# HVDC Operators' Forum

## Introduction to the methodology used to develop generic functional requirements for the MTDC building blocks, in the context of the North Sea Wind Power Hub initiative

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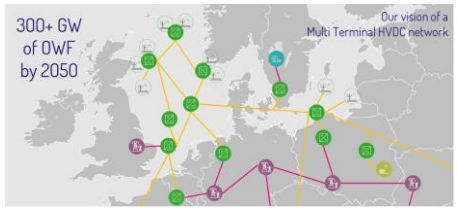


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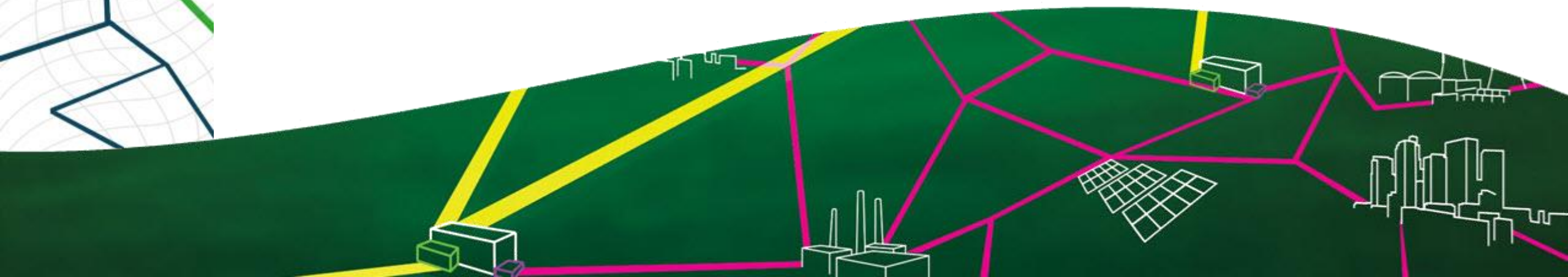
# Context



# North Sea Wind Power Hub Consortium

- To reach climate neutrality in 2050, significant offshore wind capacity needs to be built (from 15 GW to 300 GW in EU)
- Need to pro-actively facilitate affordable and secure connection and integration of this vast amount of energy
- North Sea Wind Power Hub proposes a modular **hub-and-spoke concept** based on **HVDC building blocks**, with the ambition to realise the first hub in the early 2030s

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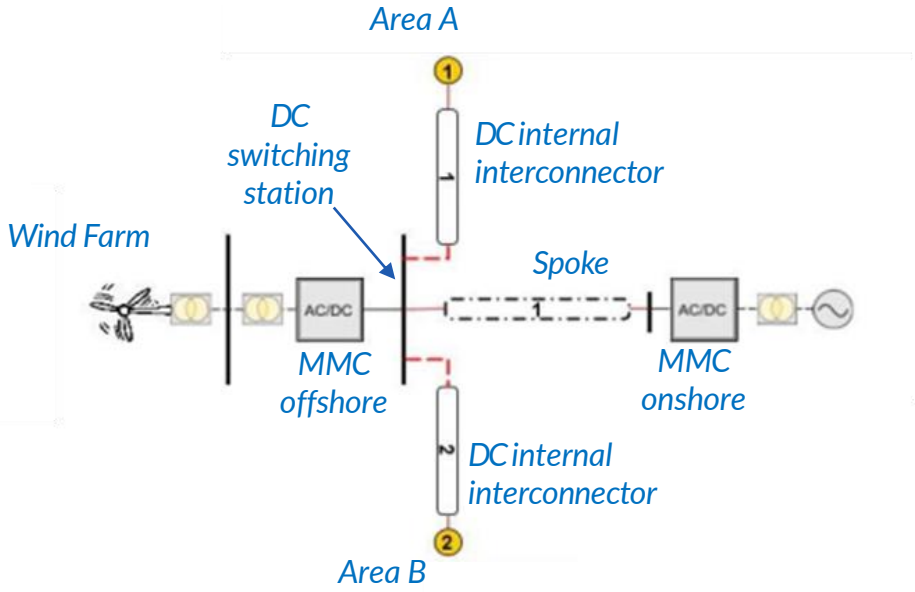
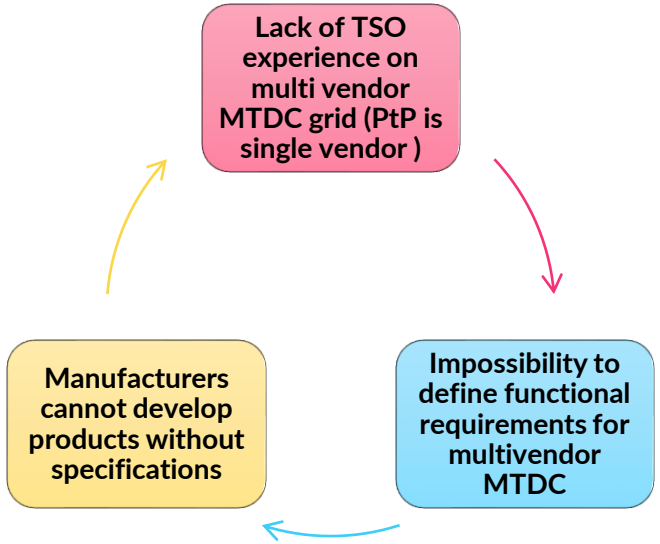
# HVDC building blocks

- HVDC building blocks of 2 GW 525 kV
- MMC converters, Bipolar with metallic return

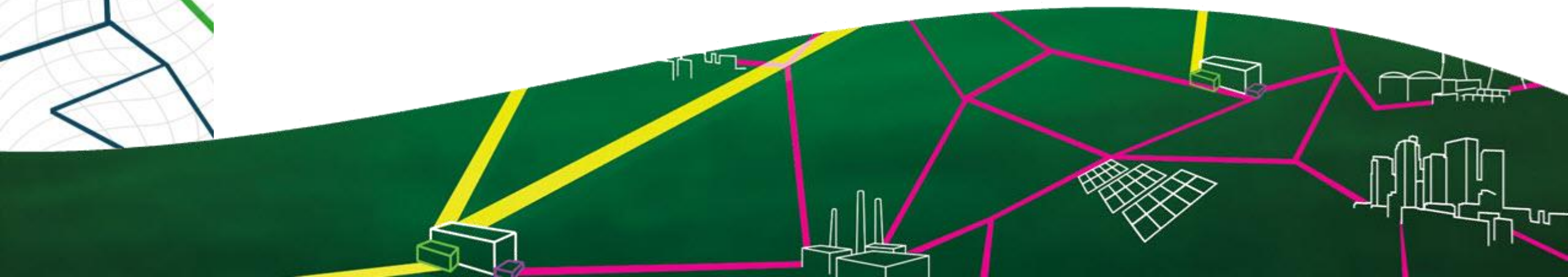



***The vicious circle***

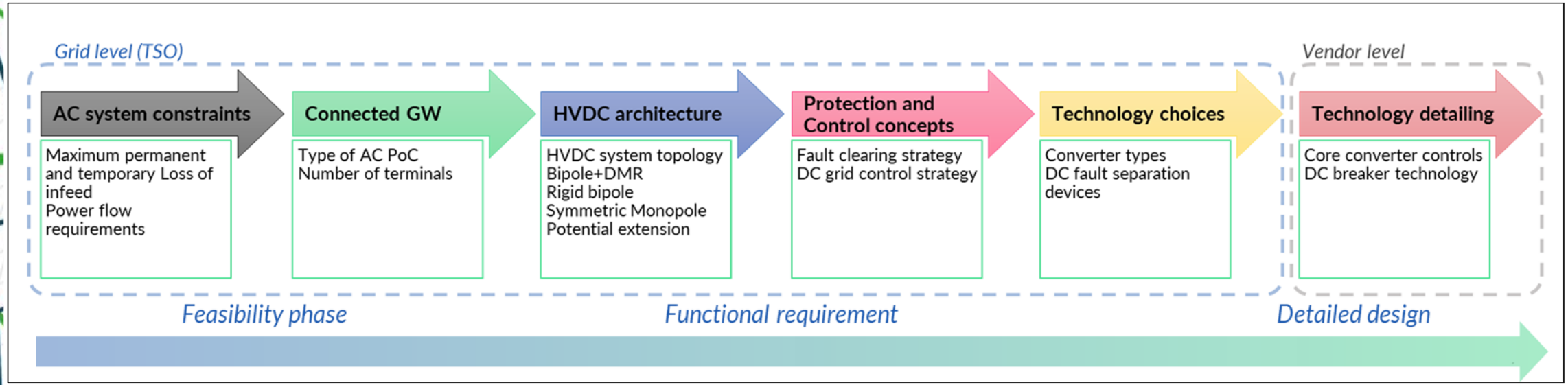



- The present work is intended to be a proposal toward the breaking of the vicious cycle
- Proposal of a methodology to derive and specify Functional Requirements (FR) as well as Parameter Ranges (PR) for the HVDC building blocks

# Methodology

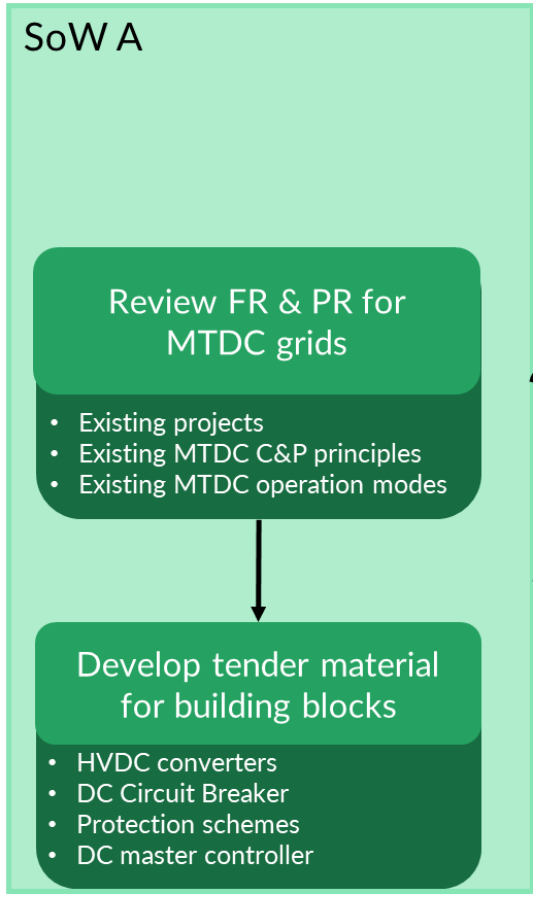


# Systematic approach for HVDC grid planning

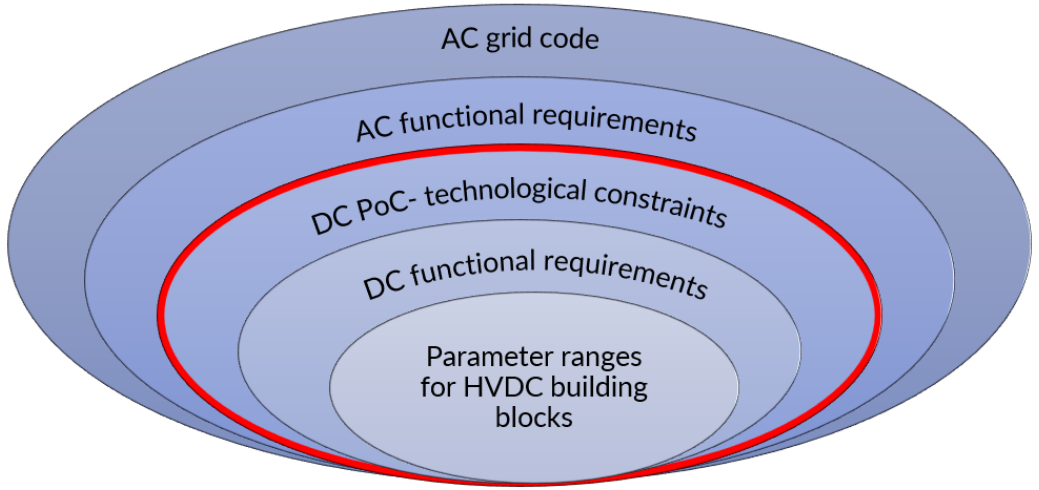



- Different layers of functional requirements are defined at different stages of planning
- This study focused on definition of FR and PR from a TSO point of view, and definition of tendering material for vendors : pre-FEED phase

# Project Overview – SoW A



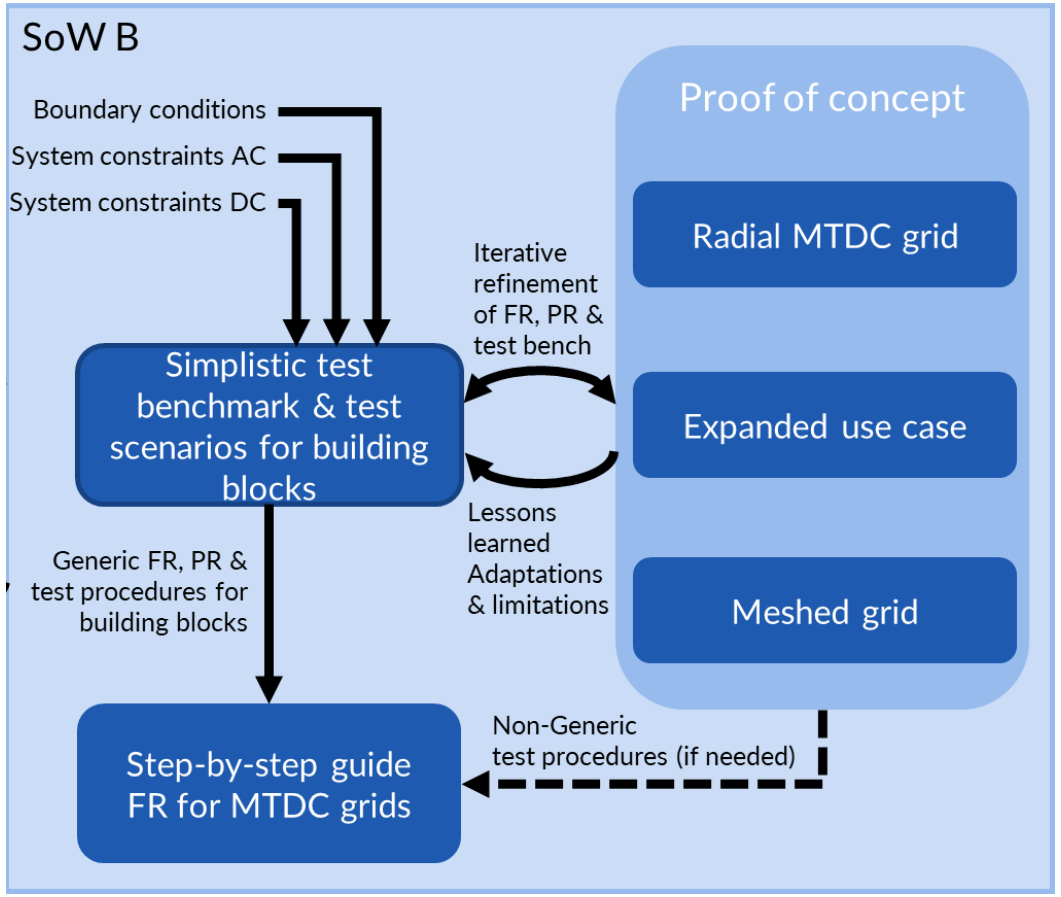

- Scope of Work A
  - Review of functional requirements existing in literature
  - Focus on DC point of Connection (DC-PoC)
  - Identify gaps of existing standards and CENELEC / IEC TV 115_N319 reference
  - Develop a first tendering material based on existing literature



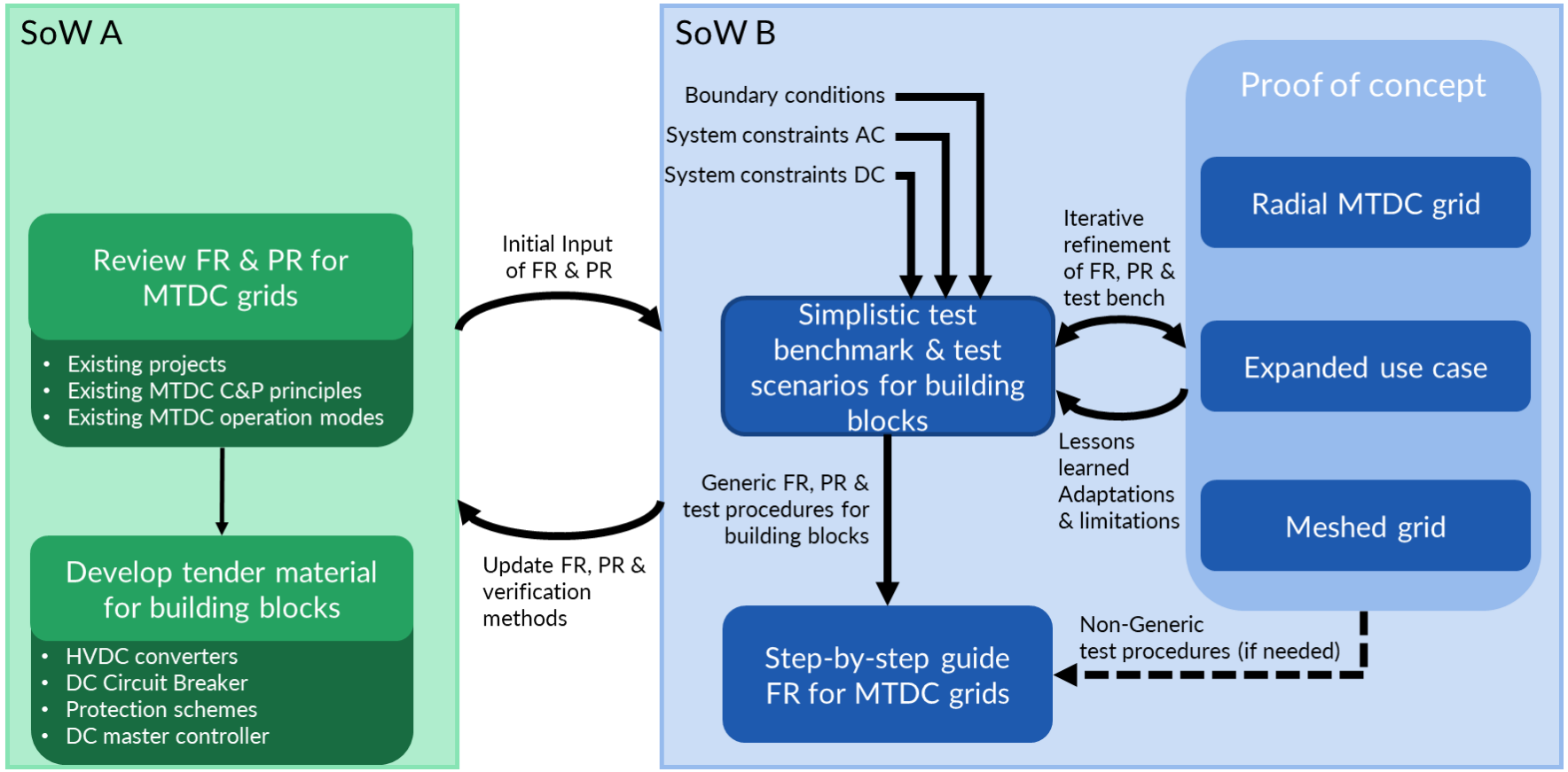
# Project Overview – SoW B

## Scope of Work B

- Development of generic Simplistic Test Benchmarks (STB)
- STB is composed of several elementary models of MTDC grid components with reduced complexity
- STB are assembled to build a test environment to define FR and PR through a set of dedicated dimensioning scenarios
- Step-by-step validation through a proof of concept consisting of 3 use cases implemented within PSCAD



# Project Overview




Reports (2023) available on:
https://northseawindpowerhub.eu/knowledge/generic-functional-requirements-and-parameter-ranges-hvdc-building-blocks

# Functional Groups

The structure the analysis of functional requirements, four functional group are defined

**Functional Group 1 – DC Grid Control**

- Steady state DC voltage range
- Primary DC voltage control
- Post fault active power recovery
- Secondary DC voltage control
- …

**Functional Group 2 – DC Grid Protection**

- AC system constraints
- Protection schemes / DC fault ride through
- DCCB operating time and current capability
- DCR specifications
- …

**Functional Group 3 – Ancillary Services**

- DC energy balance (DBS)
- Energization of DC subsystem
- Energization of a converter
- …

**Functional group 4 – Operational Regimes**

- Start up sequences
- DC connection modes
- Bipole/monopole operation
- …

Some functional requirements counter interact on certain parameters, a compromise should be made

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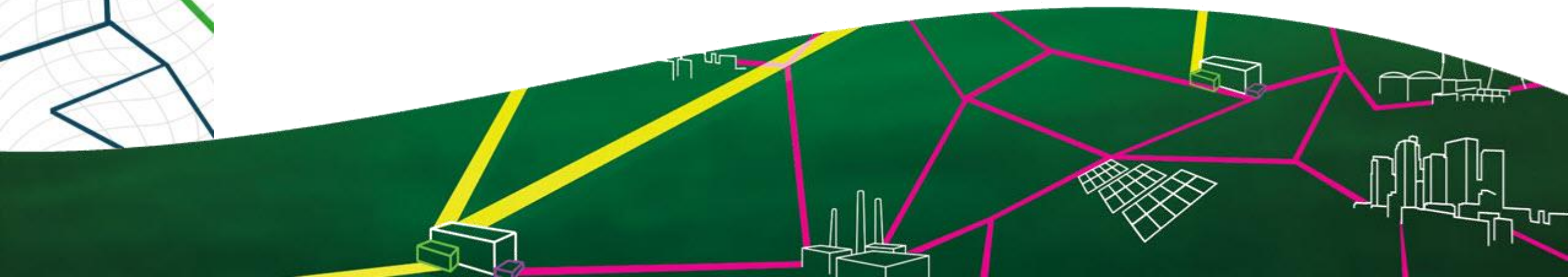
# Use Cases



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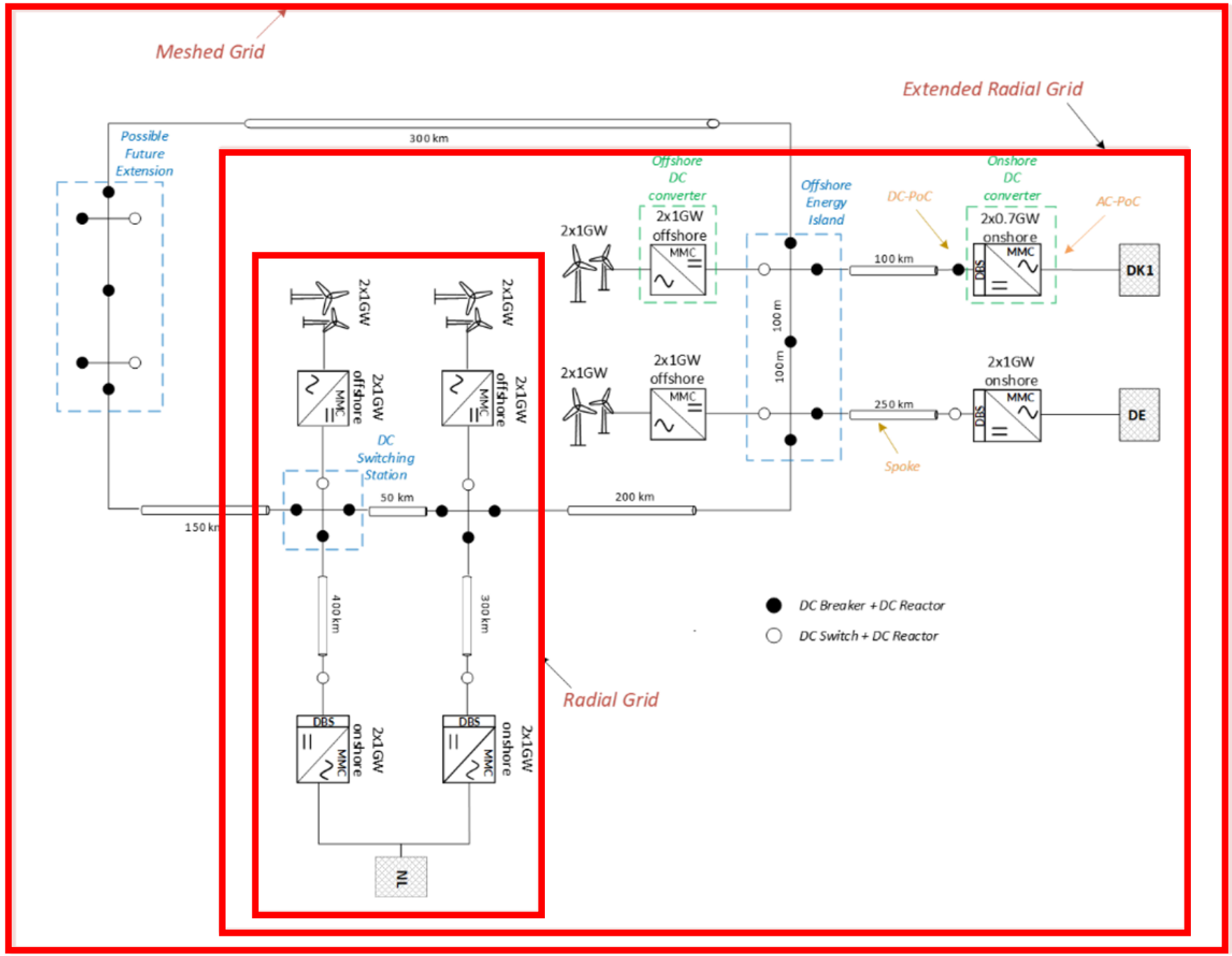

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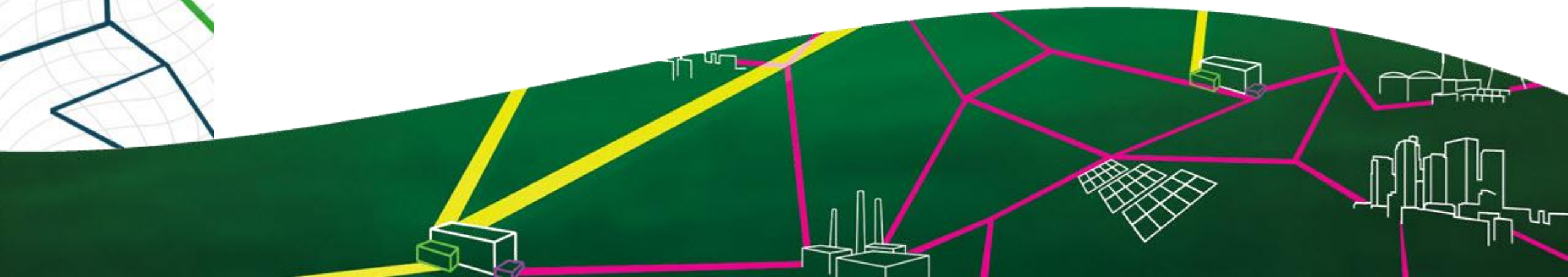
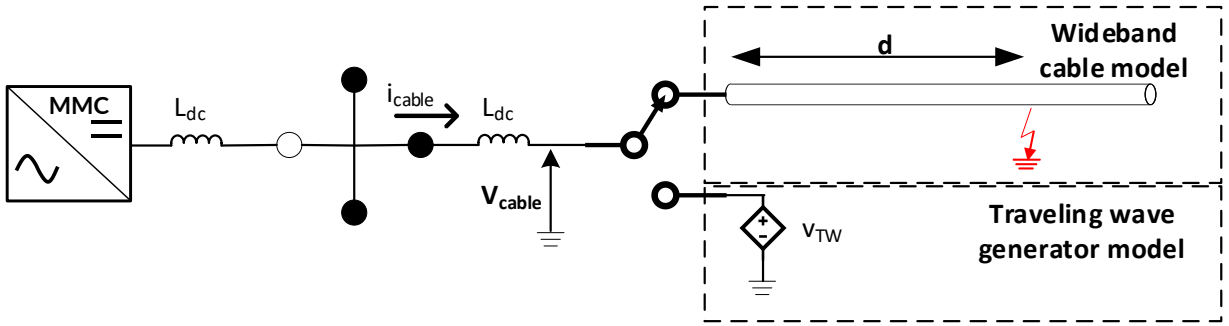
# Main Results

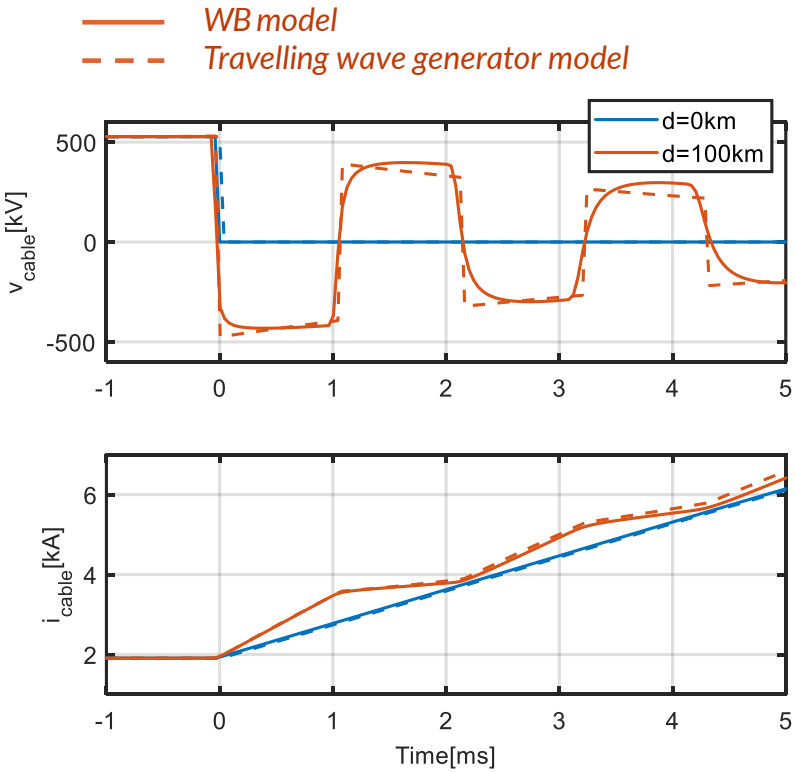


# Example of Simplistic Test Benchmark for DC Grid Protection

## STB for the determination of short circuit current considering travelling waves

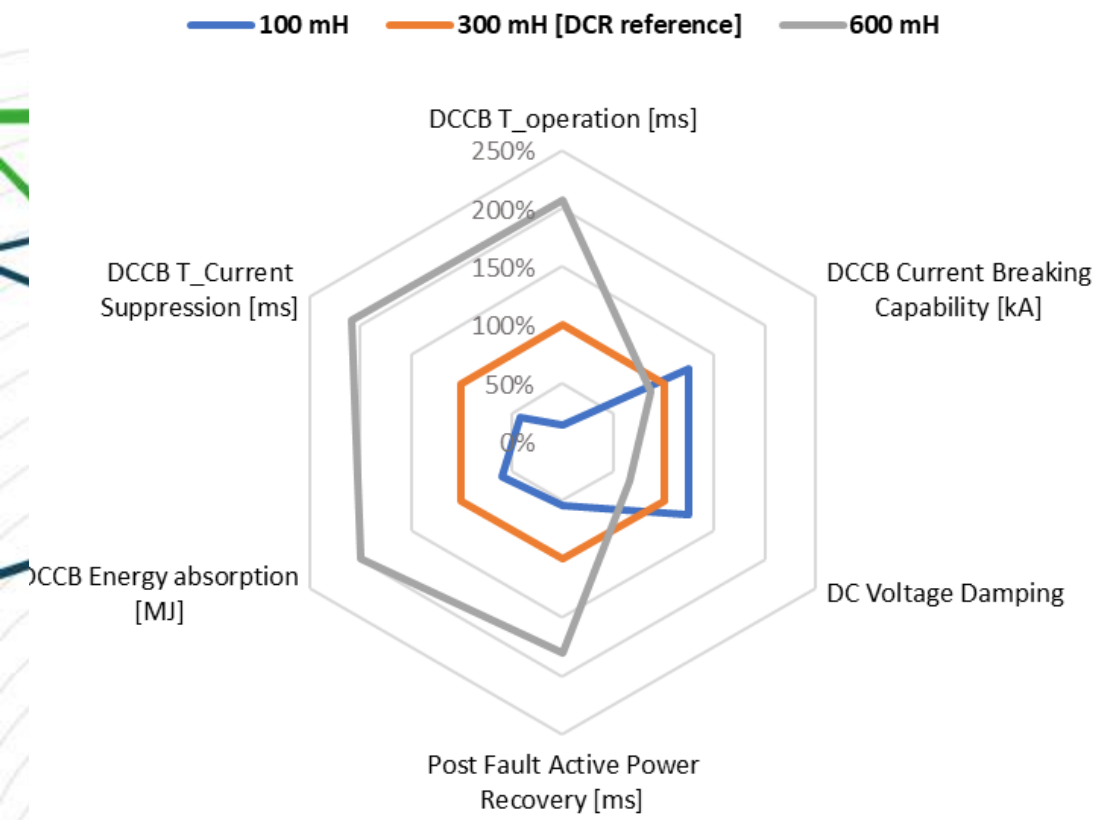
- A traveling wave generator model “simulates” cable faults with variable fault distance
- Alternative of more complex wideband cable modelling
- The rise of fault current is also accurately represented for multiple traveling wave propagations

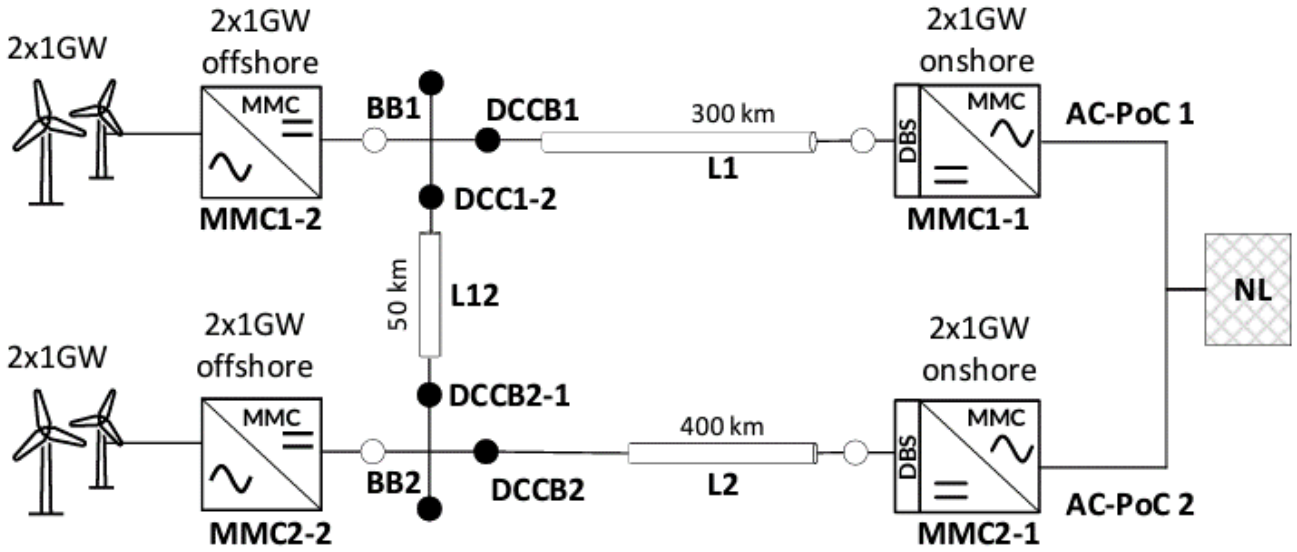


# Example of results using STBs for a radial grid

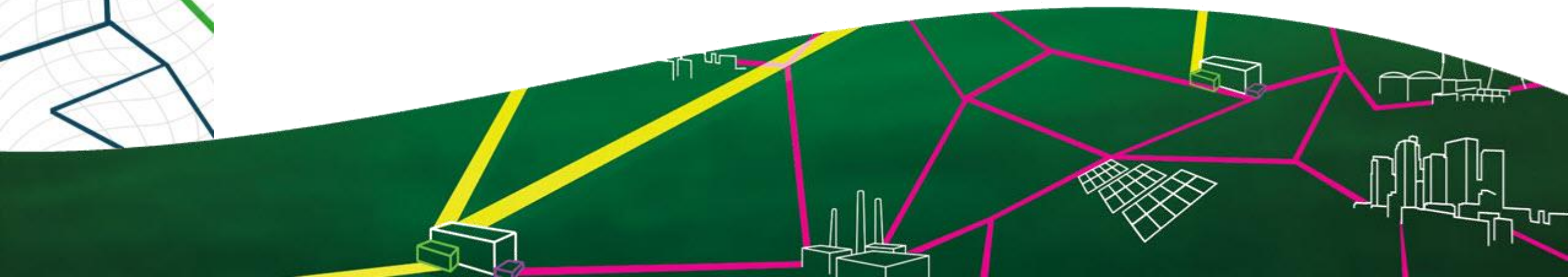
## Impact of DC Reactors value (indicative) for various Protection and Control parameters




- Relay time of 0,5ms (local)
- MMC blocking current of 3PU at DC side
- DC voltage controller response time of 30ms

# Conclusions



# Conclusions

- **The work proposes a methodology to define functional requirements for future HVDC building blocks based on Simplistic Test Benchmark**
- **Results have been used to create a tendering material for future projects, with indicative parameters and ranges for the building blocks**
- **The STB approach appears to be particularly suitable for:**
  - Identification of DC steady state voltage ranges
  - Preliminary determination of DC grid control parameters
  - Analysis of DC reactor on system behavior
  - Preliminary design of DC components such as DCCB, DC reactors and pre-insertion resistances for cable energization
  - Definition of DC current and voltage profiles at the DC-PoC
- **Hypotheses and assumptions used within the project need to be challenged and further investigations are recommended in view of a future multivendor interoperable DC grid**
- **Results of NSWPH project are being used as inputs for EU projects such as InterOPERA project**

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# Thank you

## Any questions ?