READY4DC 2nd STAKEHOLDER ENGAGEMENT EVENT

3 May 2023, 14.00 – 16.00 CEST

READY DC

Funded by
the European Union

Introduction

Antonello Monti, RWTH Aachen

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AGENDA

READY4DC - 2nd Stakeholder Engagement event	
14:00 – 14:05	**Introduction** • Antonello Monti, RWTH Aachen
14:05 – 14:15	**Opening** • Eric Lecomte, DG Energy, European Commission
14:15 – 14:25	**Overview of the READY4DC project** • Ilka Jahn, RWTH Aachen
14:25 – 14:45	**WP1: Modelling, simulation framework and data sharing for multi-vendor HVDC interaction studies and large-scale EMT simulation** • William Leon Garcia, SuperGrid Institute
14:45 – 15 :05	**WP2: Legal Framework for the Realization of a Multi-vendor HVDC Network** • Vincent Lakerink, University of Groningen
15:05 – 15:15	**Coffee Break**
15:15 – 15:35	**WP3: Multi-vendor Interoperability Process and Demonstration Definition** • Nico Klötzl, TenneT
15:35 – 15:55	**WP4: Framing the future European Energy System** • Ilka Jahn, RWTH Aachen
15:55 – 16:00	**General Q&A and closing** • Antonello Monti, RWTH Aachen

Opening remarks

Eric Lecomte, DG Energy, European Commission

READY4DC – Stakeholder workshop
Energy and R&I policy context

Jan 2023

Eric Lecomte, DG Energy, Unit B5 Research, Innovation, Digitalisation, Competitiveness

Offshore renewable strategy – Nov 2020

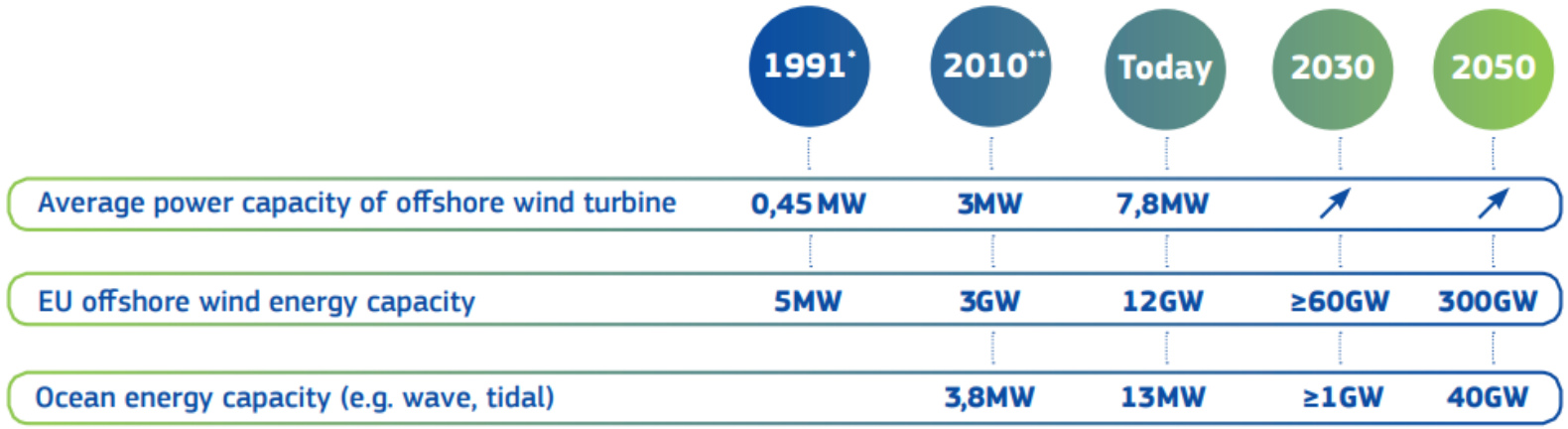
- **opportunities** for offshore renewable energy **all across Europe -** from the North Sea and Baltic Sea to the Atlantic Ocean, the Mediterranean Sea and the Black Sea

all of Europe will benefit

- feed into the European **grid**;
- offer **cleaner** energy to citizens;
- reduce our dependence on energy **imports**;
- support **industry** in the EU

Main elements:

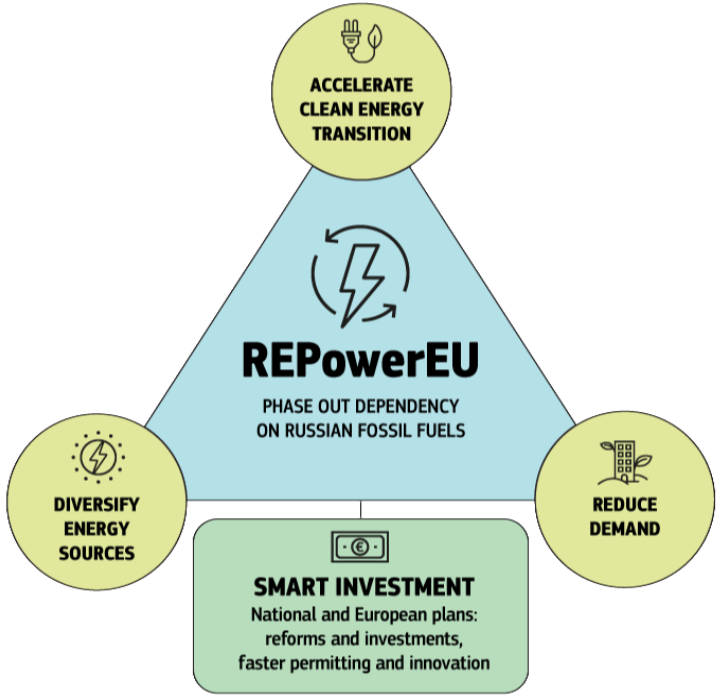
- Investments,
- Regional Cooperation
- Legal framework
- Supply chain, innovation

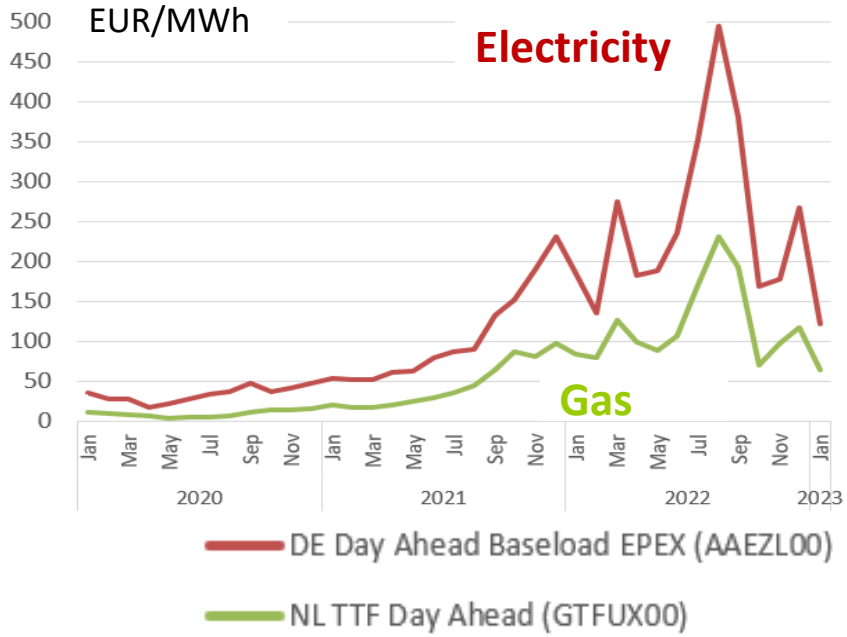


European Commission

REPower EU

- **Renewables Directive**: the EU Council and Parliament agreed to increase the **EU's 2030 target for renewables** from the current 40% **to 42.5%** (aspiration to 45%).
  - 45% would bring the total **renewable energy capacities to 1236 GW by 2030**,
    in comparison to 1067 GW by 2030 envisaged under Fit for 55 for 2030
- Regulation on **Permitting and Go-to areas**





promote the creation of a more supportive environment for **deploying the clean tech manufacturing capacity** required to meet Europe's ambitious green targets.

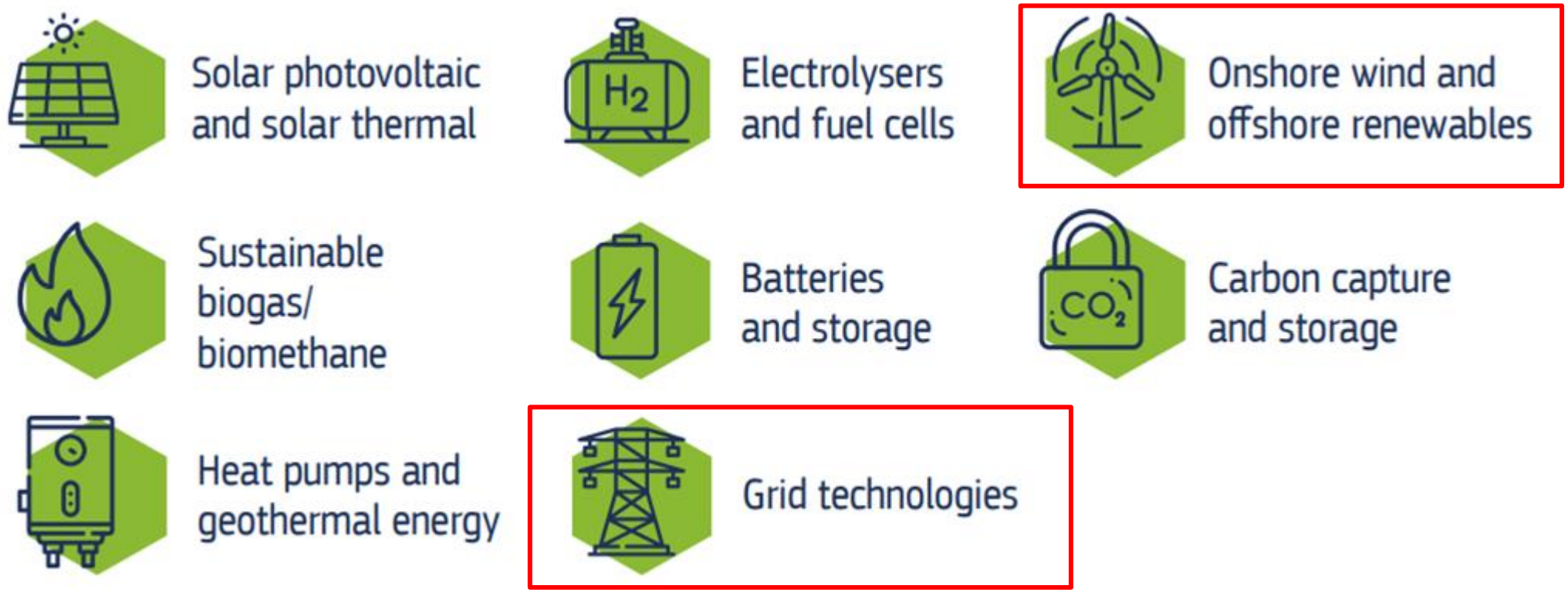
European Commission

Net Zero Industry Act (EC proposal March 2023)

- Art 1: This Regulation establishes the framework of measures for innovating and **scaling up the manufacturing capacity of net-zero technologies** in the Union to support the Union's 2030 target of reducing net greenhouse gas emissions by at least 55 % relative to 1990 levels and the Union's 2050 climate neutrality target, and to **ensure the Union's access to a secure and sustainable supply of net-zero technologies** needed to safeguard the resilience of the Union's energy system and to contribute to the **creation of quality jobs**
- **How:**
  - One stop shop for **faster permitting,**
  - **Financing: Net-zero strategic projects,**
  - **Market: public procurement criteria**
  - **skilled workforce**
  - **Innovation: sandboxes**

European Commission

Strategic Net Zero Technologies



European Commission

Horizon Europe - Cluster 5 Work programme

Destination 1 – Climate science

- Climate science

Destination 2 – Cross-cutting solutions

- Batteries
- Cities
- Breakthrough technologies
- Citizen and stakeholder engagement

Destination 3 – Energy supply

- **Renewable energy**
- **Energy system, grids** and storage
- CCUS
- Cross-cutting activities

Destination 4 – Energy demand

- Buildings
- Industry

Destination 5 - Clean and competitive solutions for all transport modes

- Zero-emission road transport
- Aviation
- Waterborne transport
- Transport-related health and environmental issues

Destination 6 - Transport and Smart Mobility services

- Connected, Cooperative and Automated Mobility
- Multimodal and sustainable transport systems for passengers and goods
- Safety and resilience

European Commission

FP7 – H2020 topics and projects

Title	Budget	Type	Projects
FP7-ENERGY.2013.7.2.3 - Large-scale demonstration of innovative transmission system integration and operation solutions for (inter)connecting renewable electricity production	35.5 M€		Best Paths Oct 2014- Sep 2018
H2020-LCE-05-2015 - Innovation and technologies for the deployment of meshed off-shore grids	34.5 M€		Promotion Jan 2016 – Sep 2020

Horizon Europe topics and projects

Title	Budget	Type	Projects
HORIZON-CL5-2021-D3-01-02 - **Laying down the basis** for the demonstration of a Real Time Demonstrator of **Multi-Vendor Multi-Terminal HVDC** with Grid Forming Capability:	1 M€	CSA	Ready4DC Apr 2022 – Sep 2023
HORIZON-CL5-2021-D3-02-08: Electricity system **reliability and resilience by design**: High-Voltage, Direct Current **(HVDC)-based systems** and solutions	15 M€	RIA	NEWGEN 7.6M€, Oct22-Sep26 HVDC-WISE 6.6M€, Oct22-Mar26,
HORIZON-CL5-2021-D3-02-10: Demonstration of **advanced Power Electronics** for application in the energy sector *(notably for MV-HVDC)*	10 M€	IA	AdvanSiC, 3.2M€, Jan23-Dec25 SiC4GRID, 3.8M€, Oct22-Mar26 FOR2ENSICS, 4.4M€, Oct22-Sep26
HORIZON-CL5-2021-D3-03-12: Innovation on **floating wind energy** deployment optimized for deep waters and different sea basins (Mediterranean Sea, Black Sea, Baltic Sea, North-east Atlantic Ocean)	50 M€	IA	BLOW, 15.5M€, Jan23-Dec27 WHEEL, 16.7M€, Jan23-Dec27 INFINITE, 15.5M€, Nov22-Oct26 NEXTFLOAT, 16M€, Nov22-Apr27
HORIZON-CL5-2022-D3-01-09: Real Time Demonstrator of **Multi-Vendor Multi-Terminal VSC-HVDC** with Grid Forming Capability (in support of the offshore strategy)	55 M€	IA	InterOPERA, 50.7M€ Jan 2023 – Apr 2027

HEU-Cluster5 – open topics

Title	Budget	Type
HORIZON-CL5-2023-D3-01-05: Critical **technologies for the offshore wind** farm of the Future	18 M€ (3pj of 6 M€)	RIA
HORIZON-CL5-2023-D3-01-11: Demonstration of **DC powered data centres, buildings, industries and ports**	18 M€ (2 pj 9 M€)	IA
HORIZON-CL5-2023-D3-01-12: Development of **MVDC, HVDC and High-Power Transmission systems and components** for a resilient grid	22 M€ (2 pj of 11 M€)	IA
HORIZON-CL5-2024-D3-01-15: HVAC, HVDC and High-Power cable systems (incl. superconducting)	16 M€ (3pj of 5-5.5 M€)	IA

European Commission

SET Plan (Strategic Energy Technologies Plan)

- **Goal**: to **align national and European R&I strategies** priorities and programmes
- **Cooperation** between Member States, Associated Countries, industry, research institutions and the EC

- Launched in 2007
- Last Communication issued in 2015
- Yearly conference (Q4)
- Yearly Progress Report

https://setis.ec.europa.eu/

SET Plan – Implementation Working Groups (IWGs)

And Direct Current technologies

Thank you!

HorizonEU

http://ec.europa.eu/horizon-europe

Getting ready for multi-vendor and multi-terminal DC technology

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Dr. Ilka Jahn, RWTH Aachen University

3 May 2023

Basic Facts

- Expected Outcome: The call is intended to support all the preparatory phases among all stakeholders (HVDC systems manufacturers, TSOs, wind turbine manufacturers and windfarm developers) leading to a demonstration project to de-risk the technology to enable the installation in Europe of the first Multi-Vendor Multi-Terminal HVDC system with Grid Forming Capability.
- Type: CSA
- Budget: 1 Million Euros
- Duration: 18 months

Partners

E.ON Energy Research Center | RWTH AACHEN UNIVERSITY

SuperGrid Institute
Shaping power transmission

university of groningen

Research Institutions

entsoe

Wind EUROPE

T&D europe

Stakeholders associations

TenneT

Major TSO active in two countries

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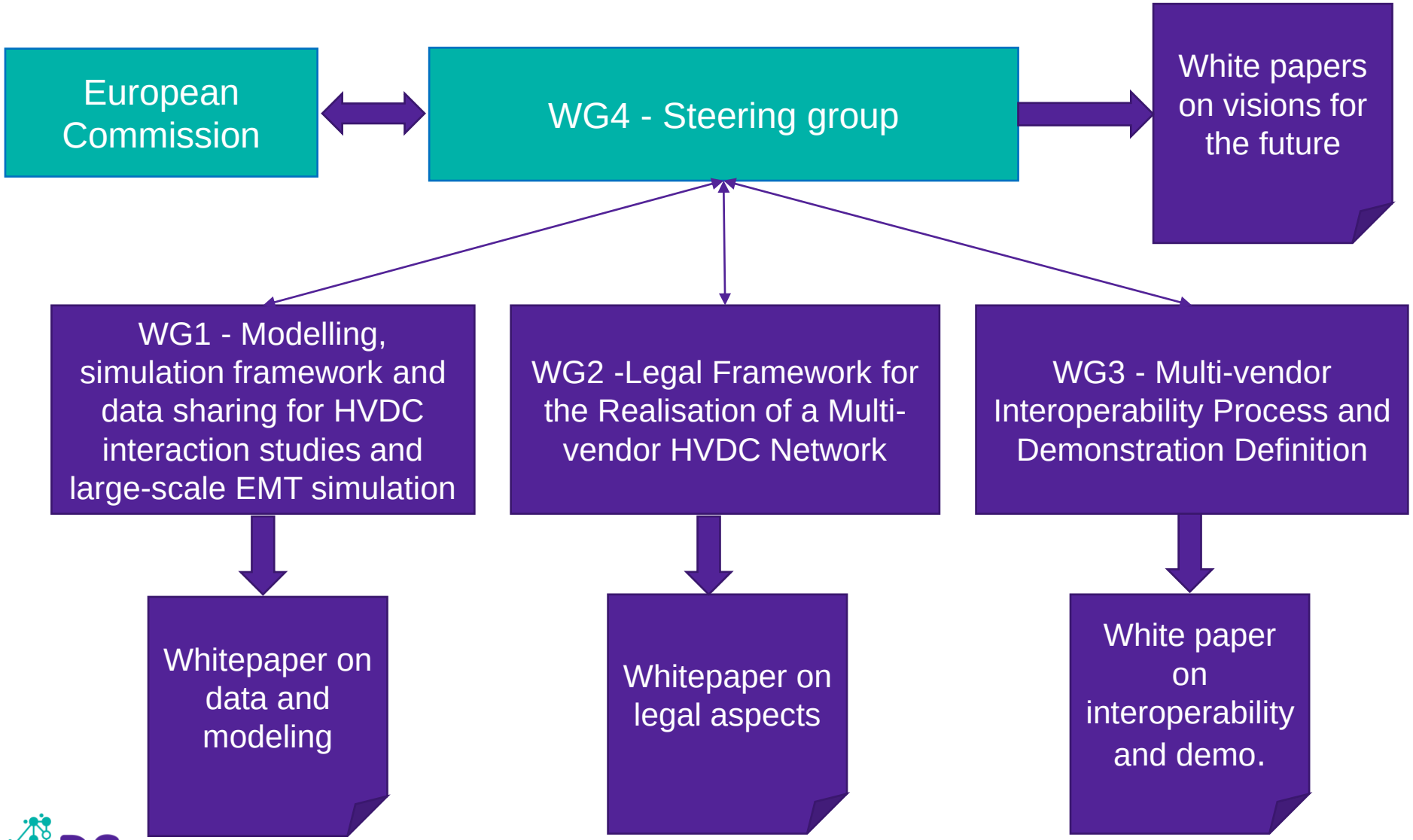
Scope

- The supports all the multiple preparatory tasks, which will **lead to a global agreement among stakeholders** and define the **detailed planning** for the full-scale industrial demonstrator. These include, but are not limited to:
- Coordination and organization of a **platform involving all stakeholders** (HVDC system manufacturers, TSOs, third-party HVDC system integrators, wind turbine manufacturers, offshore wind farm developers).
- Compatibility of **modelling tools** towards interoperability.
- Model sharing between TSOs: **legal framework**.
- **Roles and responsibilities** on interoperability issues.

Measurable Objectives

O1:	**Define an approach to a common modelling and simulation framework, and data sharing principles for multi-vendor HVDC interaction studies and large-scale EMT simulations**
O2:	**Define a technically justified legal Framework for the Realisation of Multi-vendor HVDC systems**
O3:	**Definition of roles, responsibilities and methods needed within the interoperability process**
O4:	**Enable from a technical and commercial perspective the first multi-vendor multi-terminal multi-purpose HVDC system with Grid Forming Capability**
O5:	**Definition of required activities to develop a vision for the future of the European Energy system**
O6:	**Creation of a large diverse community of stakeholders for each of the topics covered by the work of READY4DC**

Project Concept



Process per WG

WG1 Modelling, simulation framework and data sharing for multi-vendor HVDC interaction studies and large-scale EMT simulation	• Modelling framework and process • Legal aspects of data sharing • Integration with simulation tools
WG2 Legal Framework for the Realisation of a Multi-vendor HVDC systems	• Analyse the current status of legislation and regulation • Addressing the gaps in the legislative framework • Legal framework for coordination and governance of multi-vendor, multi-terminal HVDC networks
WG3 Multi-vendor Interoperability Process and Demonstration Definition	• Planning the first multi-vendor HVDC demonstration project • Placing demonstrators in the European grid • Going beyond a demonstration project
WG4 Framing the future European energy system	• Technical Coordination • Vision for the short-term impact of the project • Vision for the long-term impact of the project • Involvement in BRIDGE and SetPlan activities

SuperGrid Institute
Shaping power transmission

university of groningen

TenneT

RWTH AACHEN UNIVERSITY

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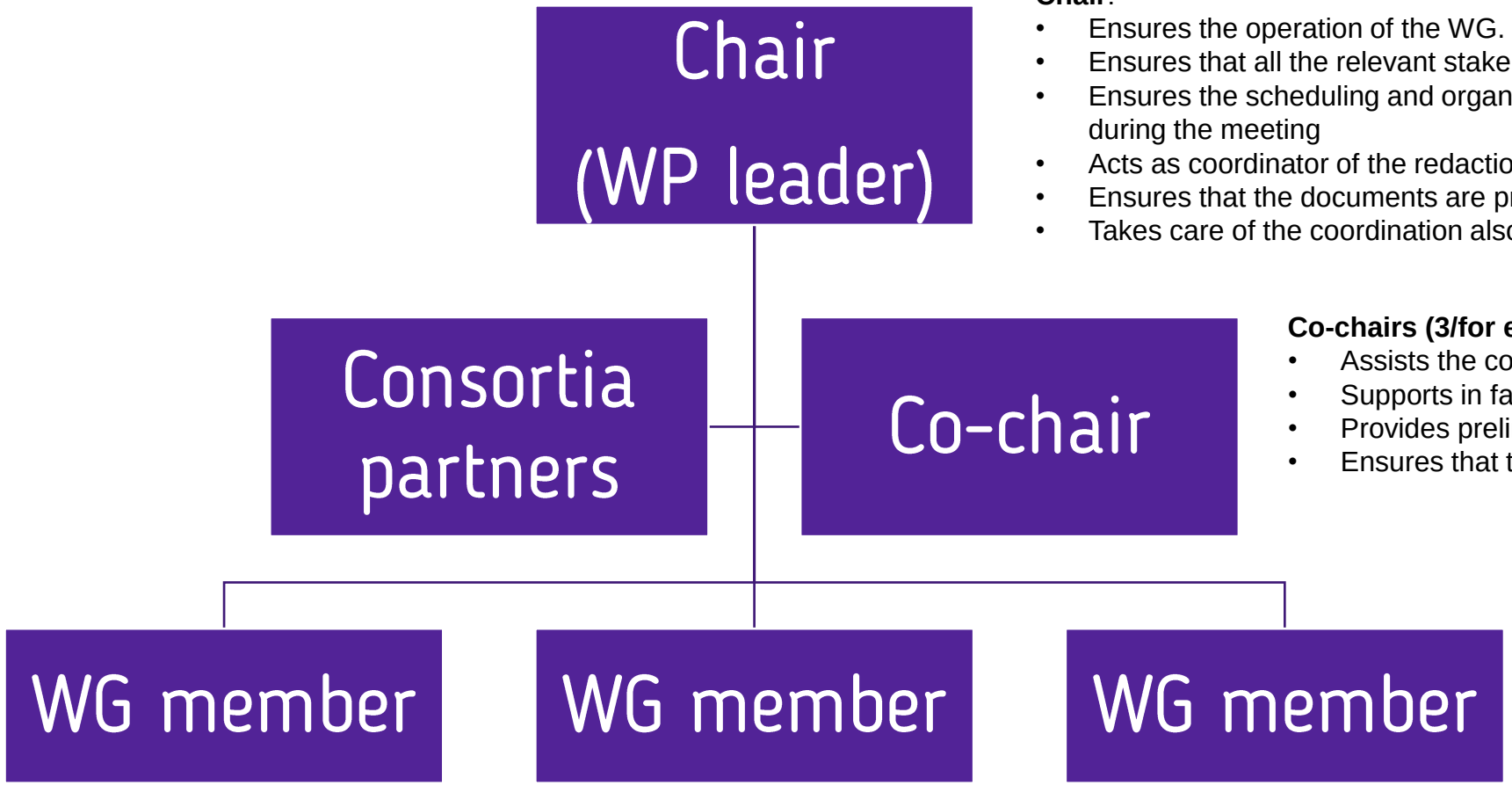
WG governance structure (example)



Chair:
- Ensures the operation of the WG.
- Ensures that all the relevant stakeholders are fairly represented.
- Ensures the scheduling and organization of the periodic meetings. Acts as moderator during the meeting
- Acts as coordinator of the redaction of the documents.
- Ensures that the documents are prepared on time and at the right level of quality.
- Takes care of the coordination also with the other WG.

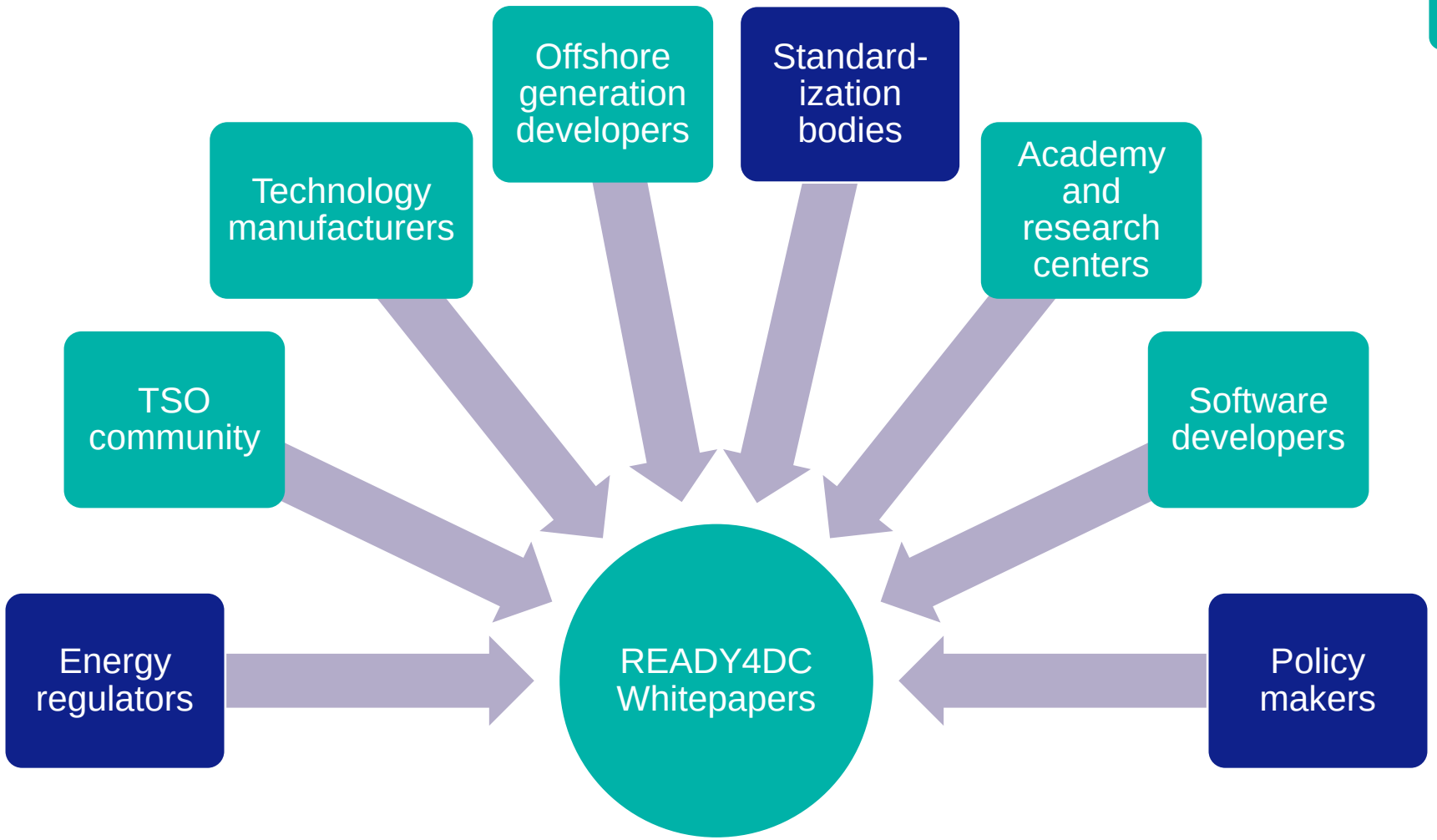
Co-chairs (3/for each key stakeholders group):
- Assists the coordination and operation of the WG.
- Supports in facilitating the moderation
- Provides preliminary feedback to the content of the white papers.
- Ensures that the voice of the stakeholders they represent is heard.

WG members (unlimited):
- Provides inputs and feedback to the content of the white papers.
- Raise the voice of the stakeholder they represent

READY4DC community

Dialog and consultation

WG Members



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Other efforts towards multi-vendor multi-terminal HVDC

- **CIGRE B4.81:** Interactions: VSC-HVDC, FACTs, HV power electronics, and conventional AC equipment
- **CIGRE B4.85:** Open source HVDC Control & Protection
- **PROMOTioN:** Technical and commercial readiness (road map) for HVDC grids (2020)
- **COMPOSITE:** Multi-infeed studies for offshore HVDC grids
- **CENELEC / IEC 63291**: HVDC Grid functional requirements / parameters
- **IEC 63471**: DC Voltages for HVDC Grids
- **InterOPERA** EU project
- ...

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- Subscribe to mailing list
- Follow us on LinkedIn

THANK YOU

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WG1 – Modelling, simulation framework and data sharing for Multi-Terminal Multi-Vendor HVDC interaction studies and large-scale EMT simulation

2nd Stakeholder Engagement Event

READY DC

William LEON GARCIA

03 May 2023

Agenda

1. **Introduction**
   - Context and motivation
   - WG1 vs whitepaper structure
2. **Generalities on interaction studies**
   - Current perimeter on interaction studies tools
3. **Interaction studies generic workflow**
   - Discussed methodologies and roles
   - Influence on controls accessibility
4. **Simulation tools**
5. **Next steps**

1

Introduction

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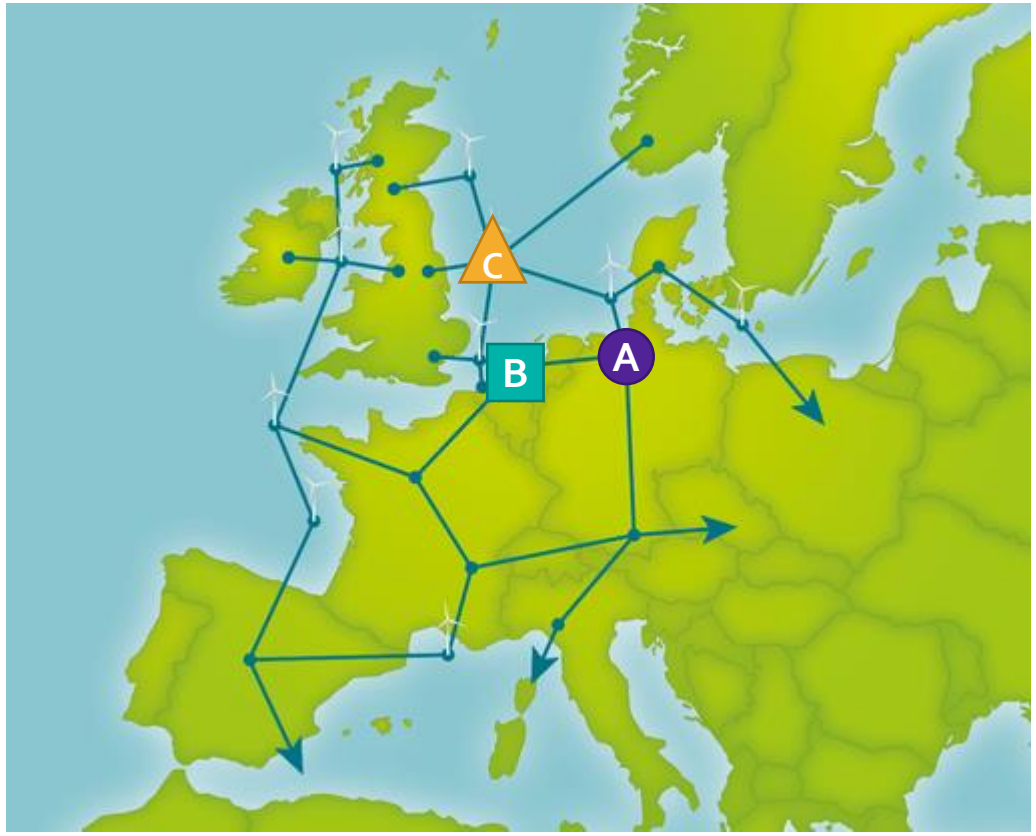
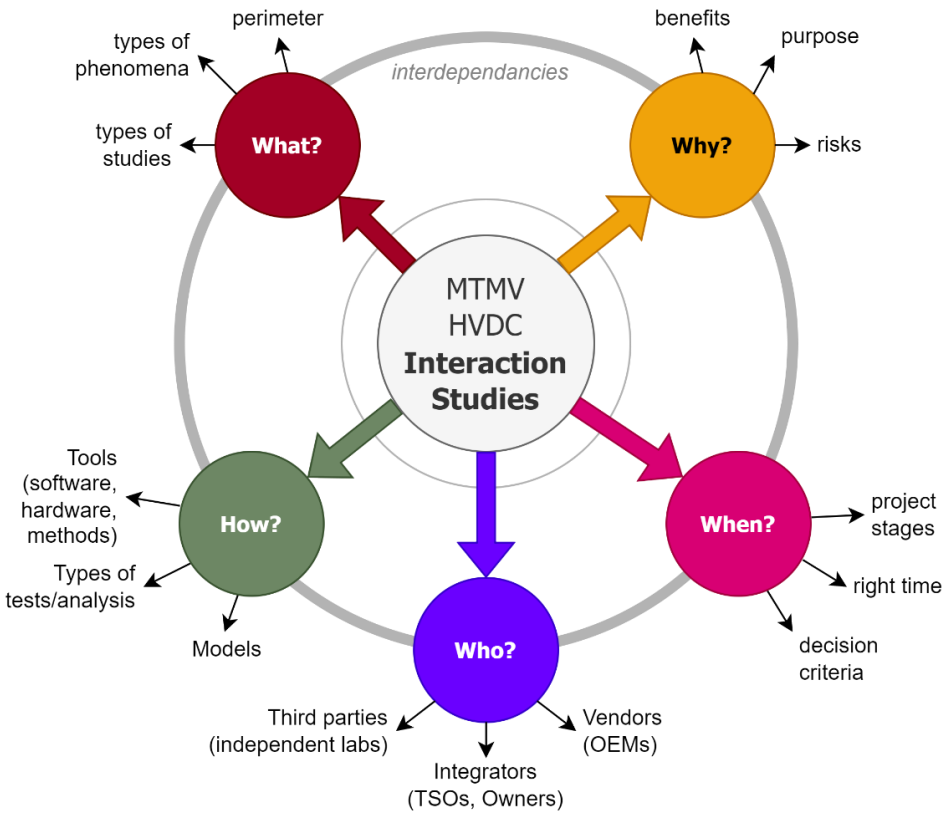
Context and motivation



Multi-terminal multi-vendor HVDC system vision (Corbett, 2020)



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WG1 Tasks vs Whitepaper Structure

Task 1: Modelling framework & process

Task 2: Legal aspects of data sharing

Task 3: Integration with simulation tools

1 – Brief introduction to interaction studies

2 – Workflow

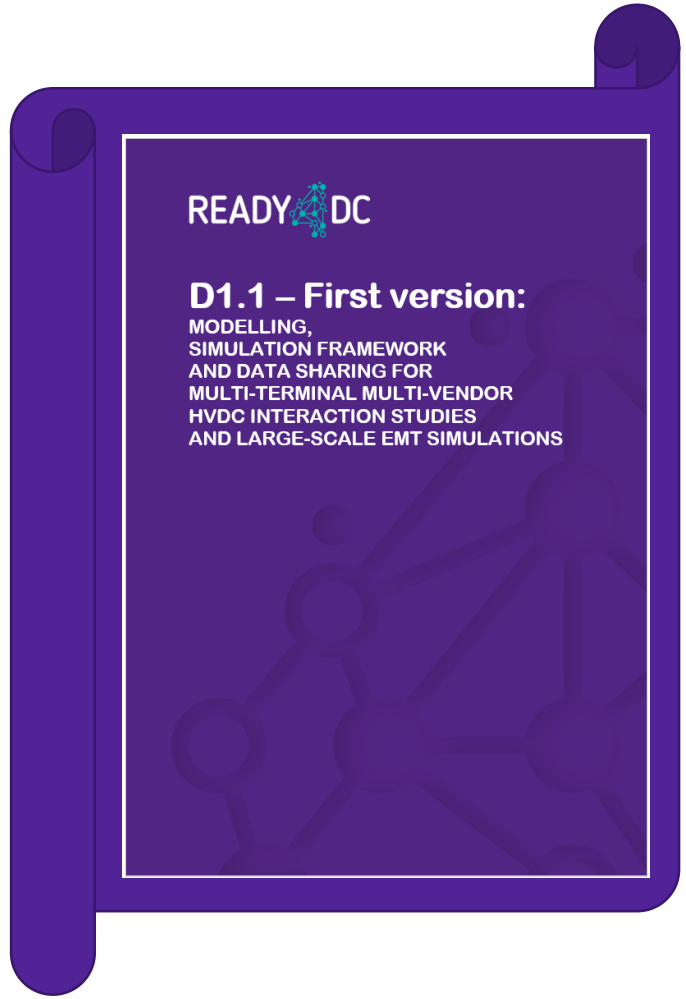
3 – Methodological scenarios

4 – MMC control aspects

4 – MMC control aspects

6 – Risks of data sharing (WIP)

5 – Analysis of EMT simulation tools



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Generalities on interaction studies

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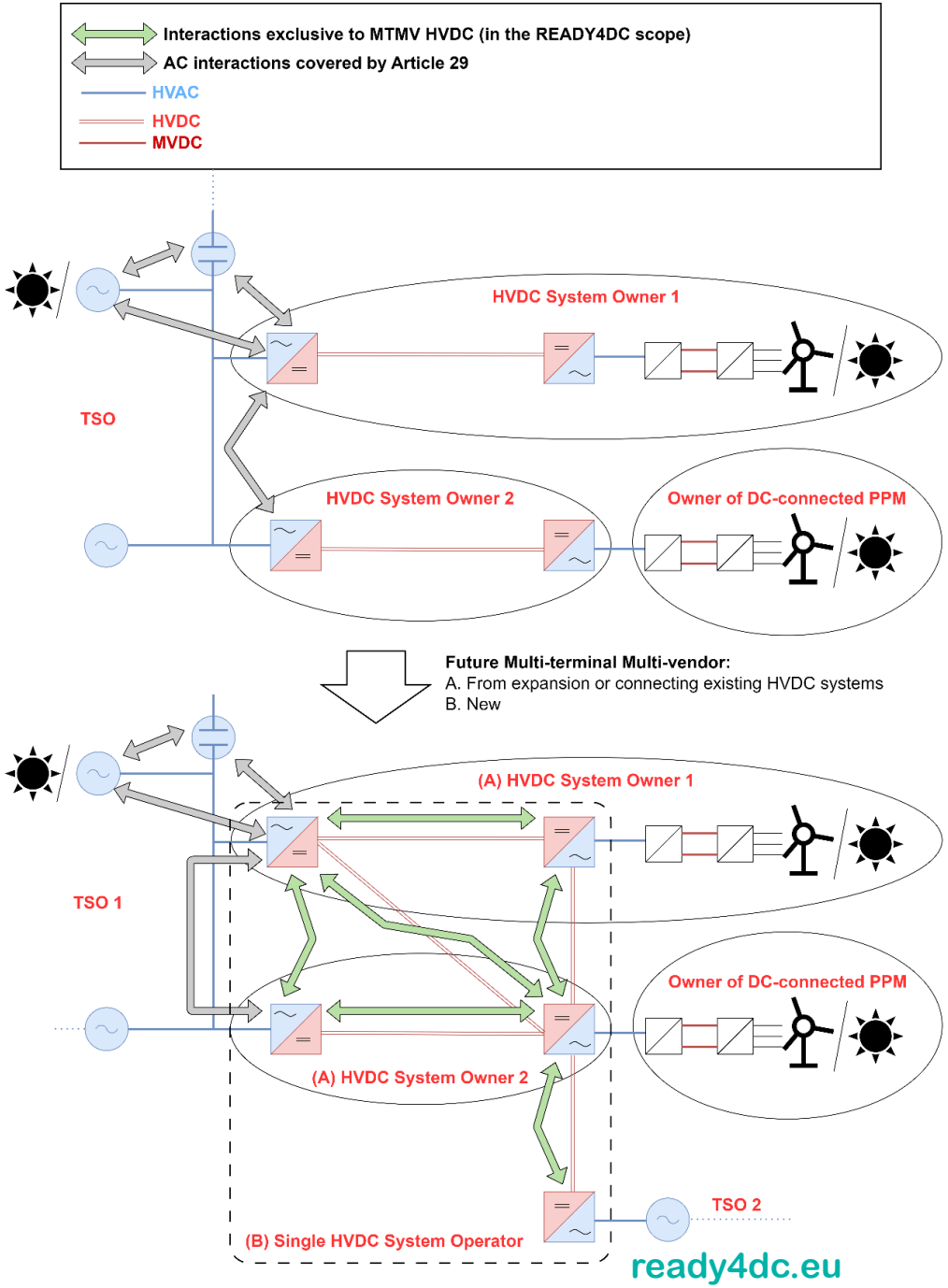
Generalities on interaction studies

LEGEND 1 (colored dot): ● AC specific | ● DC specific | ● AC or DC **LEGEND 2 (font):** Roman: from CIGRE B4-81 / *Italic: Proposed*

Multi-infeed and Interaction Studies

Interactions between: at least two main power electronic devices (HVDC, FACTS, Renewables, etc.)

Control loop interactions			Interactions due to non-linear functions			Harmonic and Resonance interactions	
Steady-state	**Slow Dynamics**	**Fast Dynamics**	**AC fault performance**	***DC fault performance***	**Transient stress and other non-linear interaction**	**Sub-synchronous resonance**	**Harmonic emission and resonance**
● *Converter power headroom management* ● *DC voltage limits (upper/lower)*	● AC filter hunting ● Voltage control conflicts (AC) ● P/V stability (AC)	● Power oscillations ● Control loop interactions ● Sub-synchronous control interactions ● *Voltage control conflicts (DC)* ● *P/V stability (DC)*	● Commutation failure ● Voltage distortion ● Phase imbalances ● Fault recovery ● Protection performance	● *Fault recovery* ● *Protection performance* ● *Interactions with passive components (i.e., converter interactions with DC reactors)*	● Load rejection ● Voltage phase shift ● Network switching ● Transformer saturation ● Insulation coordination ● *Electrostatic energy interactions (among converters)*	● Sub-synchronous torsional interactions (SSTI) ● Sub-synchrounous resonance (SSR)	● Resonance effects ● Harmonic emission ● Harmonic instability ● Core saturation instability
● *Static analysis (power flow)*	● Static analysis ● RMS time domain	● RMS time domain ● EMT time domain ● Small-signal analysis	● RMS time domain ● EMT time domain	● EMT time domain	● EMT time domain	● *RMS time domain* ● EMT time domain	● EMT time domain ● Small-signal analysis ● Harmonic analysis



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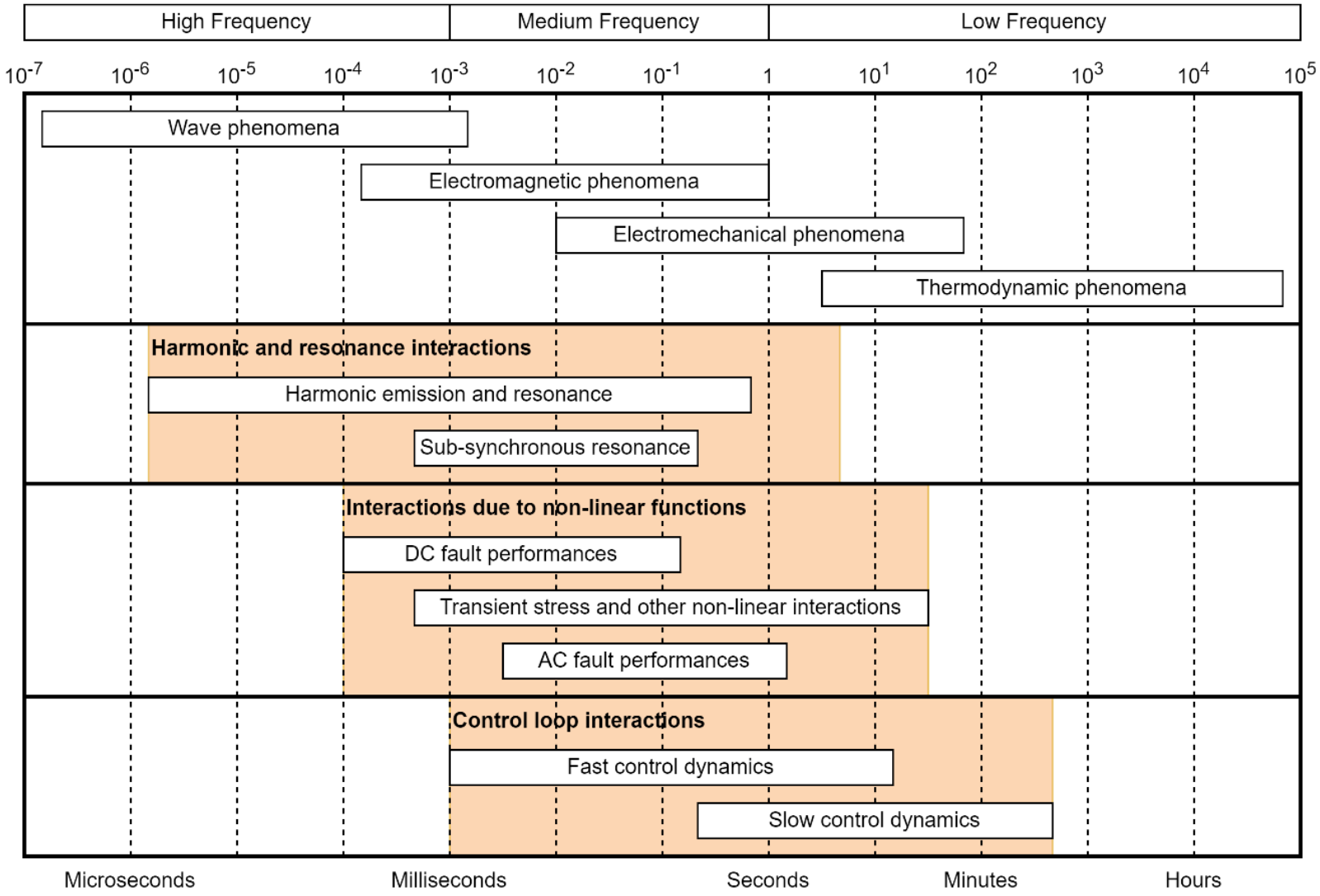
Current perimeter on interaction studies tools

- Design and testing
  - Small-signal analysis
  - Harmonic analysis
  - Modal analysis
  - RMS time domain (dynamic phasors)
  - **EMT time domain**
- **EMT simulations**
  - **Offline simulations**
  - **Real-time simulations**
    - **SIL and HIL**



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Interaction studies generic workflow

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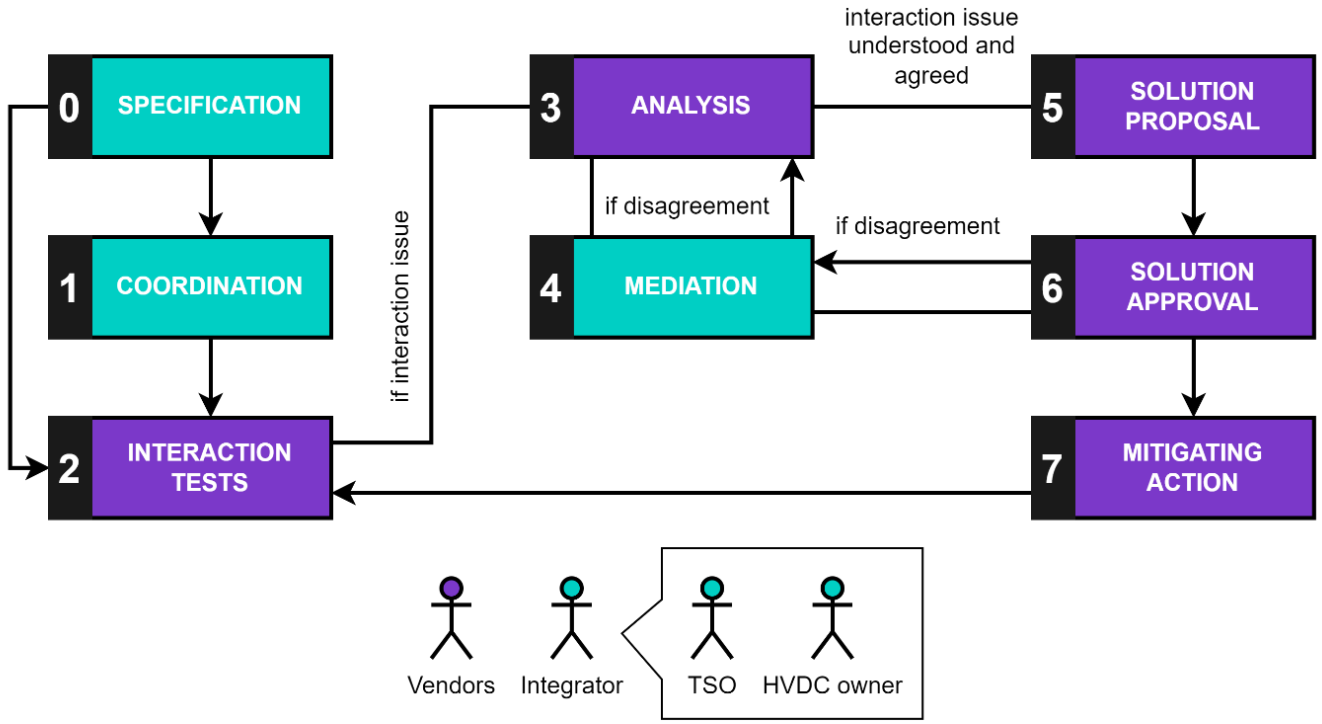
Initial workflow
Classic one evoked by T&D EU



Role analysis based on current EU code (Art.29)

ID	Stage	AC TSOs	HVDC system operator	HVDC system owner(s)	Vendors
0	Elaboration Validation Plan	Need to participate	Mandatory	Can participate	Need to participate
1	Animation: coordination of the models' exchange	Possible	Mandatory	Possible	Not responsible
2	Simulations: performing all case studies	Possible	Possible	Not responsible	Possible
3	Analyze the simulation results in case of interoperability issues	Mandatory	Mandatory	Not responsible	Possible
4	Mediation: In case of disagreement	Possible	Mandatory	Possible	Not responsible
5	Solution: recommending control update	Possible	Possible	Not responsible	Possible
6	Solution approval: update of the functional/technical specifications	Mandatory	Mandatory	Possible	Mandatory
7	Control Update: performing the control update/tuning	Not responsible	Possible	Not responsible	Possible

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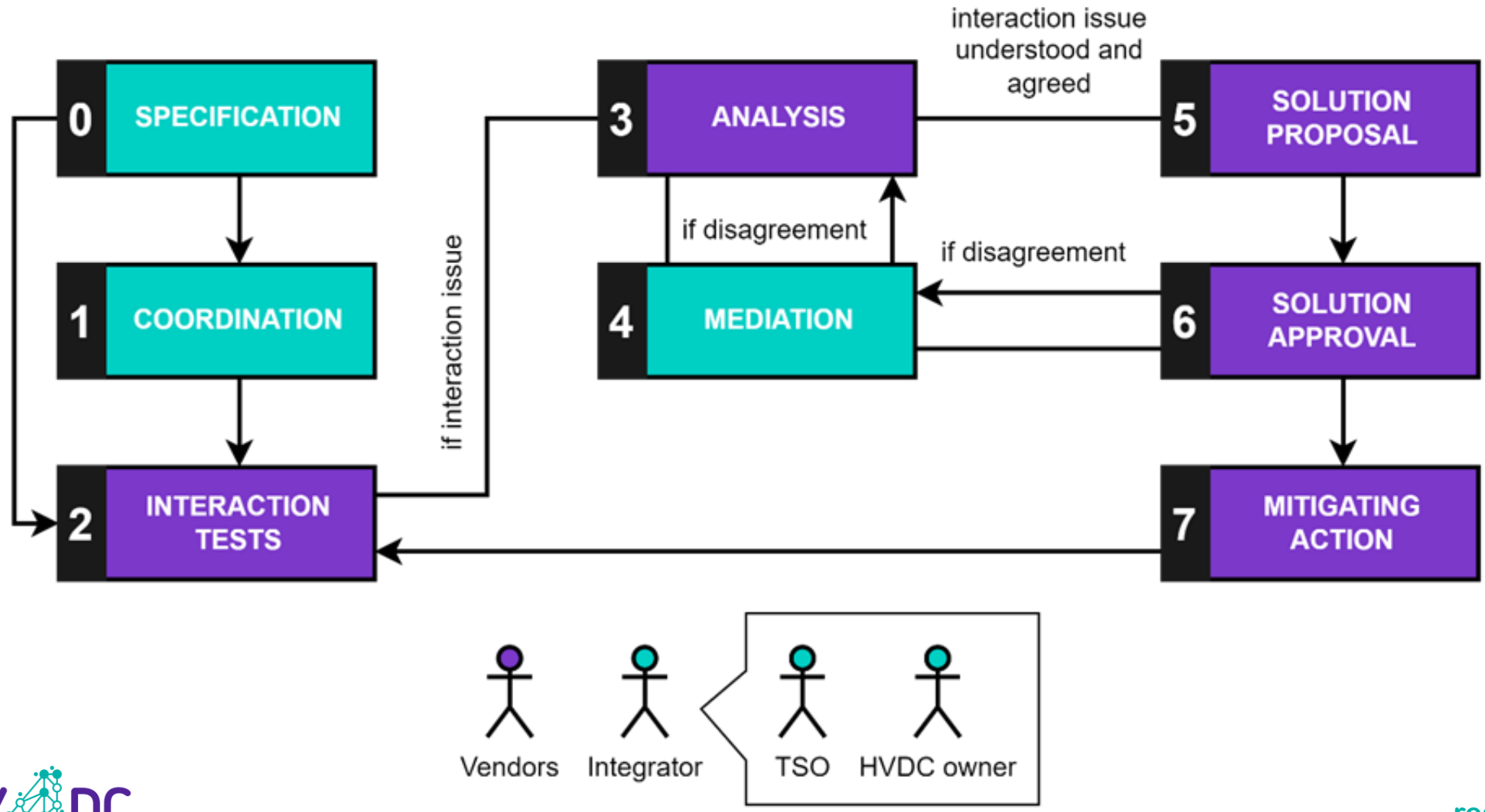
Scenario 1



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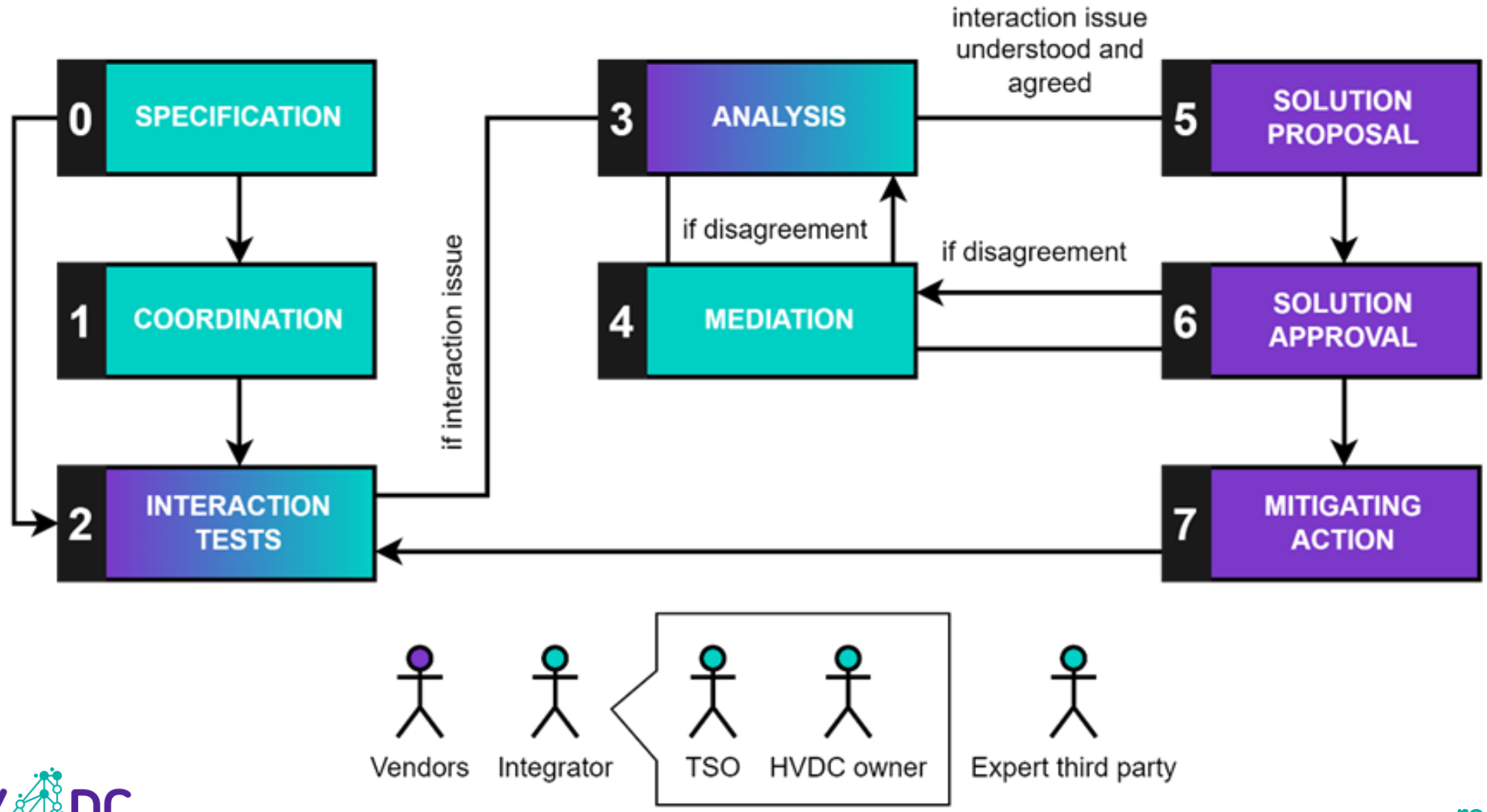
Scenario 2



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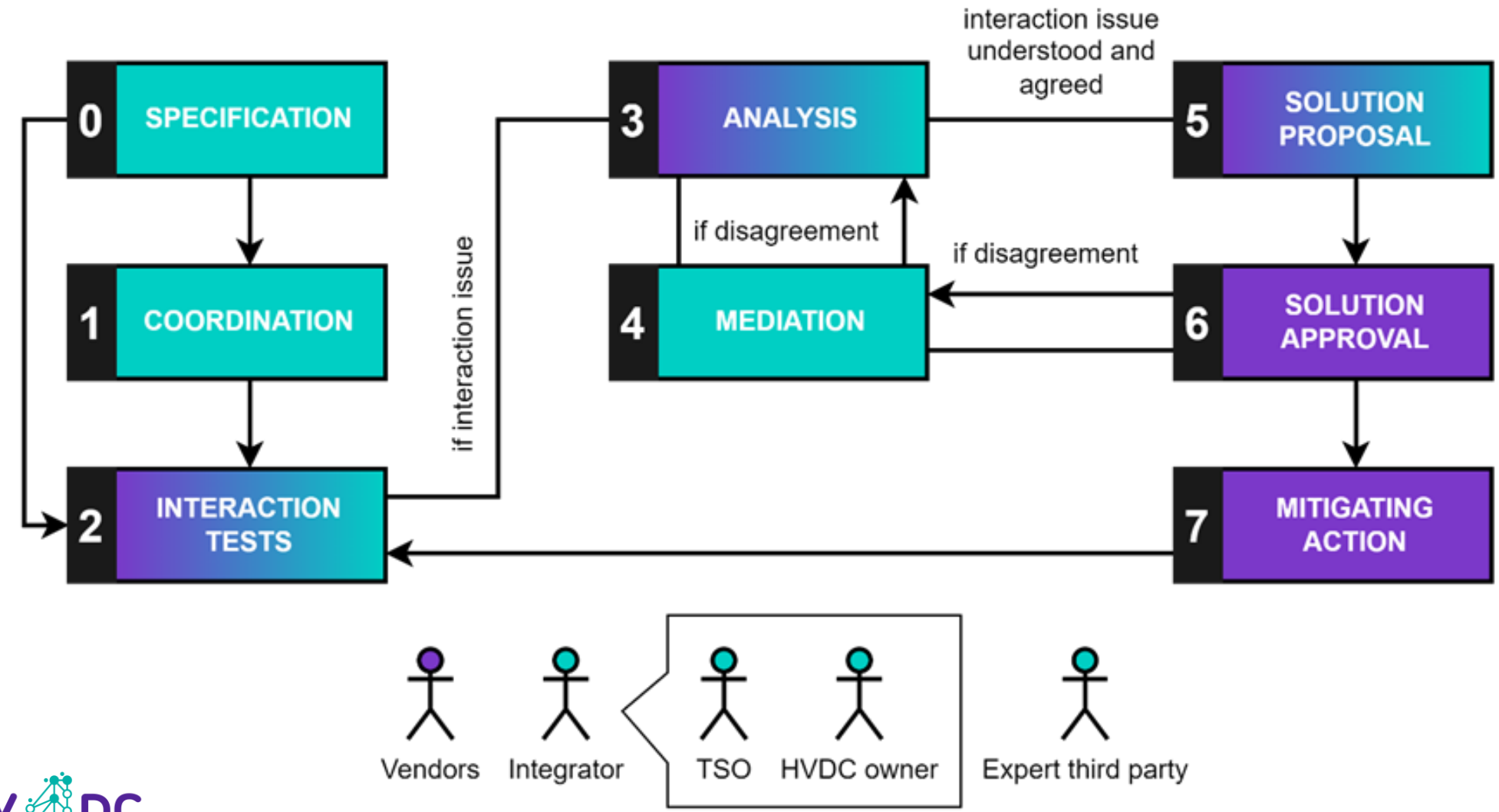
Scenario 3



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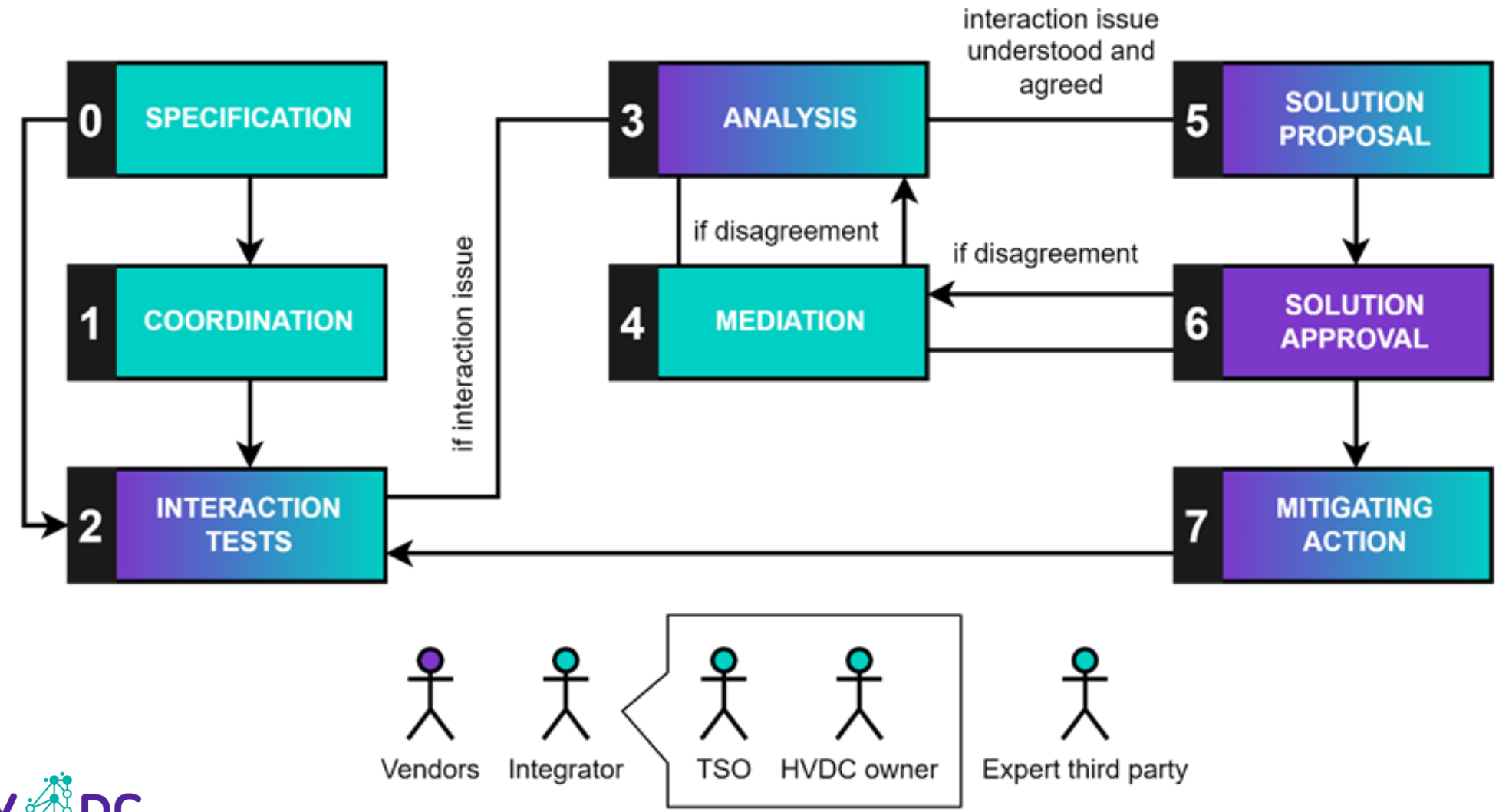
Scenario 4



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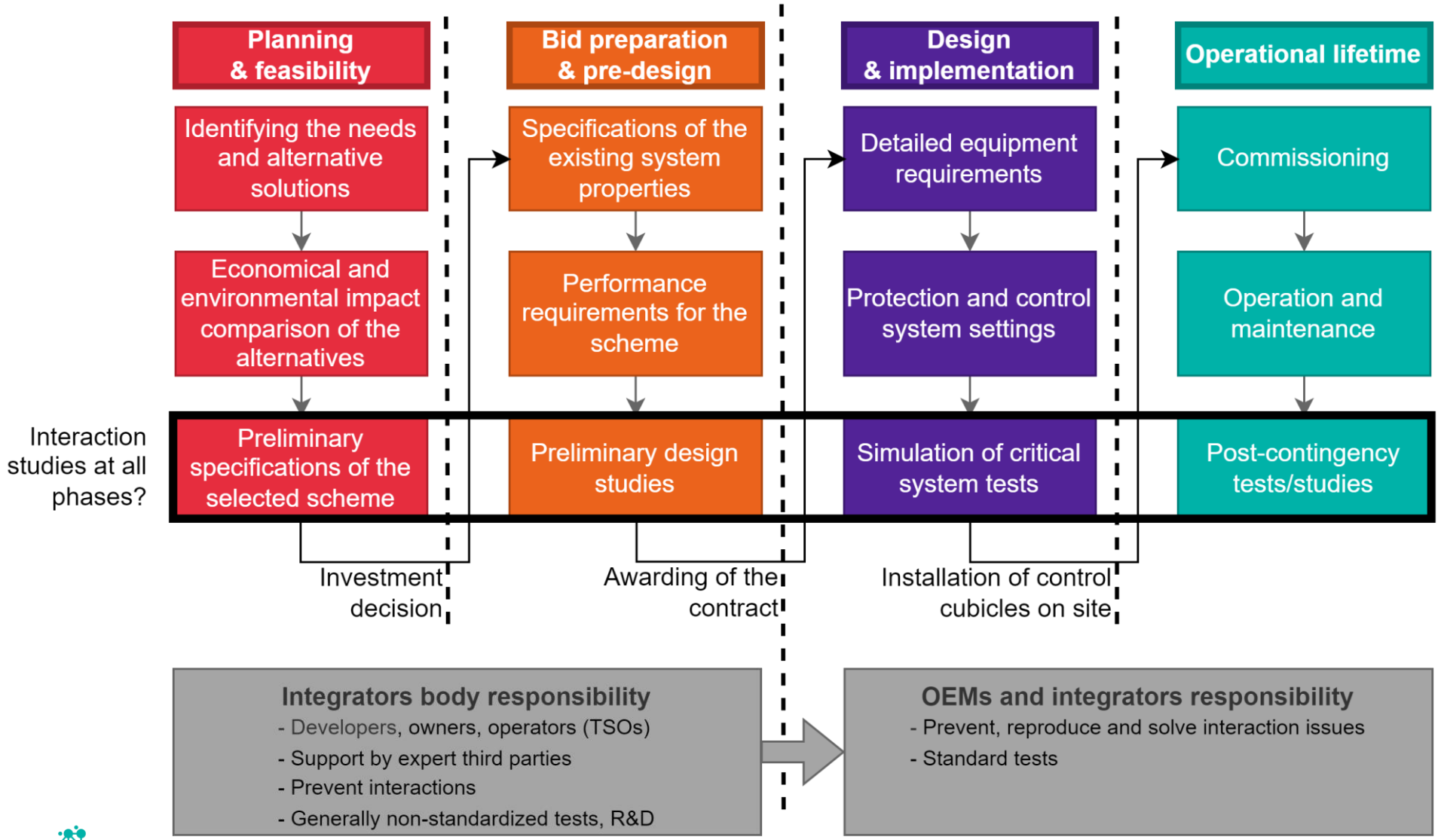
When are interaction studies relevant?



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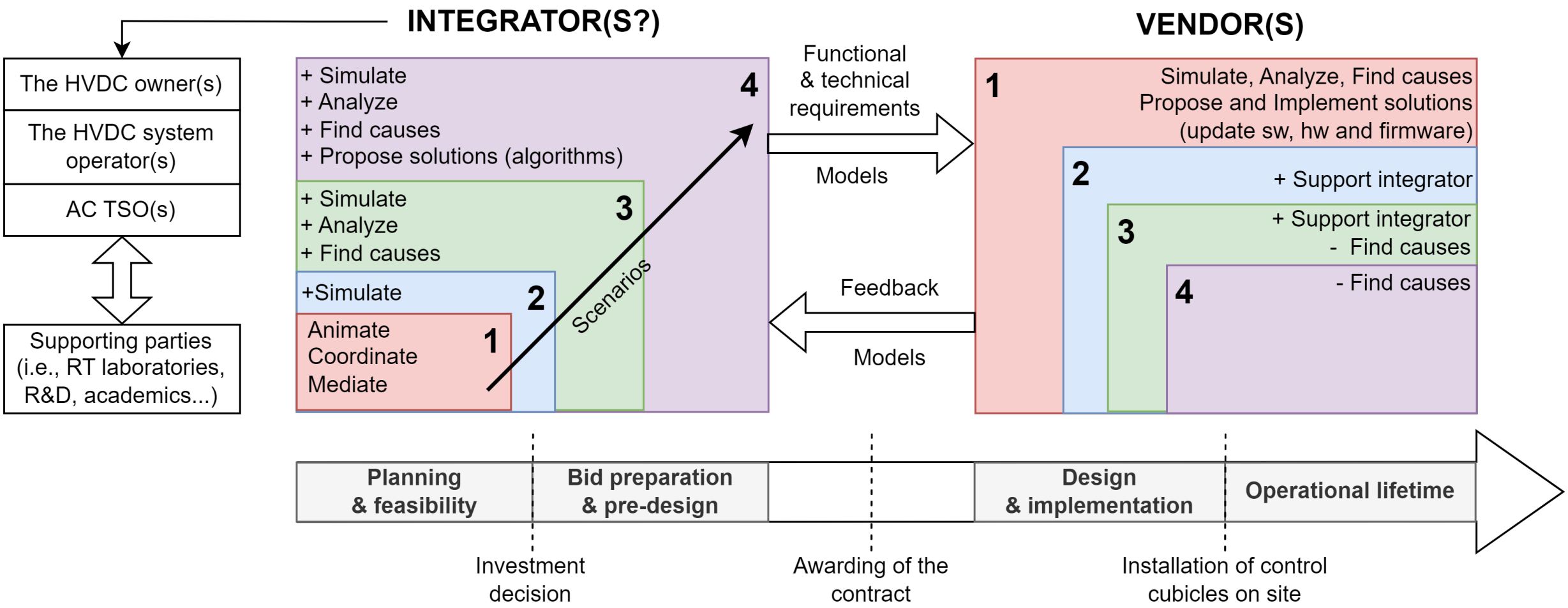
Discussed methodologies and roles



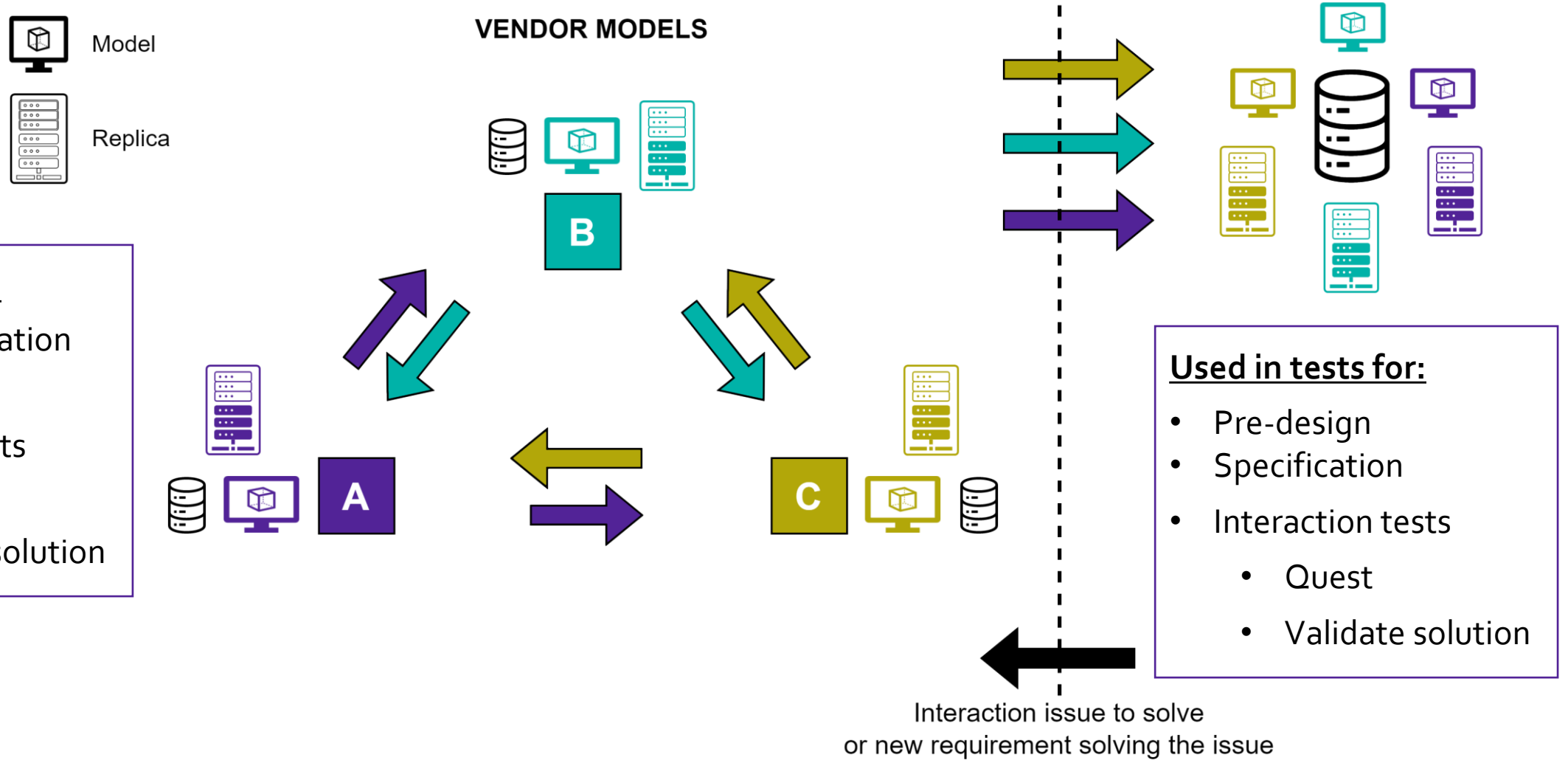
Impact of MMC accessibility scenarios on methodologies

Degree of accessibility of MMC control	Methodological Scenarios for Interaction Studies			
	1-Integrator delegates interaction studies **to vendors**	**2-Integrator-led** interaction studies **with strong vendors' support**	**3- Integrator-led** interaction studies **with limited vendors' support**	**4-Integrator-only** interaction studies
Low-degree	**Possible**	**Possible**	**Not practical**	**Not possible**
Medium-degree	**Not practical**	**Possible**	**Possible**	**Not practical**
High-degree	**Not possible**	**Not practical**	**Possible**	**Possible**

Solutions to enable interaction studies lead by an integrator at pre-bid stages while protecting vendors IP:

- Work with black-boxed models
- Other analysis methods not requiring models

Status on model exchanges in a MTMV context



Used in tests for:

- Design & validation
- FAT
- Interaction tests
  - Quest
  - Validate solution

Used in tests for:

- Pre-design
- Specification
- Interaction tests
  - Quest
  - Validate solution

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Simulation tools

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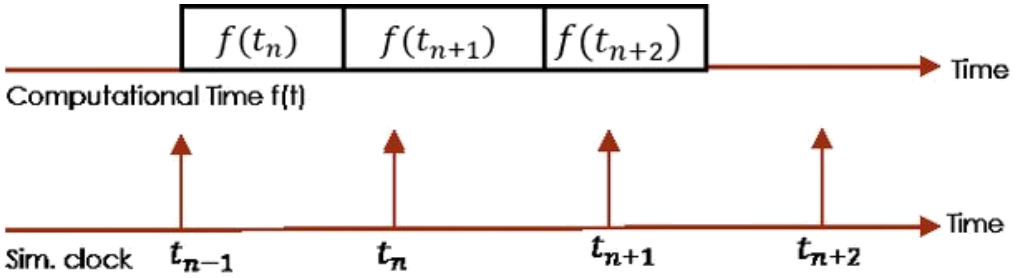
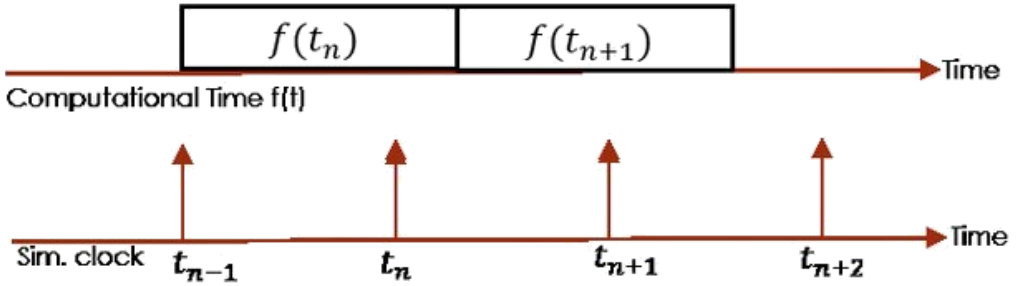
Section structure

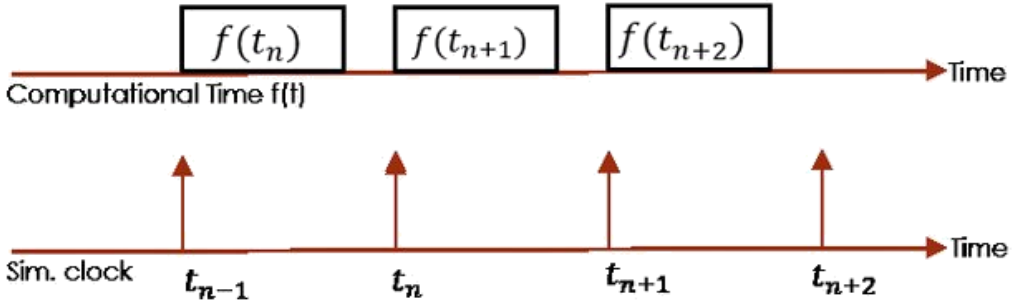
- EMT simulation a widespread approach for interaction studies at all stages
- Description of offline and real-time EMT studies
- Model compatibility, integration and validation aspects on each case
- Comparison of tools according to a variety of criteria



a. Offline Simulation: Faster than Real Time



b. Offline Simulation: Slower than Real Time



c. Real Time Simulation: Synchronized

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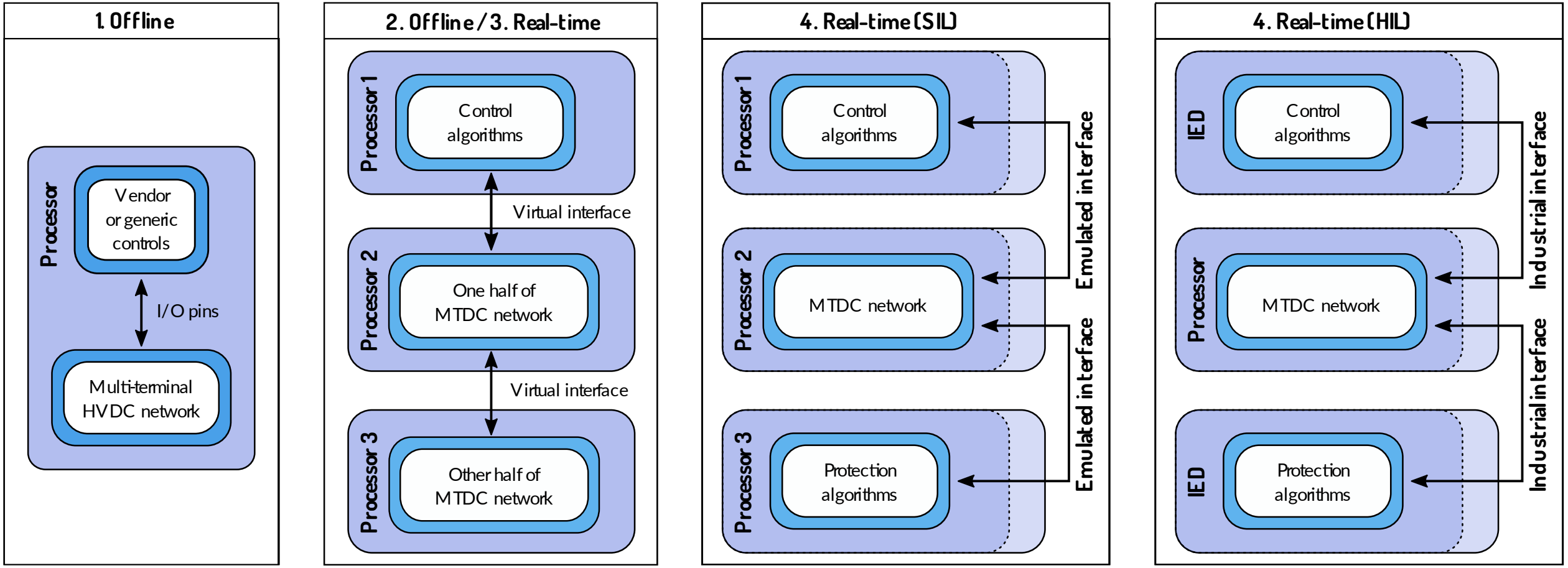
Simulation tools

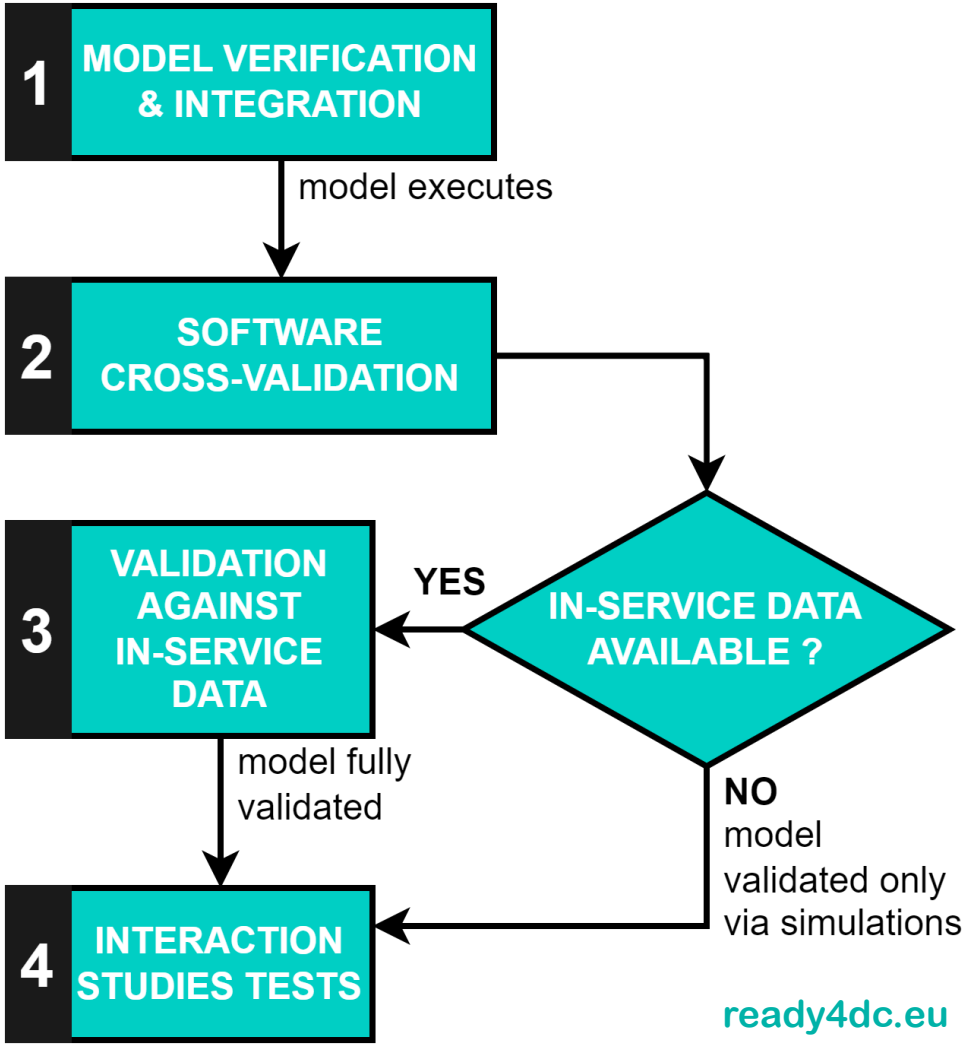
Description of offline and real-time EMT studies



Simulation tools

Model compatibility, integration and validation aspects on each case

1. **Complexity depending on**
   - Component modelled, MMC converter
   - Associated model documentation
   - Format and time step
2. **Complexity depending on**
   - Data available for comparison
   - System size
3. **During design & implementation stages**
4. **Interaction testing**
   - W/O in-service data, how relevant are interaction investigations ?



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Simulation tools

Comparison of tools according to a variety of criteria

	Type of models	Type of interface	Required simulator	HIL-ready	Popularity	Setup complexity	Computation speed	O&M costs	Fidelity to real control software	Fidelity to real hardware dynamics	Reusability	Maintenance effort	FPGA compatibility
Offline	Vendor or generic	Virtual IOs	Standard computer	No	Very common	Normal	Slow	1	1	Innacurate	High	High	No
Offline +	Vendor or generic	Virtual IOs	Advanced computer	No	Very common	Normal	Fast	2	1	Innacurate	High	High	No
SIL	Vendor or generic	Virtual IOs	Dedicated SW&HW	No	Uncommon	Moderate	Very fast	3	2	Innacurate	Moderate	Moderate	Maybe
SIL +	Vendor or generic	Physical IOs	Dedicated SW&HW	Yes	Uncommon	Moderate	Very fast	4	3	Unknown	Moderate	Moderate	Maybe
HIL	Vendor or generic	Physical IOs	Dedicated SW&HW	Yes	Rare	High	Very fast	4	3	Realistic	High	Moderate	Maybe
HIL +	Configurable hardware	Industrial IOs	Dedicated SW&HW	Yes	Rare	High	Very fast	5	4	Realistic	High	Moderate	Yes
HIL ++	Vendor replica	Industrial IOs	Dedicated SW&HW	Yes	Common	High	Very fast	5	5	High-fidelity	Low	Low	Yes

5

Summary & next steps

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Summary and next steps

Summary

- Positive and active internal feedback
- Four scenarios in a generic methodology are analyzed
- Just a start, but a good first step, cooperation has to continue
- EMT tools seem very important to analyse interactions:
  - However, black-boxed models (DLLs) are mostly used in offline simulations.
  - Replicas offer vendors low-risk control sharing, but seems unpractical for large EMT studies

Next steps

- Integrate feedback from InterOPERA relevant WPs
- Focus on legal risks of data sharing from a technical perspective
- Expand on technical aspects of model sharing
- Prioritize interaction phenomena with respect to the C&P architecture of MTMV system
- Summarizing the contents & minor form and structure changes

THANK YOU

Time for questions…

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WG2 Legal and Regulatory Framework Preliminary Results

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Dr. Philipp Ruffing and Vincent Lakerink

20-03-2023

1

Introduction

Introduction

- Whitepaper on Three Main Issues
  - Governance & Roles & Responsibilities (Ceciel Nieuwenhout)
  - Standardisation, IP, competition law (Vincent Lakerink)
  - Defining Liability and Risk Allocation (Philipp Ruffing)

- Current Phase:
  - Deliverable 2.1 – Status Quo: Ready and Available Online: Link
  - Deliverable 2.2: Preliminary White Paper ready and Available Online Link
  - Deliverable 2.3: Final White Paper > October 2023, After General Stakeholder Review

2

Defining Liabilities and Risk Allocation for Multi-Terminal Multi-Vendor HVDC Systems

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Introduction

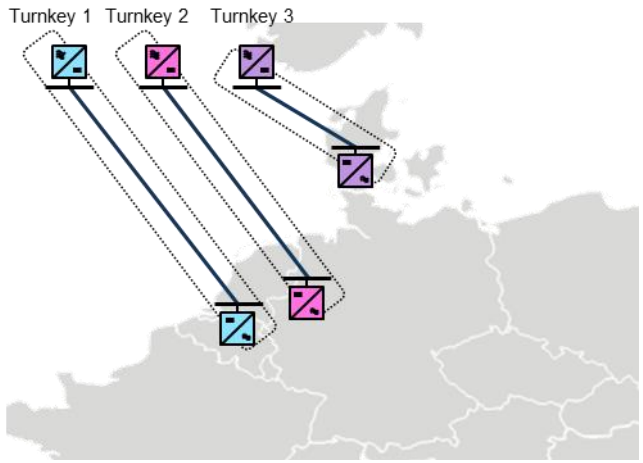
- Multi-Terminal Multi-Vendor HVDC systems are complex and involve multiple stakeholders and vendors.

- Defining liabilities and risk allocation is crucial to ensure **accountability** and avoid disputes in case of system **malfunctioning and interoperability issues**.

- Within Ready4DC principles and considerations for defining liabilities and risk allocation in such systems were outlined.
  - ➢ Deliverable 2.2

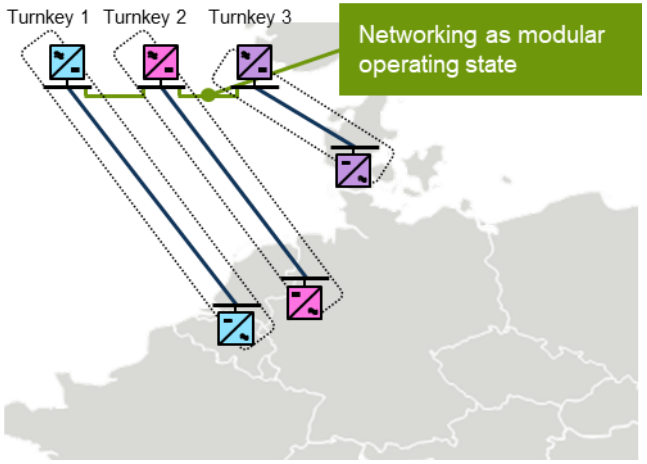
From Turn-key to Multi-Vendor Systems

Status Quo – Point-to-Point HVDC Systems



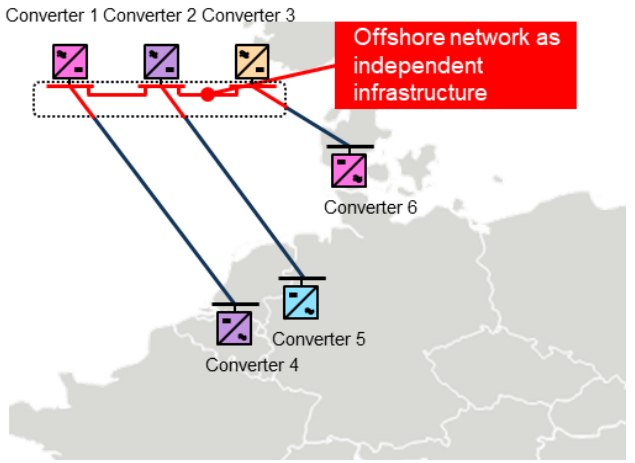
- Turn-key systems by a single vendor

DC-side connection of Multi-Vendor-Point-to-Point Systems



- Network based on the connection of turn-key systems
- Turn-key systems as fallback

Distributed Multi-Vendor Multi-Terminal Systems



- Fully modular MT/MV system
- Full responsibly on the system operator(s)

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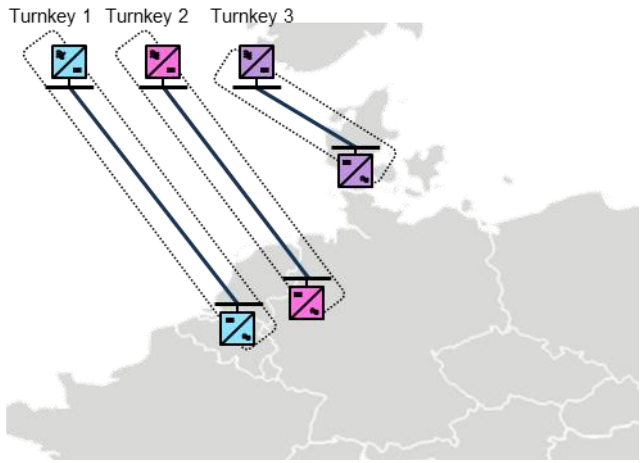
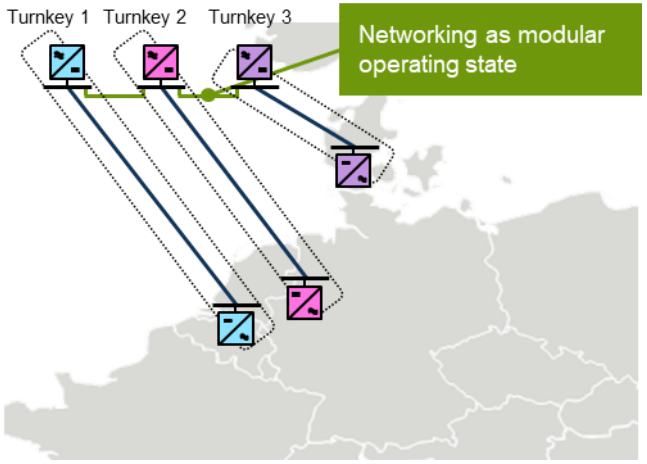
From Turn-key to Multi-Vendor Systems

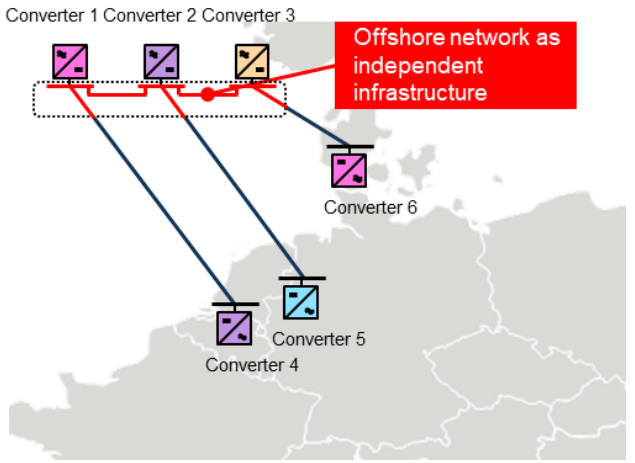
Status Quo – Point-to-Point HVDC Systems



DC-side connection of Multi-Vendor-Point-to-Point Systems



Distributed Multi-Vendor Multi-Terminal Systems



System responsibility shifts from the manufacturer to the TSO or system developer, increasing the design risk for the latter.

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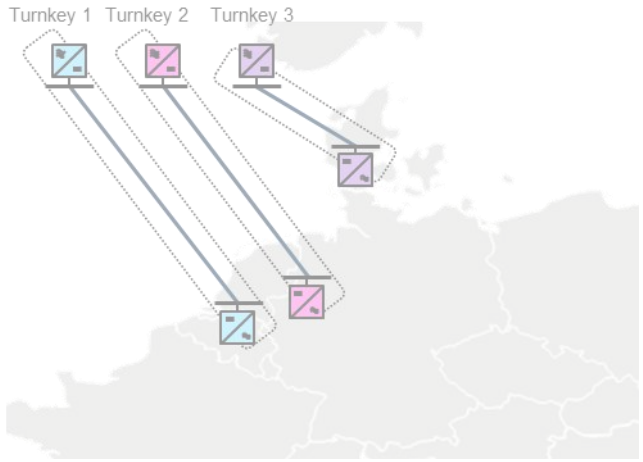
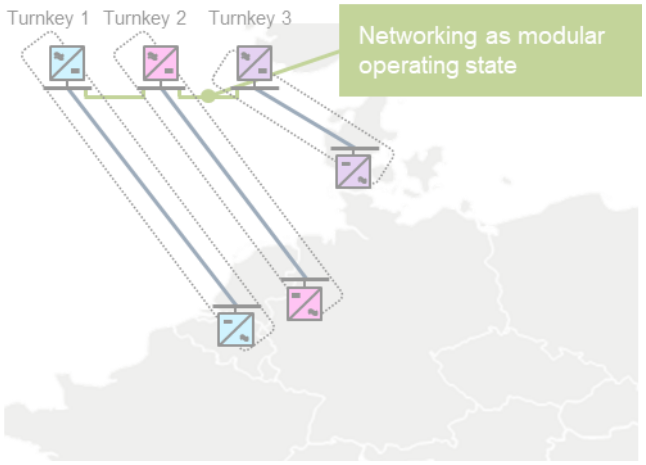
Methodology to

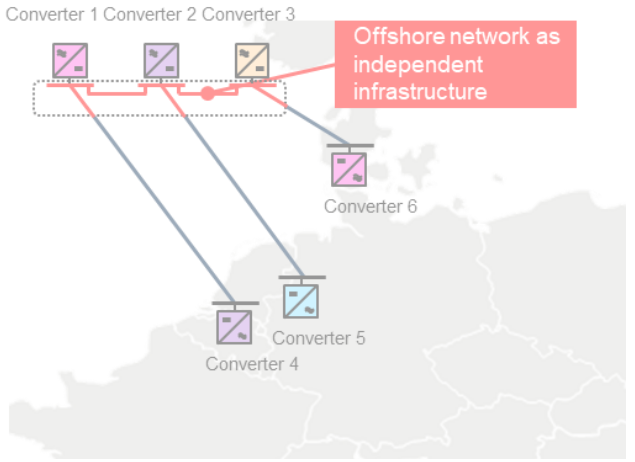
Status Quo – Point-to-Point HVDC Systems



DC-side connection of Multi-Vendor-Point-to-Point Systems



Distributed Multi-Vendor Multi-Terminal Systems



Identification of the MT/MV scenarios to be assessed → Identification of the MT/MV specific risks for all scenarios through the project phases → Proposals on how to distribute risks and liability

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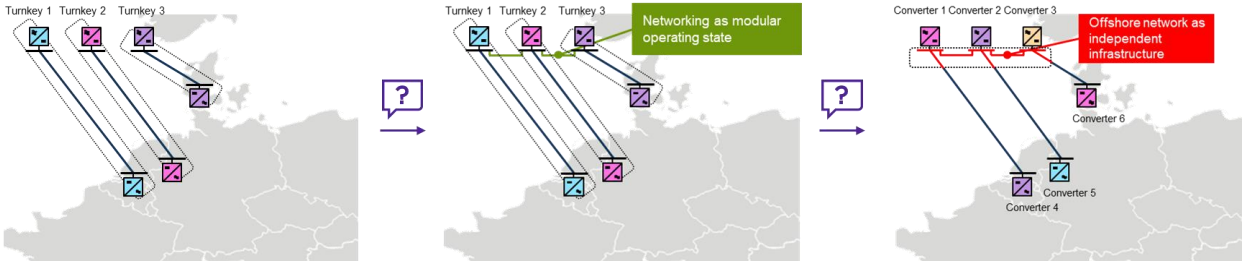
Project Preparation

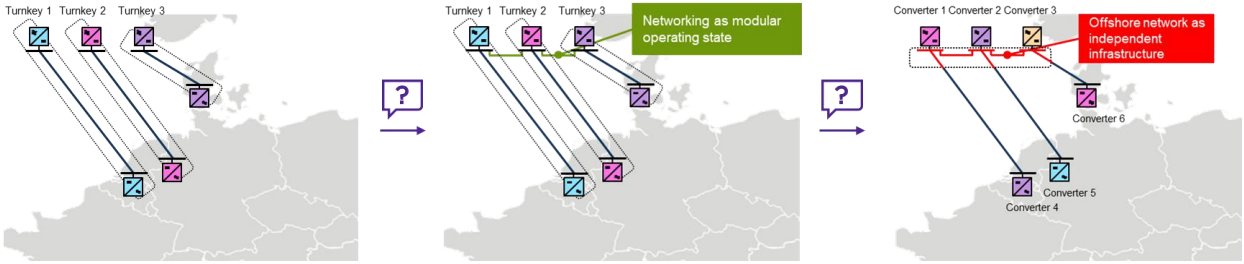


System Design

- **Responsibility for design shifts** from the vendor(s) to TSOs or system developers, increasing the design risk for the latter.
- The system developer will take on the role of the **system designer**, including the definition of functional and specific requirements at the DC connection points.
- The design of components, such as converter stations, will remain the responsibility of the HVDC vendors
  - Vendors are liable for malfunctions against the system designer's requirements

➢ Connecting turn-key systems can be an **intermediate step** in allocating risks and corresponding liabilities.

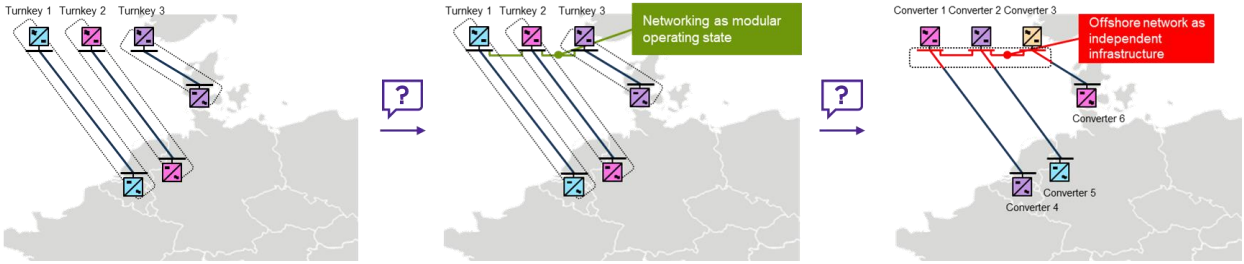
Project Preparation



Procurement

- Delays in completing a subsystem could impact the overall integration and interoperability test.
- Reliable methods are needed to determine responsibility for malfunctions of the overall system.
- Owner's requirements may not be precise enough to ensure interoperability.
- Clear assignment **in contracts** of responsibilities and liability is important.

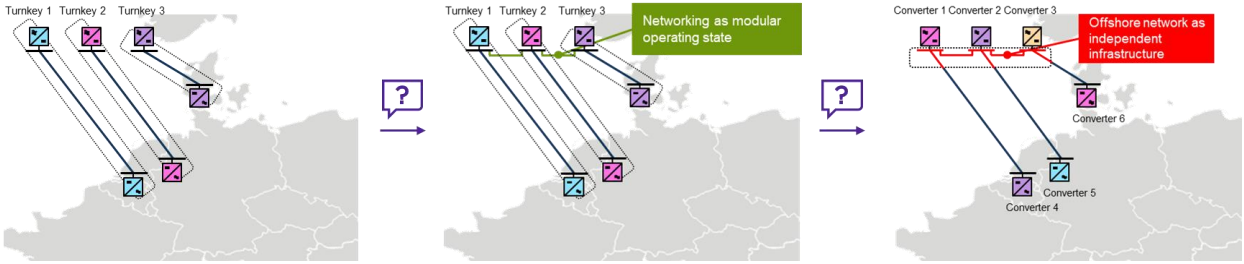
Project Execution



Engineering

- TSO and system developers bears the risk of new testing and interface challenges, such as interoperability tests between different vendors.
  (Limited experience, Delays in completing a subsystem could impact integration tests etc.)
- Delays and additional efforts that affect the schedules of other subsystems from different manufacturers
  - Risk reduction by test methods: Independent development and testing of subsystems
  - Reliable methods are needed to determine who is responsible for malfunctions

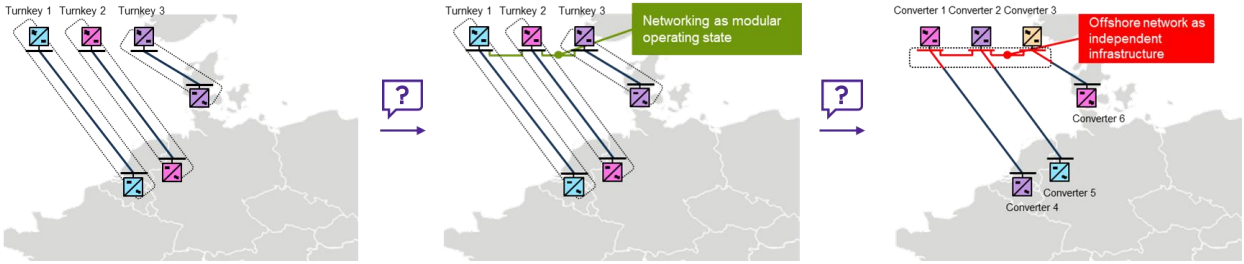
Project Execution



Commissioning

- Turn-key HVDC systems: One contractor is responsible for fulfilling the commissioning requirements for the entire system.
- Distributed multi-vendor systems: The TSO or developer of the system bears these responsibilities.
  - Interdependencies during the commissioning phase of the individual projects
  - Delays in commissioning can lead to considerable costs and liabilities for the parties involved
  - Warranties and penalties must be aligned to ensure that the party causing a delay is liable for resulting costs
  - Integration risks can arise if different modules from different vendors do not seamlessly integrate
- To reduce interdependency risks: Start with a moderate increase of interface

Operation



Malfunction / Performance related

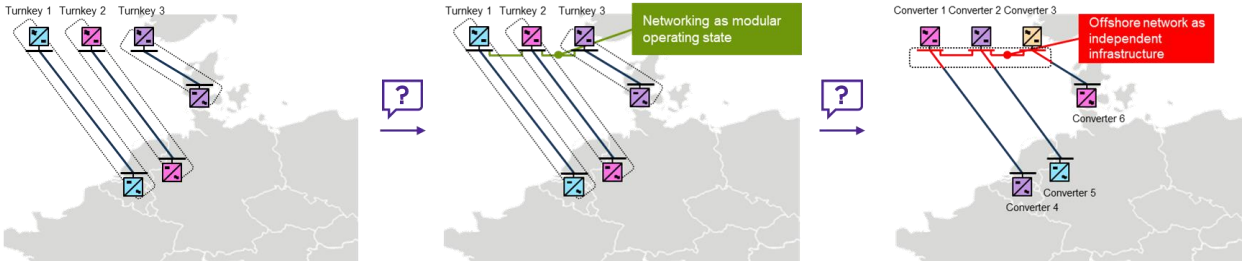
Interoperability risk:

- Cases: Power outages, reduced energy transmission and distribution, operational problems etc.
- Moving from single-vendor to multi-vendor systems shifts the liability from the vendor to the operator
- Mitigation strategies:
  - Defining and respecting responsibilities and liabilities of all parties involved
  - Formulating procurement processes and contracts to allocate liability and warranty risks

Performance Risks:

- Performance of the different modules does not meet the required specifications.
  - ➢ Reduced system efficiency and/or increased costs
- Hidden features or control methods might not be exchanged between the vendor and the owner or operator of the system
- Performance reduction and/or damages according from inadequate knowledge transfer to the operator

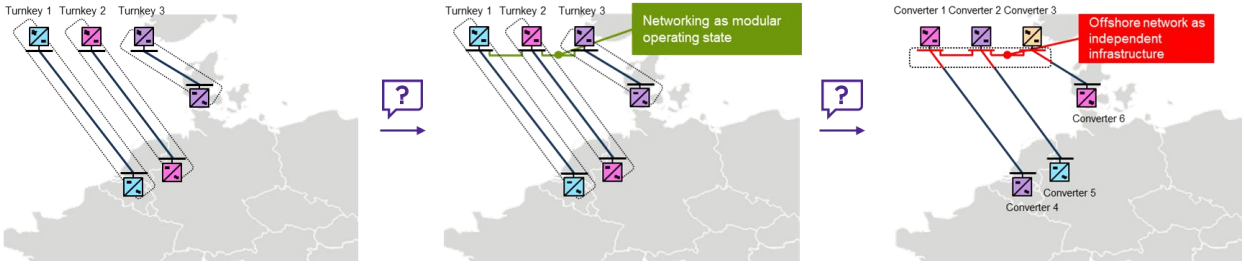
Operation



Faults causing damages

- Liability for damages depends on procurement contract and roles and responsibilities of parties involved
  - Interoperability testing to reduce risk of damages or faults from incompatible components or control systems
  - Clear allocation of roles and responsibilities in procurement contract
  - Clear procedures for investigating and allocating liability in case of fault or damage are needed
- Investigation should include review of design, installation, commissioning, maintenance, operation processes and data analysis
  - Adequate sensors, control systems, and monitoring equipment must be foreseen to facilitate investigation
  - Root cause of fault should be identified and liability allocated based on procurement contract

Maintenance



Maintenance

- Turnkey systems: contractor responsible for maintenance of entire system, including third-party components
- Multi-vendor systems: maintenance responsibility divided between different vendors, each responsible for their own components
- **Challenge:** Identifying root cause of fault and allocating liability in multi-vendor systems
- **Solution:** Clear maintenance contracts with
  - defined roles and responsibilities for each vendor
  - provisions for fault analysis and liability allocation

End of Lifetime

- Refurbishment
  - No additional risks that cause a shift of liabilities are identified.
- Decommissioning
  - No additional risks that cause a shift of liabilities are identified.

Summary and Next Steps

- The shift from turnkey HVDC systems to distributed multi-terminal multi-vendor HVDC systems can impact risks and associated liabilities in several ways:
  - **Turnkey systems:** single vendor responsible for entire project and liable for faults or damages
  - **Multi-vendor systems:** multiple vendors involved, increased risk of interoperability issues and difficulty in allocating liability
- Risk mitigation for early multi-terminal multi-vendor systems:
  - Connection of turn-key point-to-point systems from different vendors
  - Easier management and operation, possibility of separation if issues occur
- Minimization of risks and liabilities
  - clear definition of roles and responsibilities in contracts
  - clear guidelines for system integration and testing
  - thorough testing of interoperability

- Identification of the impact of MT/MV HVDC on liabilities and risk allocation
- Procurement strategy and concepts (templates) for contracts
- Implementation and lessons-learned
- Cross TSO exchange required

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3

Q&A

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Q&A

- Any questions?
- Suggestions?
- Other feedback?

Thank you!

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Coffee break

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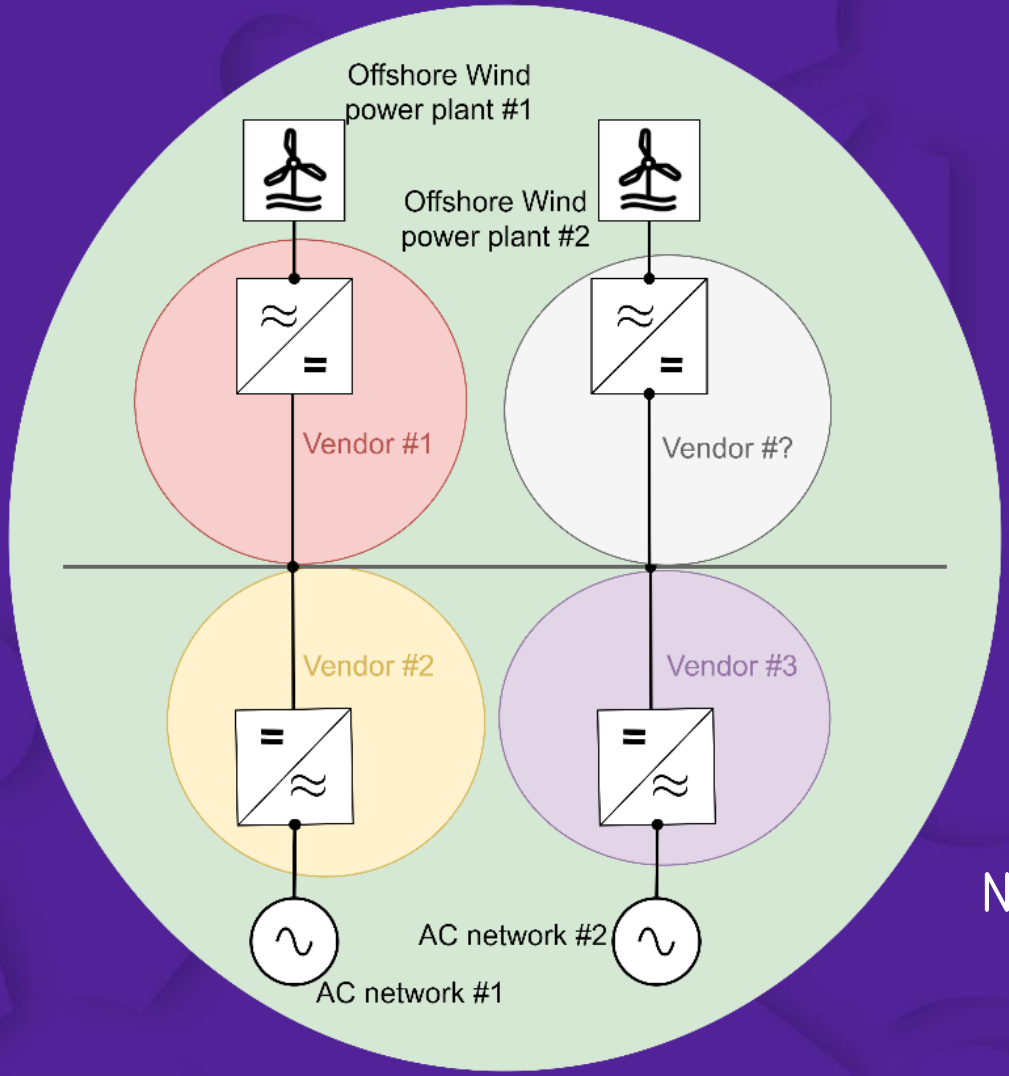
WP3 – Working Group (WG) on Multi-vendor Interoperability Process and Demonstration Definition (Lead:TenneT DE)

2nd stakeholder engagement event



READY DC

Nico Klötzl, TenneT

03.05.2023

ABOUT READY4DC

The future electricity network envisioned by READY4DC will be characterized by a growing role of multi-terminal multi-vendor (MTMV) HVDC solutions within the current AC transmission networks both onshore and offshore. READY4DC is contributing to this synergistic process by enabling commonly agreed definitions of interoperable modelling tools, model sharing platforms, clear processes for ensuring interoperability, and an appropriate legal and political framework.

DISCLAIMER:

This project has received funding from the European Union's Horizon Europe Research and Innovation programme under grant agreement No. 101069656.

PROJECT DETAILS:

Duration: 1 April 2022 – 31 October 2023

Grant agreement: No. 101069656

READY4DC

1

Overview of the WG3

WP3 Objectives

Guidelines for demonstration project in the European transmission grid (TYNDP)

- **Selection criteria** for the first MTMV demonstrator
- Proposal of potential (type of) **candidate projects**

Procedure for **selecting functional specifications**

Key milestones in implementing a first MTMV demonstrator

Roadmap future expandability beyond demonstration project

2

Early findings – Definition of selection criteria

Definition of selection criteria for the first MTMV demonstrator – Soft Criteria

- Must-have Soft Criteria
  - Multi Terminal
  - Multiple Vendors
  - Expandability
  - Reconfigurability of parameters
- Optional Soft Criteria
  - Multi-Purpose
  - Multi TSO cross-border / Inter-area projects

Definition of selection criteria for the first MTMV demonstrator - Functional specifications and DC grid needs

- Functional requirements
  - Compliance to system operation guideline (SOGL)
  - Fulfilment of transmission request
  - Provision of grid services
  - Grid Forming Capability
  - Improvement of ancillary services
  - Redundant coupling
  - Functions requiring use of technology components currently of low technology readiness level
  - Reduction of technical complexity/risk

- Design impacts
  - DC fault protection
  - DC control
  - …?

3

Early findings – Selection of potential candidate projects

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Selection of potential candidate projects

- Bornholm Energy Island
- North Sea Energy Island
- Generic MTMV system hub

4

Early findings – Procedure for selecting functional specifications

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Procedure for selecting functional specifications

5

Timeline till end of project

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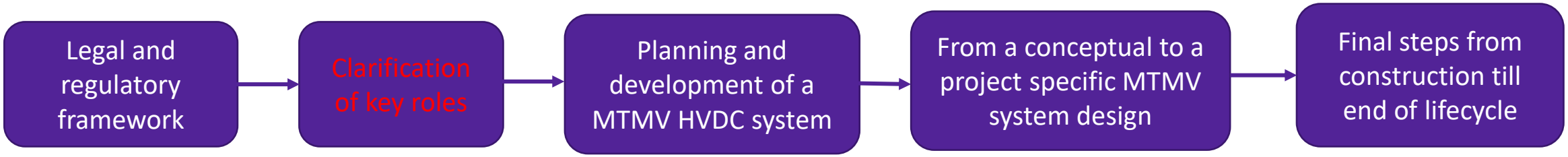
Remaining WP3 objectives

- Guidelines for demonstration projects in the European transmission grid (TYNDP)
- Procedure for selecting functional specifications of MTMV HVDC projects
- Key milestones in implementing a first MTMV demonstrator
- Roadmap future expandability beyond demonstration projects

Key milestones in implementing a first MTMV demonstrator



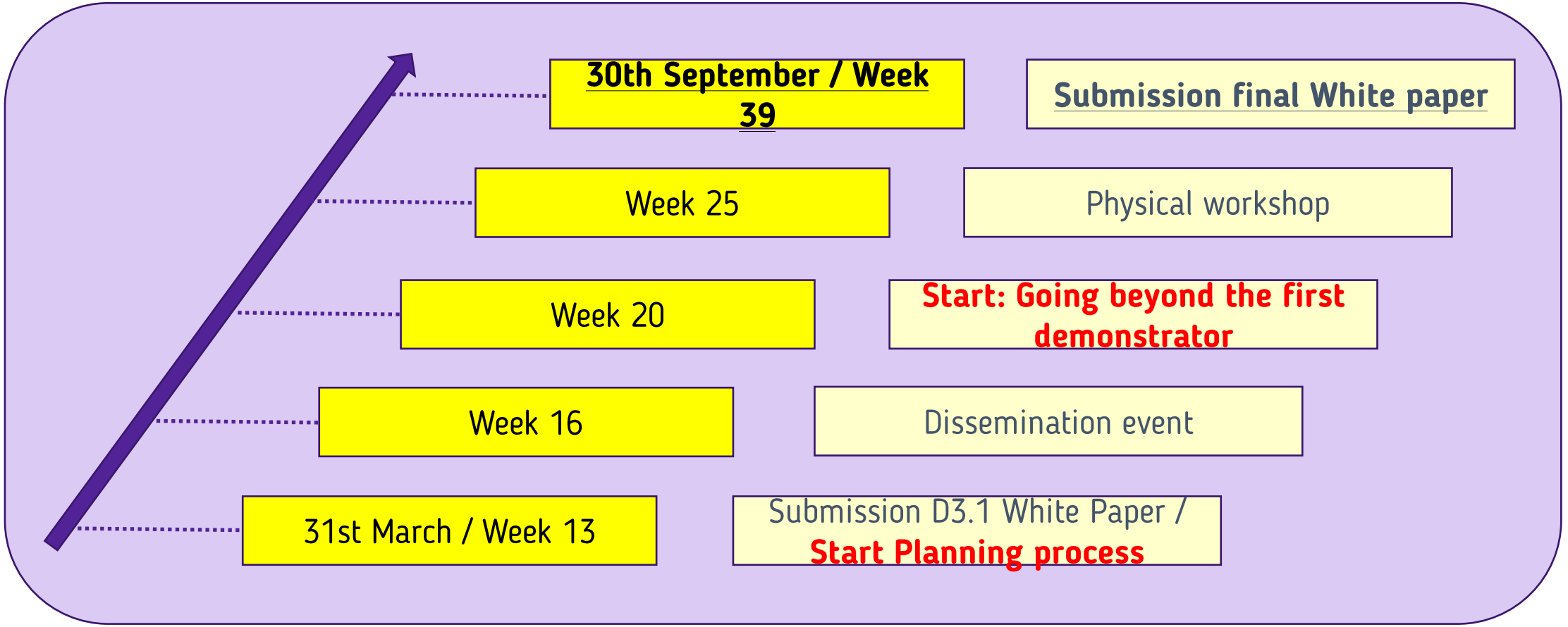
Menti.com: 21 55 13 7

Roadmap future expandability beyond demonstration projects

- Process for expandability towards largescale MV HVDC grids: e.g. impact of MTMV on Reliability and Resilience
- Review and formulate potential planning standards and roles of key actors
- Formulate recommendations to the regulatory bodies for necessary regulation
- Developments or amendments to network codes and operation guidelines
- Discuss possibilities to other DC multivendor applications on medium voltage

Menti.com: 21 55 13 7

Timeline


30th September / Week 39
Submission final White paper
Week 25
Physical workshop
Week 20
Start: Going beyond the first demonstrator
Week 16
Dissemination event
31st March / Week 13
Submission D3.1 White Paper /
Start Planning process

READY4DC project updates – call for nominations

- Aim of publicly available development of specifications
  - not only project partners but other institutions asked to contribute
  - Reach out to:
    - Nico Klötzl (nico.kloetzl@tennet.eu) or Karolina Daszkiewicz (Karolina.Daszkiewicz@entsoe.eu)
- Project website: https://www.ready4dc.eu/

Thank you!
Any questions?

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WG4 on Framing the Future European Energy System

(Lead: RWTH Aachen University)

Dr. Ilka Jahn(Chair) & Dimitar Kolichev,
Nuno Souzo e Silva (Co-Chairs)

3rd May 2023

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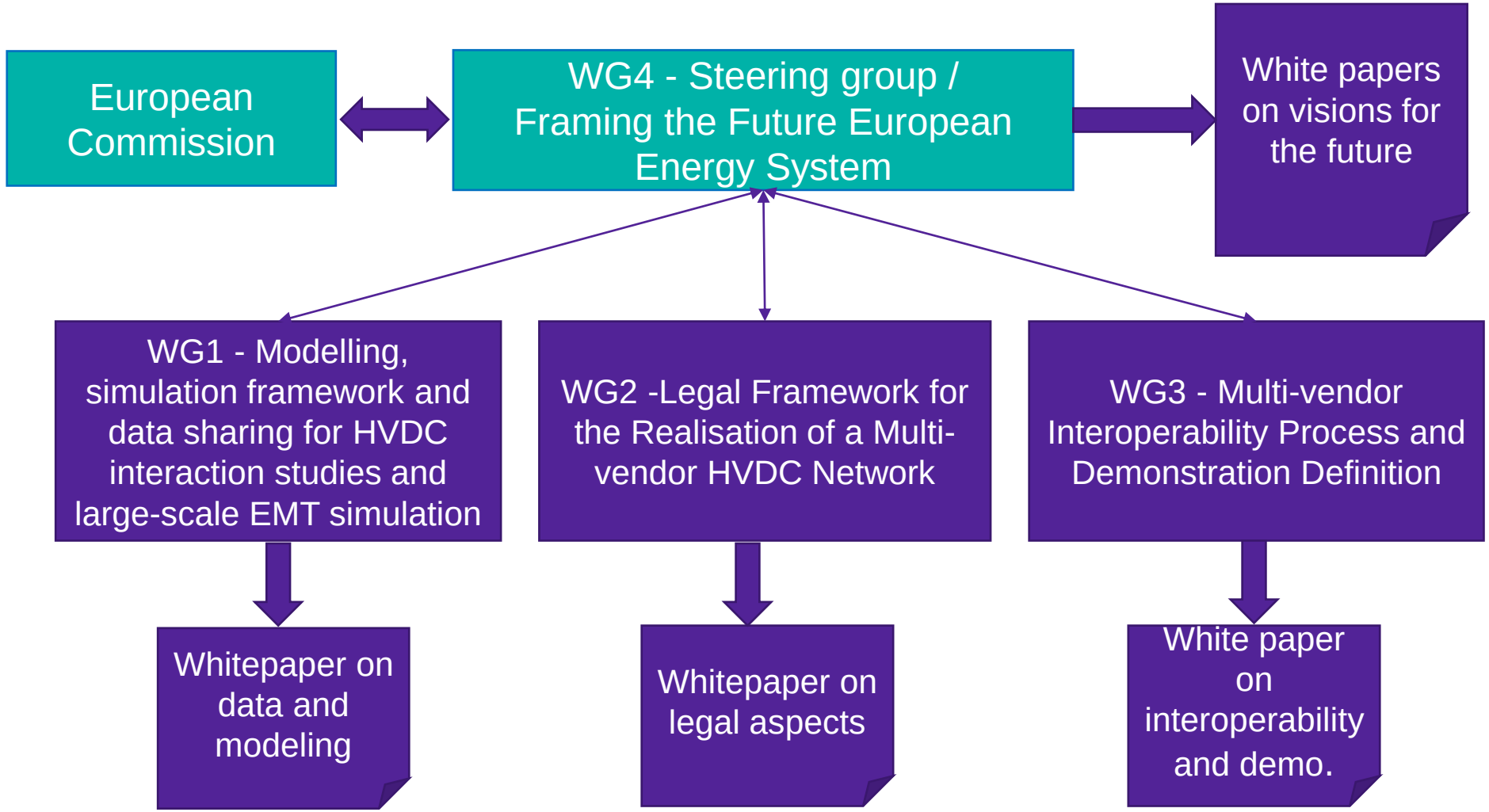
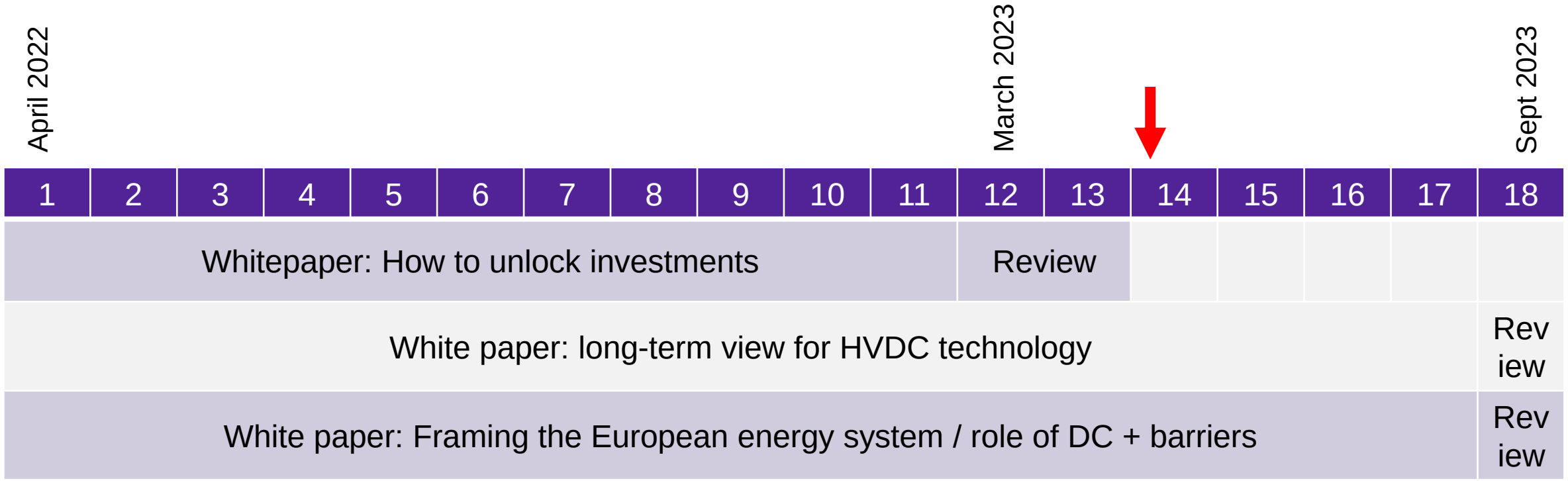
Project Structure



Timeline



Additional: Involvement in BRIDGE and SetPlan activities

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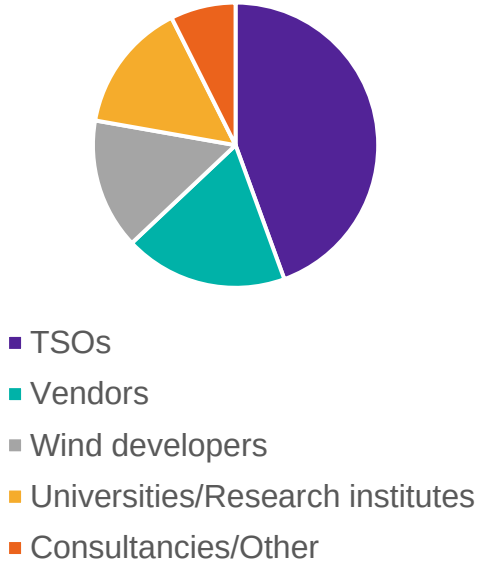
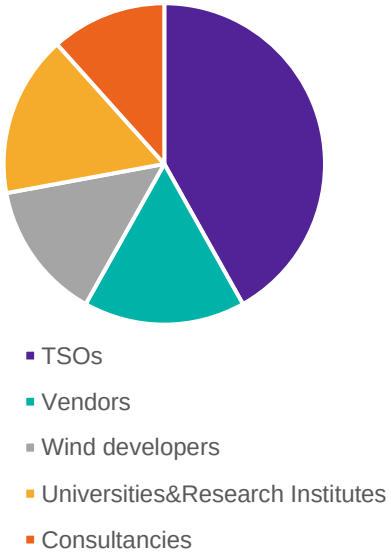
Member Statistics

WG4 list: 49 persons
Meeting attendance: 6-21 persons

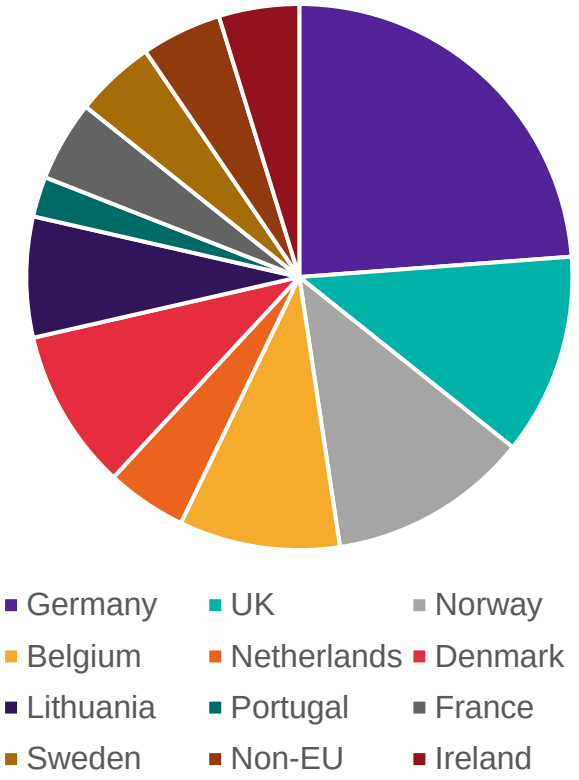
Stakeholders July 2022



Stakeholders May 2023



Countries May 2023



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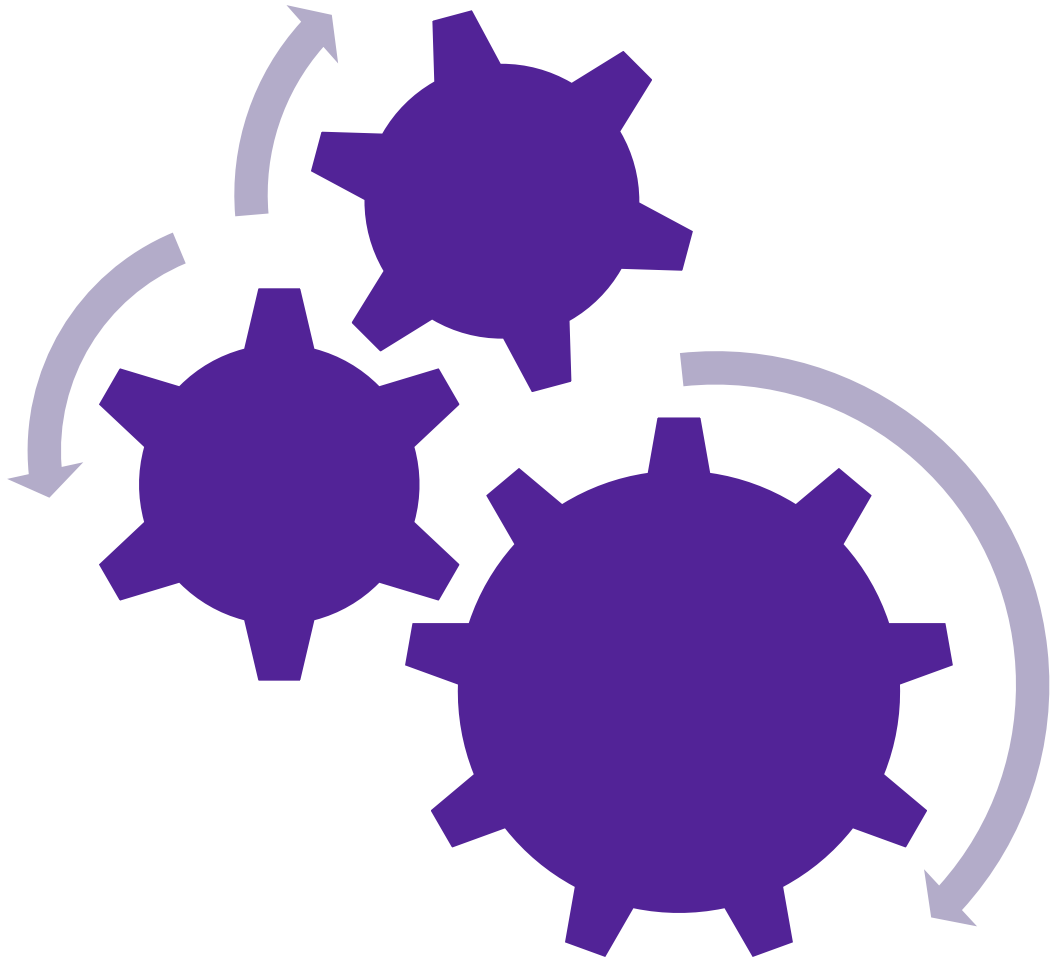
Whitepaper: Unlocking Investments

- Investment Options
- Investment Volume and Sustainability of Supply
- Blocks for Investing into the First MTMV HVDC Demonstrator
- Financial Decision-Maker Experience
- Plan to Unlock Investments

Whitepaper: Unlocking Investments --- Investment Options

- Complexity around
  - Regulation
  - Revenue stream
  - New parties joining the offshore market
  - Ownership
  - Cost sharing
  - …



Whitepaper: Unlocking Investments
--- Magnitude of an Example FOAK HVDC Component

- Size of initial FOAK (first-of-a-kind) projects may be high and outside (national) support schemes

- DC circuit breaker bypass (case study in PROMOTioN)
  - Onshore, connect two single-vendor p2p HVDC links
  - 17 million € … 38 million €
  - "Single piece of equipment"
  - Positive cost benefit yet risk considered too high

Whitepaper: Unlocking Investments --- Potential Subsidy and Funding Options

- Most likely finding for a FOAK will be with EU CEF/PCI (project of common interest)
- Open questions around anticipatory investments
  - Over-scaling of hardware, return to EU ownership?
- "FOAK Europe" for technology with strategic importance
  - Could consider technology integration aspects that can be different outside Europe
- Public/Private partnership could be a good option for financing and sharing risk (compare Neuconnect)

Whitepaper: Unlocking Investments --- Investment Volume and Sustainability of Supply

400 GW example if built point-to-point by (2050)

- 400 B€ for converters
- 120 B€ for cables

→520 B€

Converter station 2GW = 2 B€
Cable of 150 km, 2M€/GW/km

…also: cost and benefit of meshing (see e.g. PROMOTioN)

→ 20 B€ investment per year each year until 2050

vs. revenue (2022) of large North Sea TSOs roughly 10-20 B€

Whitepaper: Unlocking Investments --- Project Funding and the Long Term

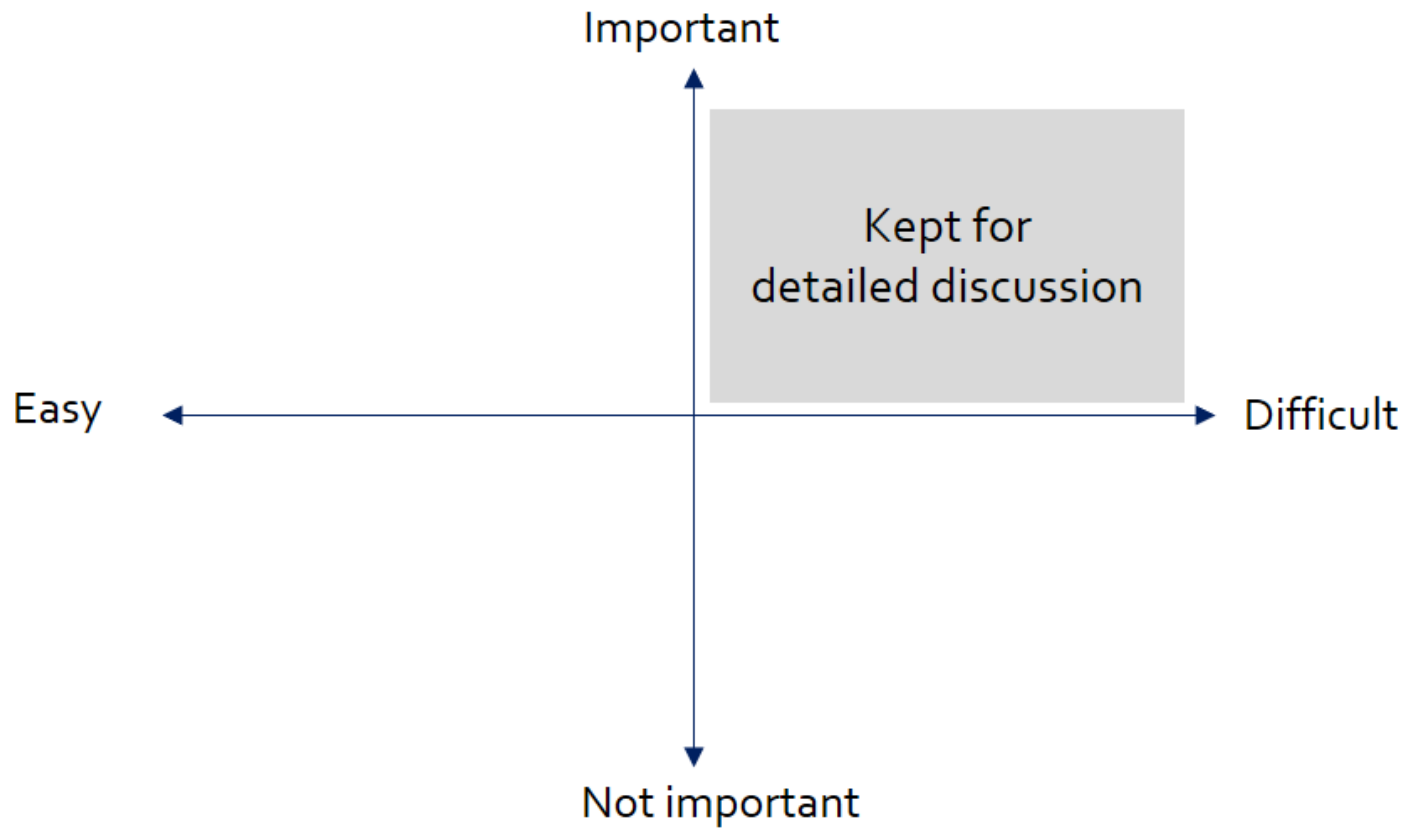
- Sheer size of investments → public/private partnerships
- Fully private initatives require cooperation of offshore grid operator

Whitepaper: Unlocking Investments --- Investment Volume and Sustainability of Supply

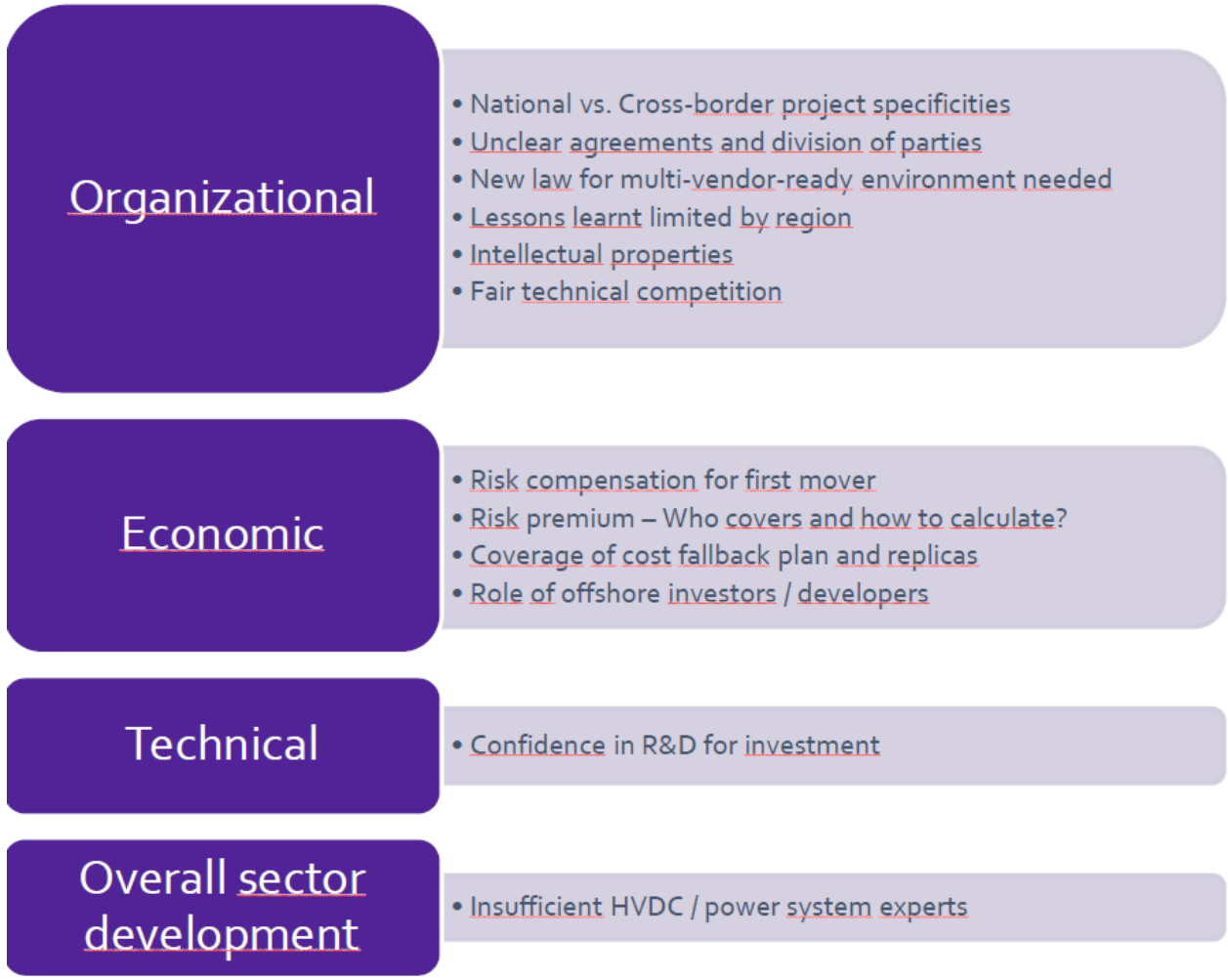
Survey in READY4DC community December 2022

- The teams' workload (during writing of this paper) ranges from 60% to 250% with
  - 15% of employees judging their team being loaded 200-250%
  - 20% of employees judging their team being loaded 130-150%
  - 41% of employees judging their team being loaded 90-120%
- More than half the teams are currently hiring 20-40% of their size.
- One year from now, most teams need 0%-60% extra staff.
- Five years from now, the teams need between 0%- up to more than 200% extra staff.

Whitepaper: Unlocking Investments
--- Blocks for Investing into the first Demonstrator



Whitepaper: Unlocking Investments --- Blocks for Investing into the first Demonstrator



Whitepaper: Unlocking Investments --- Financial Decision-Maker Experience

- Investors
  - Stable regulation
  - More appetite for unproven technology as long as long-term perspective is promising
  - Oversizing and fall-back option into single-vendor sounds good for de-risking
- TSOs
  - Political support is crucial and urgently needed for investments in new technology
  - Anticipatory investments have to be possible
- Wind Developers
  - Clear definition of ownership, governance, operation, cost-sharing etc. needed
  - Wind developer objectives vs. onshore TSO objectives
  - Revenue vs security of supply (TSO) → N-1 design and associated cost?

Whitepaper: Unlocking Investments --- Plan to Unlock Investments

- De-risking
  - Using multi-vendor HiL testing
  - Fall-back options ”core task” (e.g., wind energy to shore) and ”extra functions” (MT and/or MV)
  - Over-dimension
- Allow anticipatory investments
- Political support boosts development

(Preliminary) Feedback from InterOPERA --- open questions for WG4

- Organization – does a party have the staff and skills to deliver?
- Supply chain/procurement
  - is there sufficient supply chain organization and planning to be able to deliver the project on time (cash flows out early and revenue is delayed until the project is completed)
  - Understanding of the procurement process for partial assets (extensions of an existing grid)
- For non-TSOs or Multinational commercial projects, the ability to connect to the onshore grid on time to be able to sell into the desired markets
- Stability of the Markets, Regulation, Proposed Revenue streams

Next steps & Join us!

- WG4 on Framing the Future European Energy System
  - White paper: long-term view for HVDC technology
  - Framing the European energy system / role of DC + barriers
- Meetings by doodle
- ilka.jahn@eonerc.rwth-aachen.de
- More information: www.READY4DC.eu

THANK YOU

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Closing remarks

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THANK YOU!

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