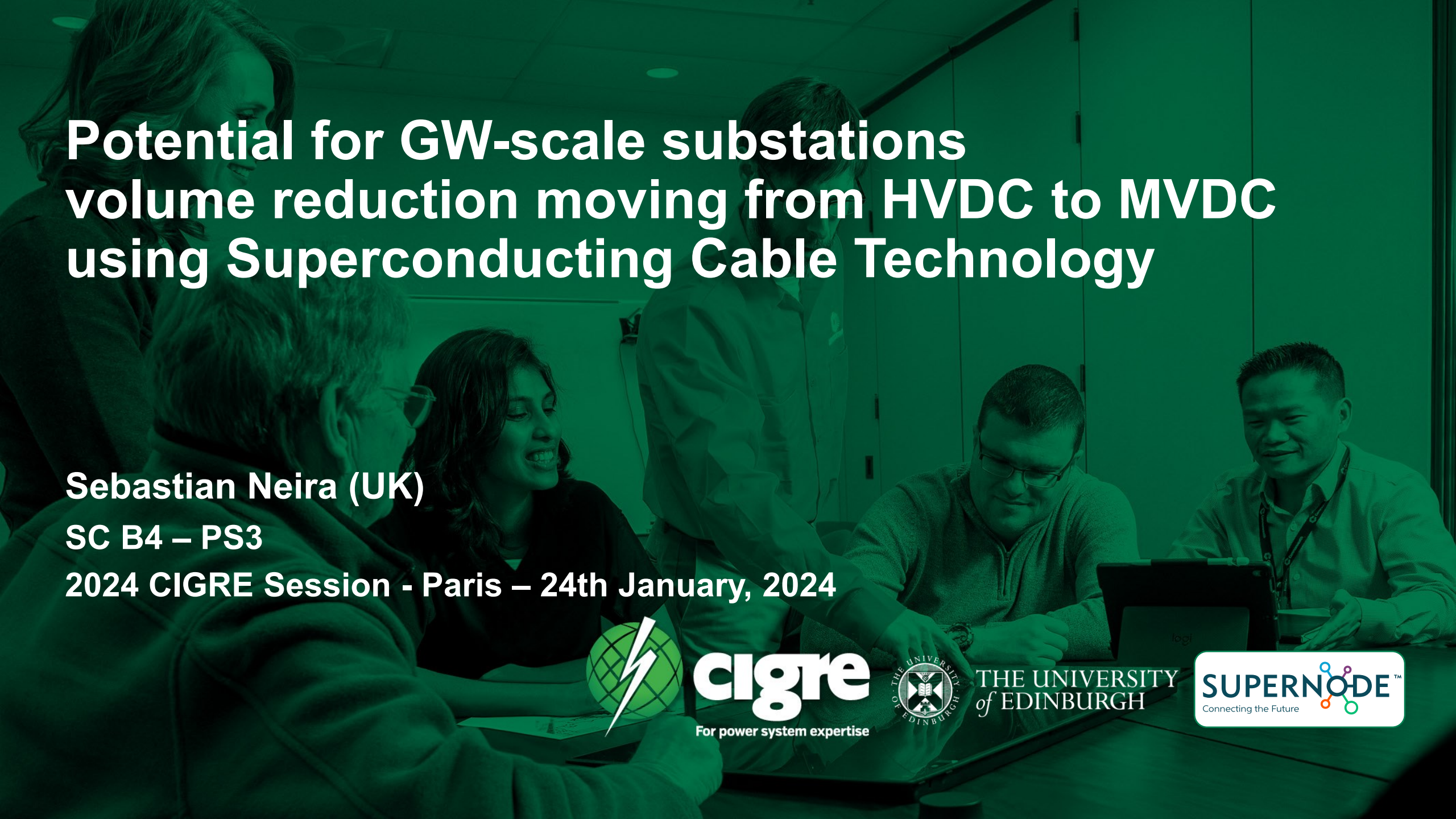

Potential for GW-scale substations volume reduction moving from HVDC to MVDC using Superconducting Cable Technology

Sebastian Neira (UK)

SC B4 – PS3

2024 CIGRE Session - Paris – 24th January, 2024

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Introduction

Superconducting Cables for Power Transmission

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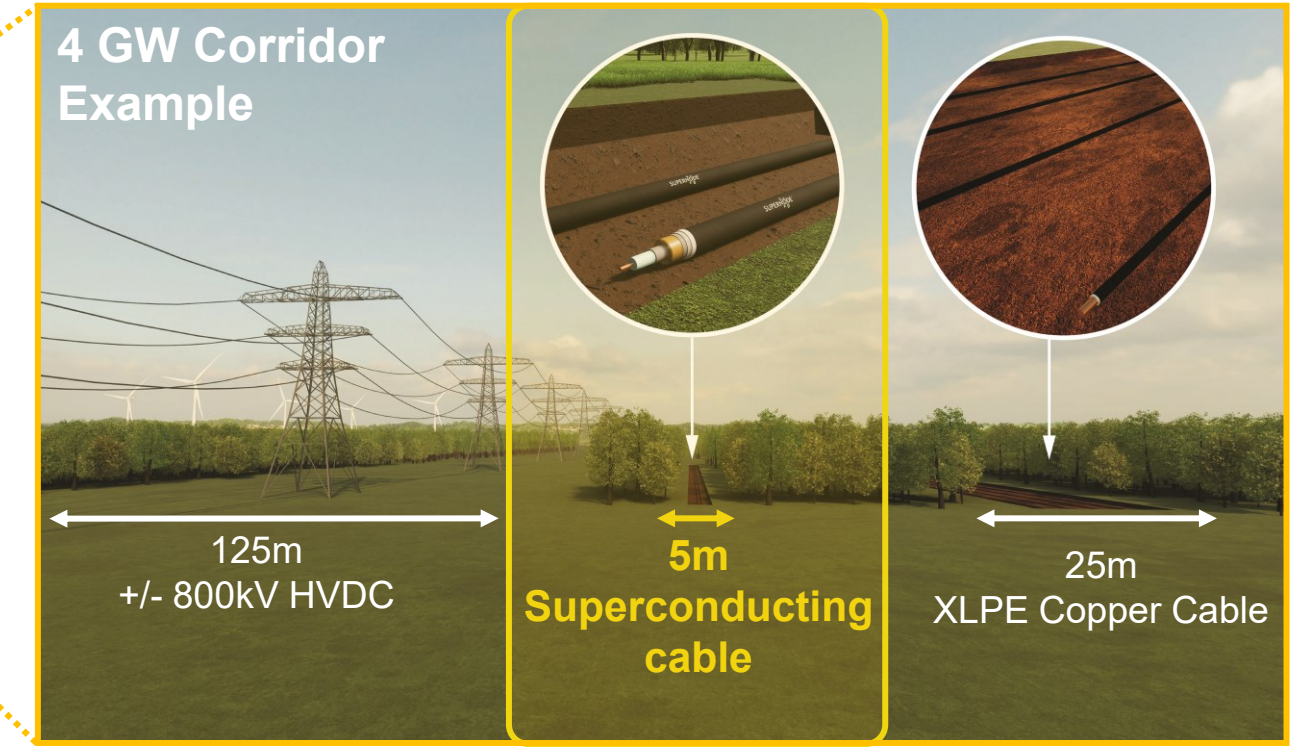
Future European grid requires several GW-scale transmission links

Electrical energy demand will triple, and renewable energies could reach up to 50%of generation mix by 2050



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Superconducting cable technology shows potential for GW MVDC transmission links

Developed projects show a trend towards longer distances and higher currents at MV levels

Recent Superconductor Projects			
2013	Nexans ELECTRIFY THE FUTURE	Ampacity, Essen	1km, 40MVA, 10kV, AC
2018	Best Paths TRANSMISSION FOR SUSTAINABILITY	EU Horizon's 'Best Paths' Project	30m, 3.2GW, 320kV, DC
2019	KEPCO	Shingal, Seoul	1km, 50MVA, 23kV, AC
2021	NKT *We connect a greener world*	Superlink, Munich	12km, 500MVA, 110kV, AC
2027*	SCARLET Superconducting CAbles for sustainable Energy Transition	EU Horizon's 'SCARLET' Project	>20km, 1GVA, 100kV, DC

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Converter topologies for high-current MVDC substations

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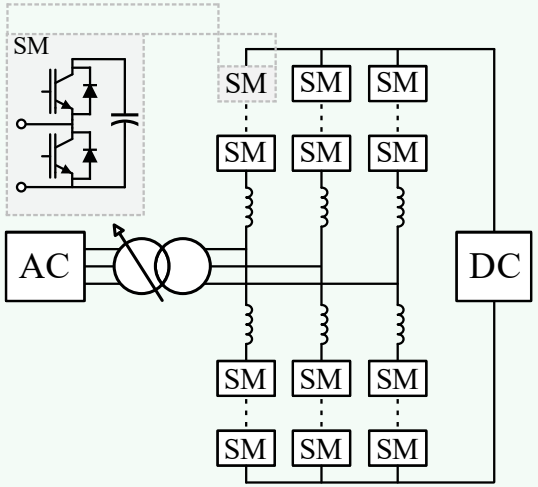
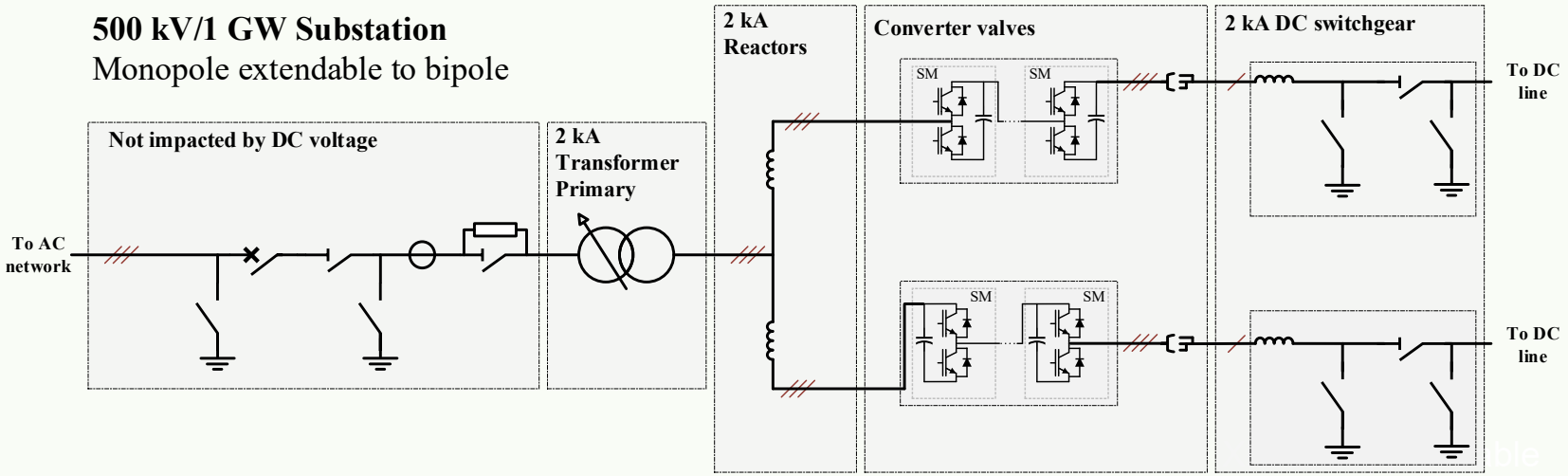
Starting point: Conventional HVDC MMC

Preferred solution for VSC substations nowadays with currents up to 3 kA

Topology



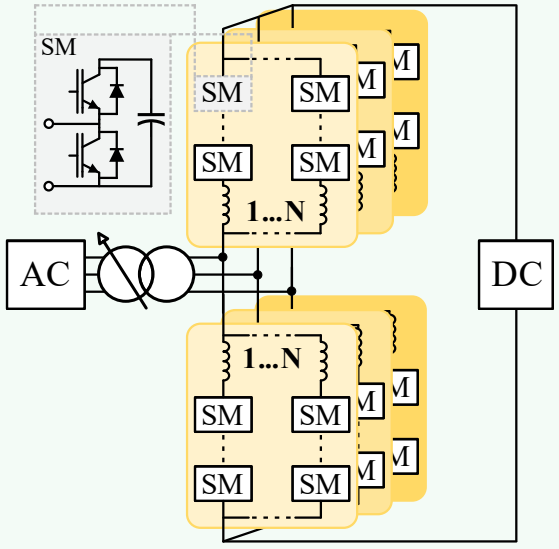
Substation Layout



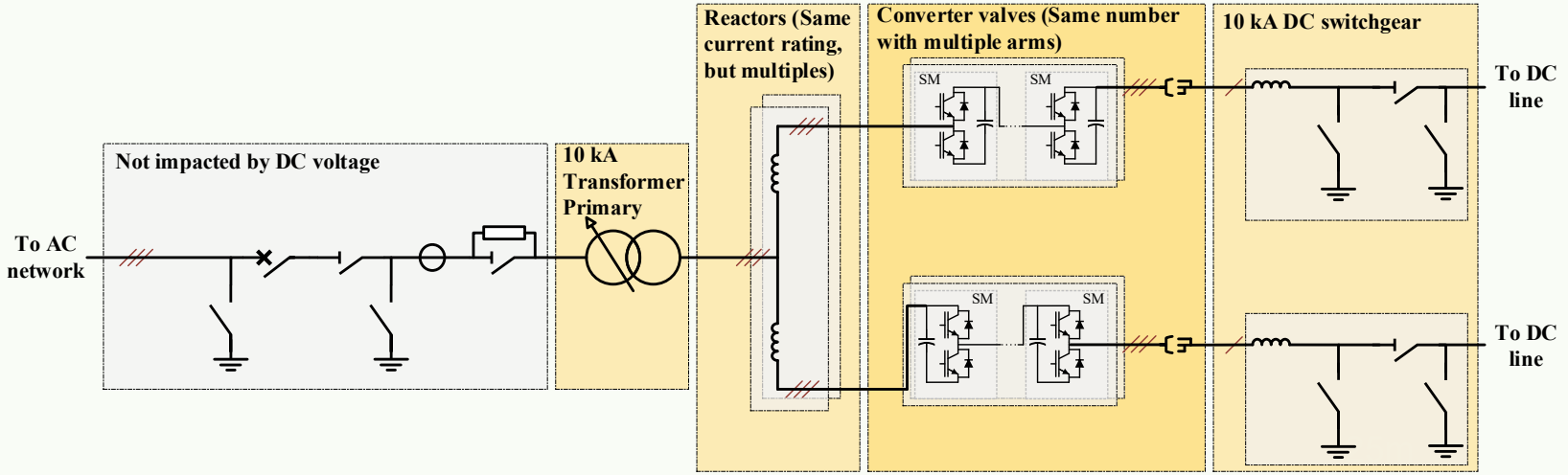
MVDC MMC with parallel arms

Topology keeps the submodule ratings, but requires modifications to AC and DC yards components

Topology



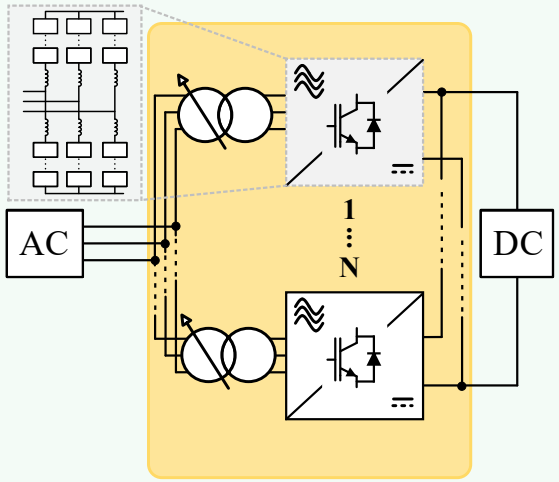
Substation Layout



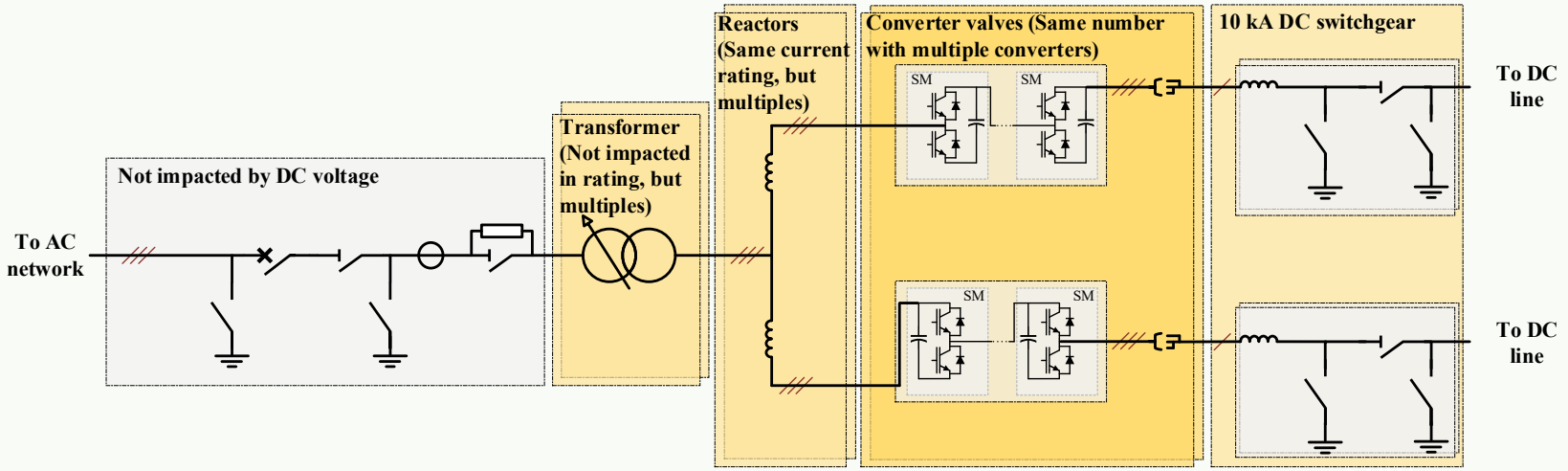
MVDC MMCs in parallel

Topology keeps all substation components ratings performing the parallel connections at converter level

Topology



Substation Layout



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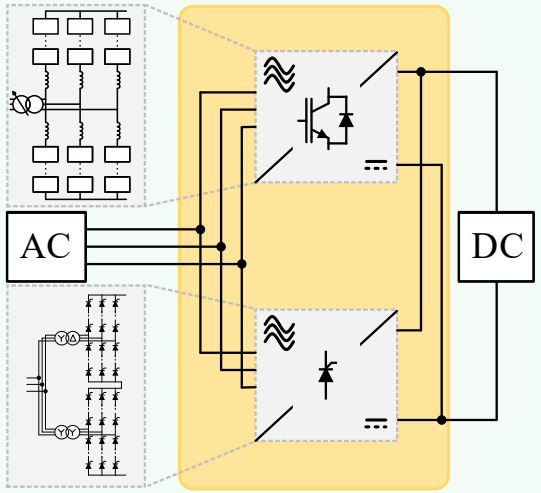
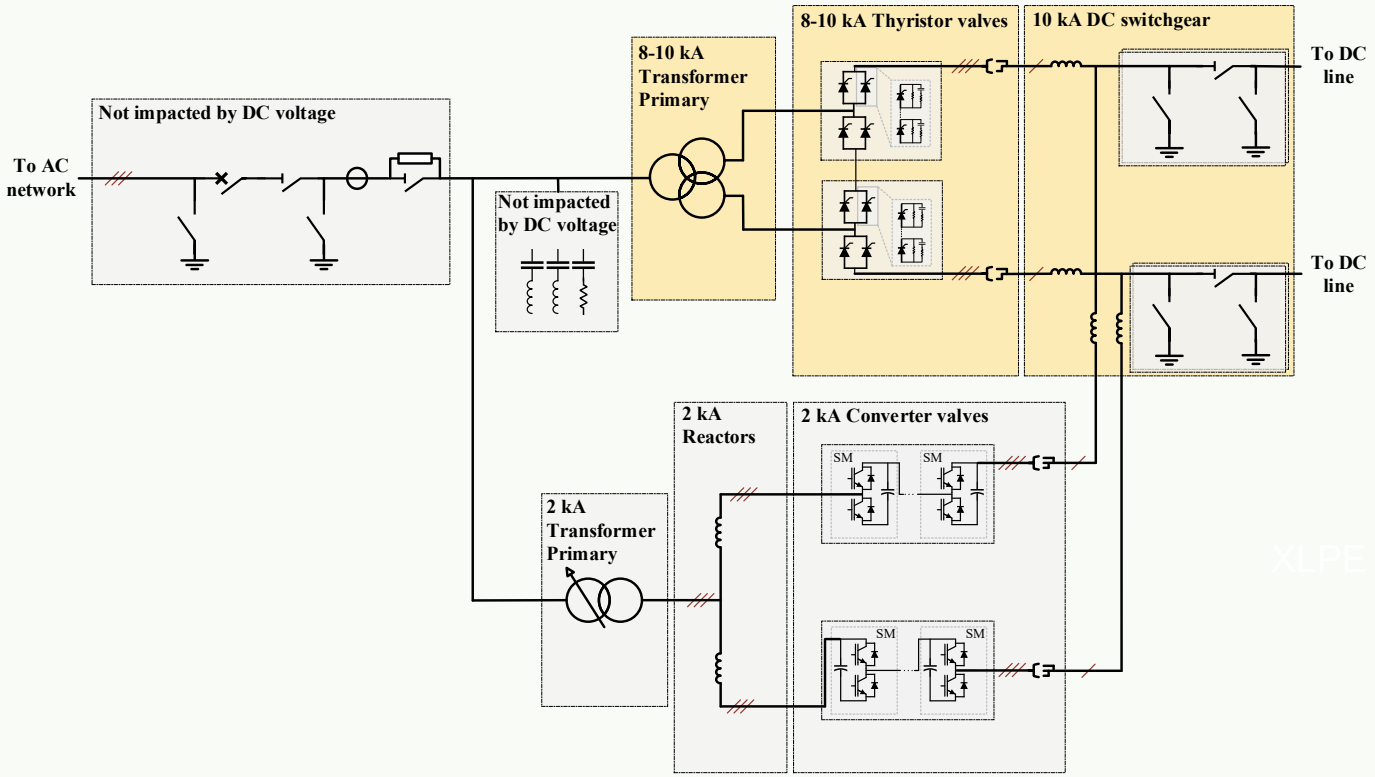
MVDC MMC in parallel with LCC

Topology uses the higher current capabilities of LCC thyristors, with enhanced controllability given by the MMC

Topology



Substation Layout



3D modelling methodology for estimating valve hall size

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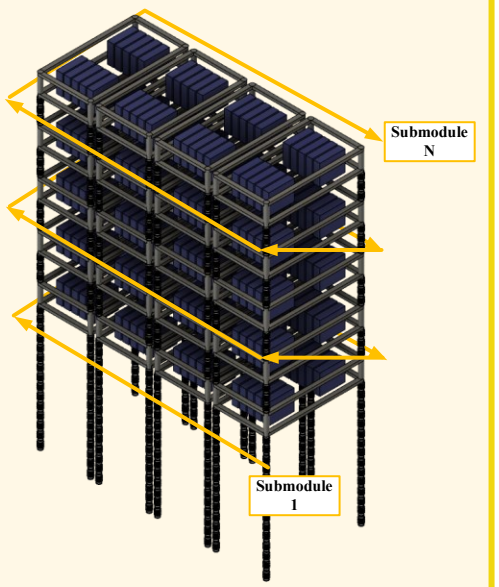
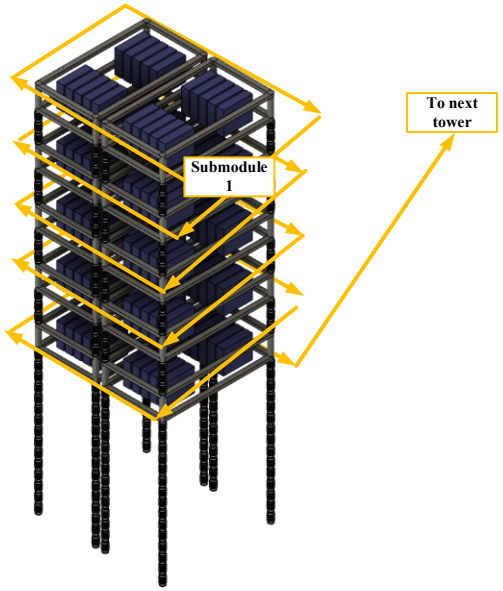
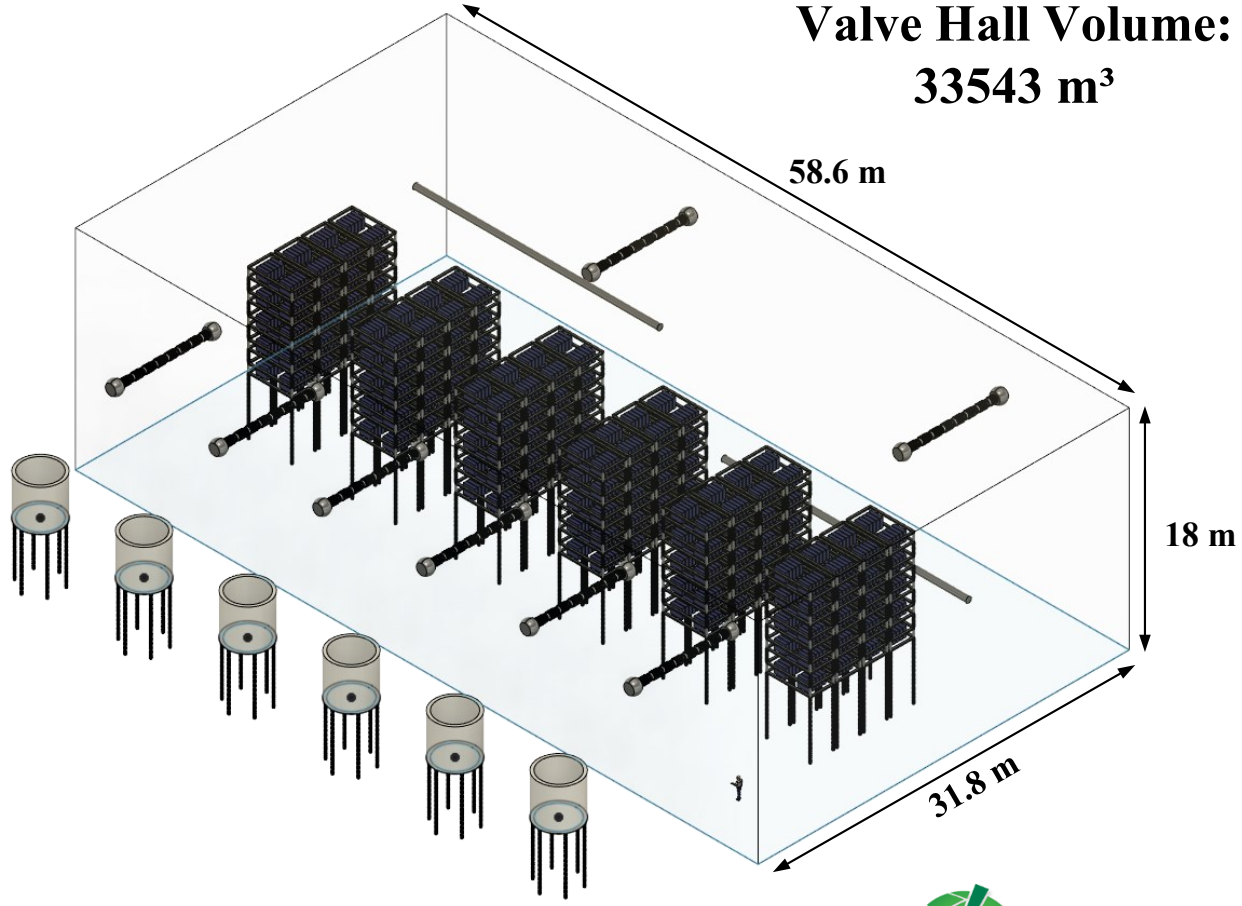
Conventional HVDC MMC valve hall



Horizontal connection



Vertical connection



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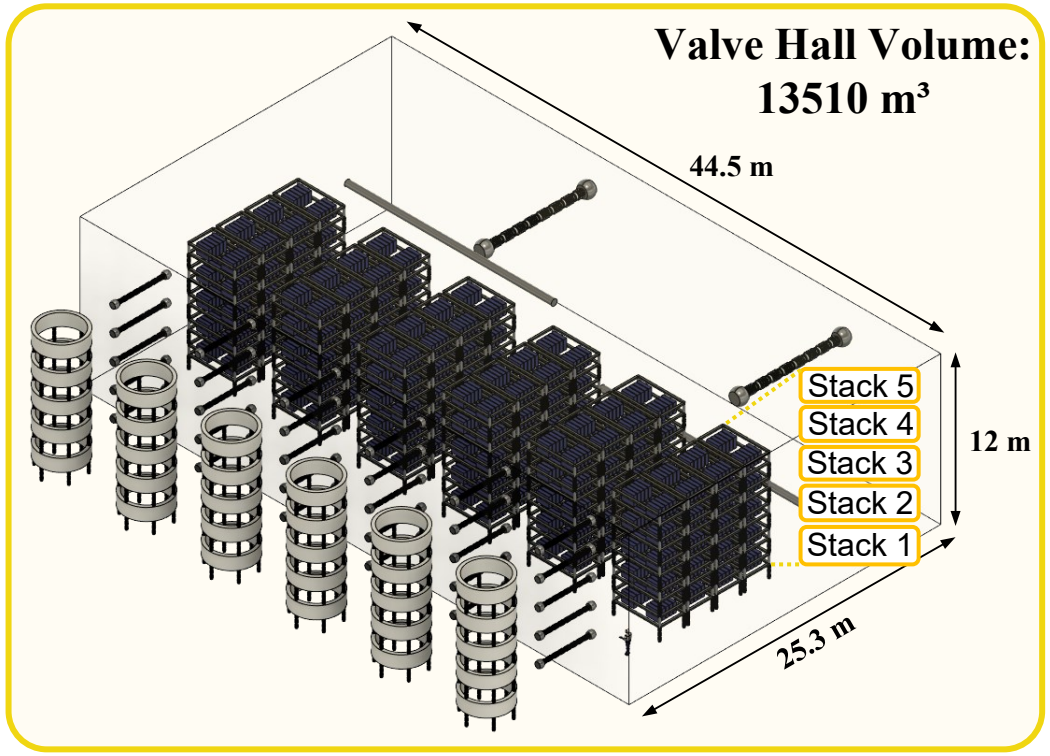
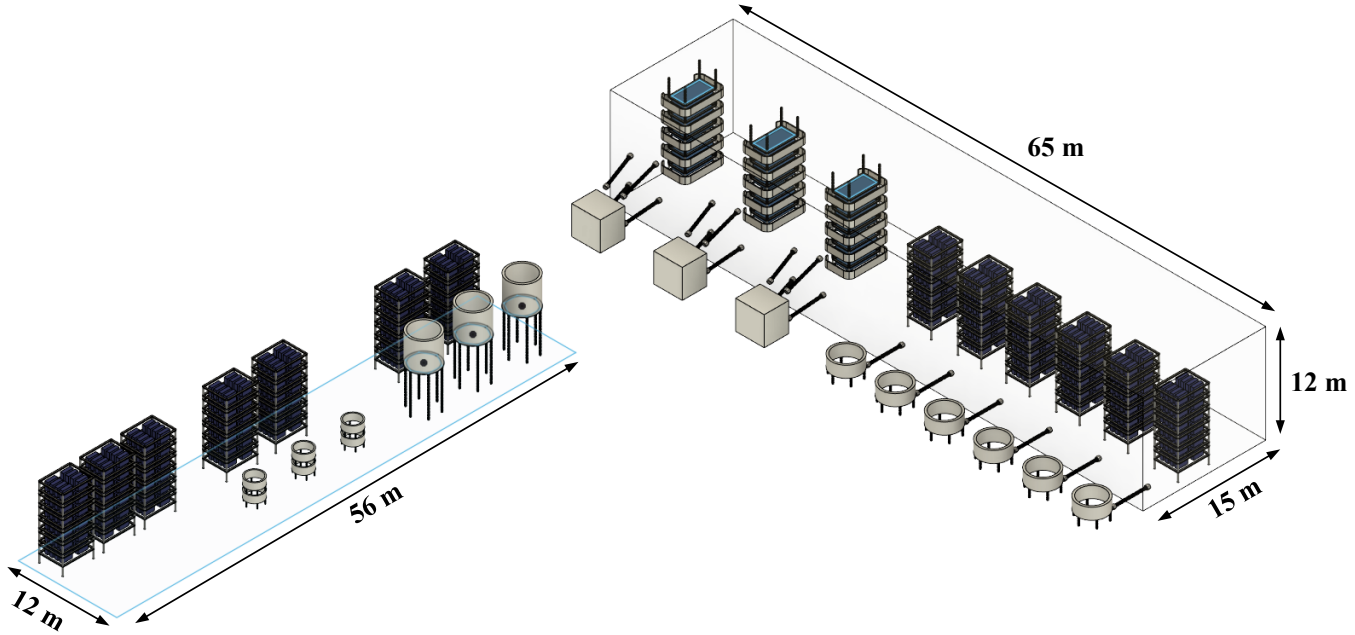
Valve hall design for MVDC high current topologies

MMC with parallel arms / MMCs in parallel



MMC in parallel with LCC



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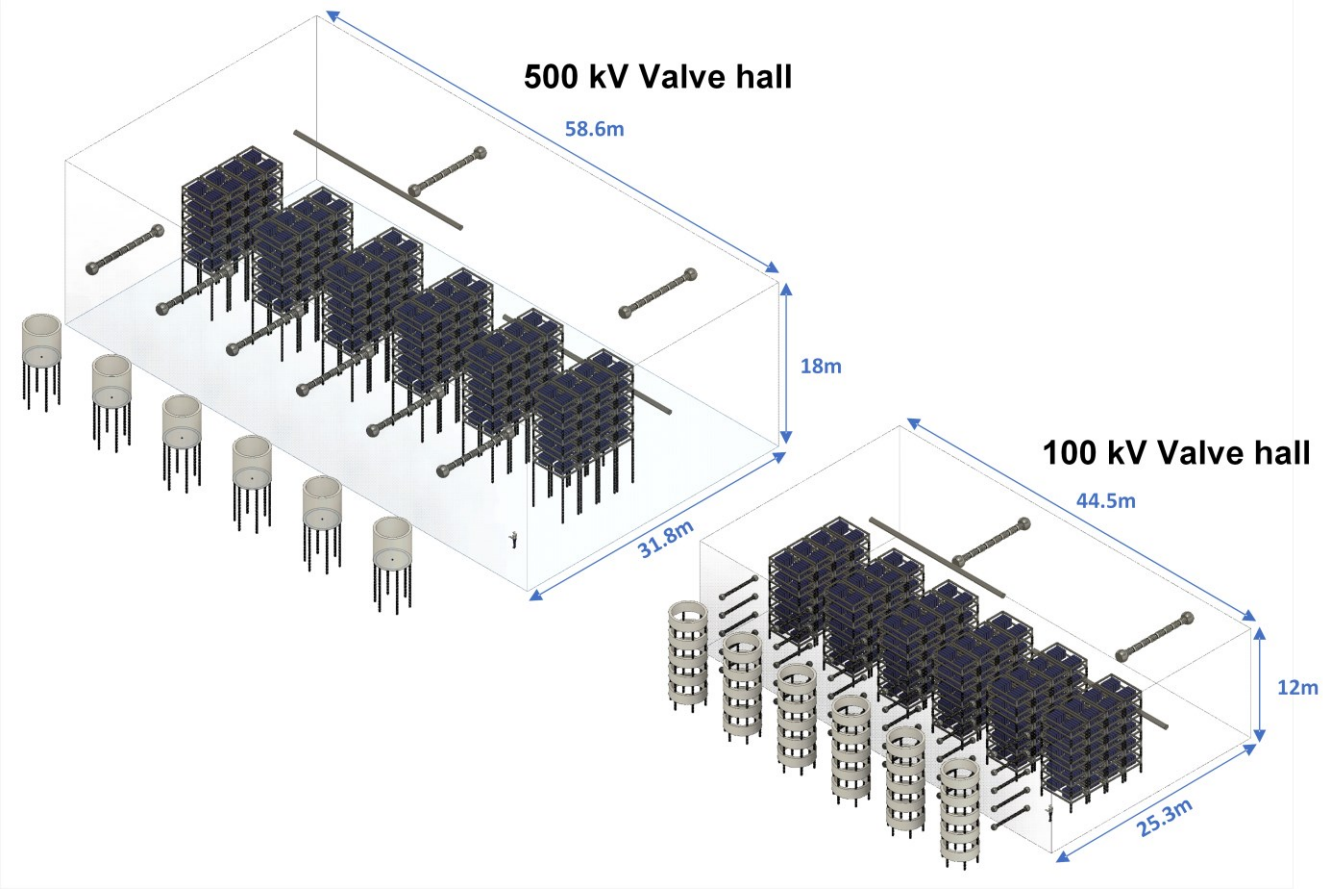
Potential reduction of 60% in valve hall volume moving from 500 kV to 100 kV

Particularly relevant for offshore applications where size of platforms is a large cost driver



Considerations:

- 5m clearance for 500 kV valve hall
- 1m clearance for 100 kV valve hall
- 3m access distance for 100 kV valve hall
- Horizontally arranged towers, 100 kV per level
- 5 levels per tower

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Conclusions

- Parallel MVDC topologies enable the operation of bulk transmission links based on superconducting cables
- 3D modelling shows potential for reducing valve hall size up to 60% due to reduced insulation distance requirements
- There is need for adapting DC switchgears and control systems to manage the operation of high-current parallel topologies

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