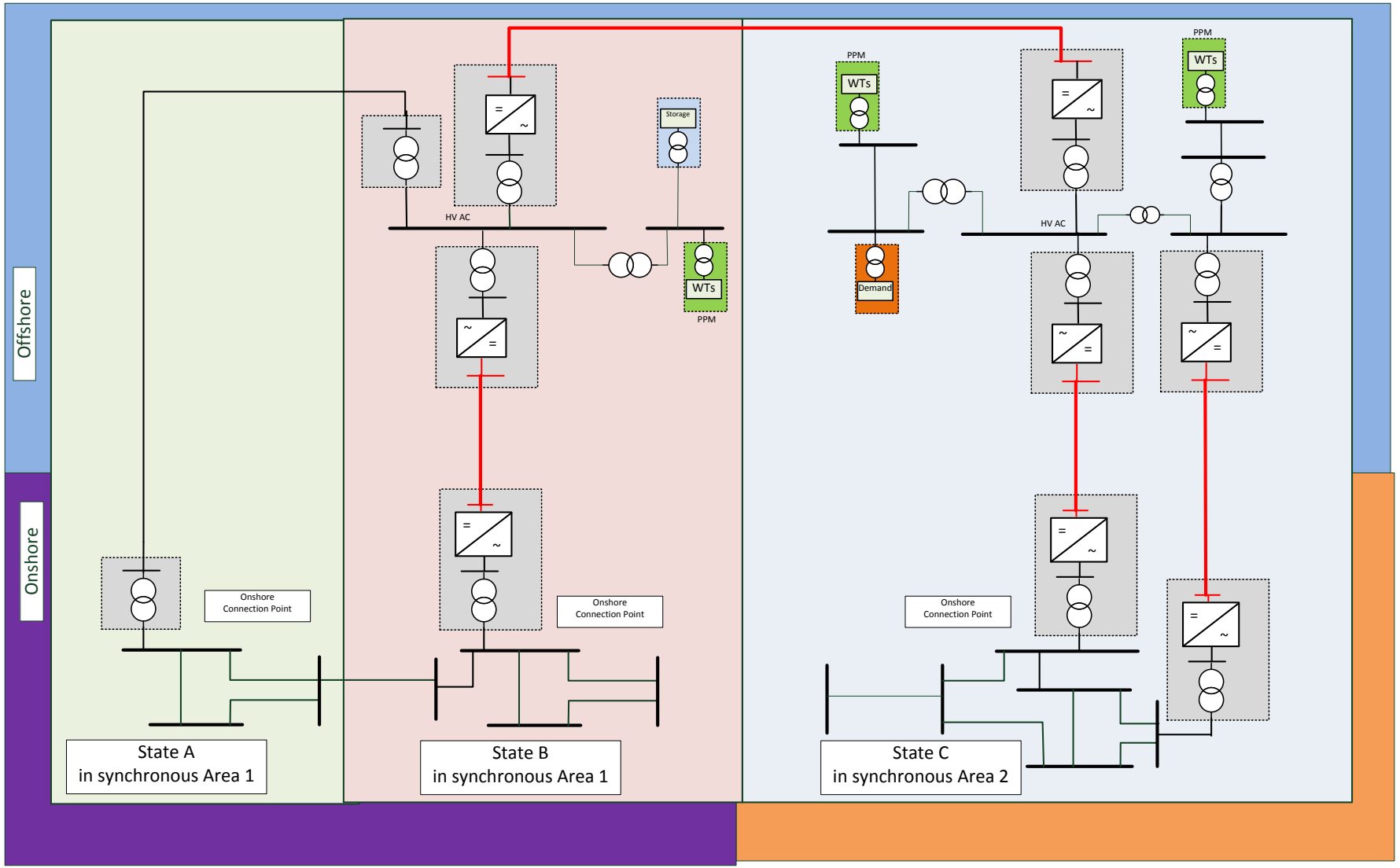
Case 2b-2: DC coupled HVDC interface points belonging to different synchronous areas



- Next to the topology of case 2b, the connection of the two HVDC interface points (isolated AC systems) belonging to different states could be substituted by a common DC connection between the two HVDC stations, as shown in case 2b-2.

Offshore Topologies and applicability of Connection Network Codes

Case 2c: Hybrid AC/DC connected PPMs shared between different states and synchronous areas



Offshore Topologies and applicability of Connection Network Codes

Case 2b: DC coupled HVDC interface points belonging to different synchronous areas

Proposal of the EG:

- The Phase II of the EG CROS should assess the applicability of the NC HVDC articles on the topologies of case 2a, 2b, 2b-b and 2c
- The assessment should be done for both the case that the states are in the same as well as in different synchronous areas.
- Moreover, the EG should define the minimum technical capabilities of such interconnectors, connecting offshore HVDC interface points (regardless if the onshore HVDC converter stations are at different synchronous areas).

Gaps to be detailed in the phase II

Topic not included in the current legislation	Relevant Regulation
DC connected Demand Facilities	NC HVDC
General applicability of Demand Facilities (article 3(2)(a))	NC DC
DC connected ESM (Energy Storage Module)	NC HVDC
General applicability of ESM	EU Regulation (NC RfG)
AC interconnection between several HVDC interface points	NC HVDC
DC connected HVDC systems (article 3(7)(b)	NC HVDC
DC interconnection between several HVDC stations with individual HVDC interface point	NC HVDC

Technical requirements to be scopped in Phase II

Technical requirement to be scoped	Relevant Regulation
Remote-end HVDC and converter station to provide voltage and frequency formation.	NC HVDC
DC connected PPM to provide voltage and frequency formation	NC HVDC
DC connected ESM to provide voltage and frequency formation	NC HVDC
Technical minimum requirements for AC interconnectors between HVDC interface points	Initial set of minimum technical requirements.
Technical minimum requirements for DC connected PPM, DC connected Demand Facilities and DC connected ESM in a shared/common HVDC interface point	NC RfG, NC DC, EU regulation (NC RfG)
Technical minimum requirements for DC connected HVDC systems	NC HVDC
Technical minimum requirements for DC coupled HVDC stations	NC HVDC