Phased Approach to MTDC: Proposed integration of DC Circuit Breakers in a DC Switching Station facilitating a partially selective protection scheme

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SC B4 – PS3

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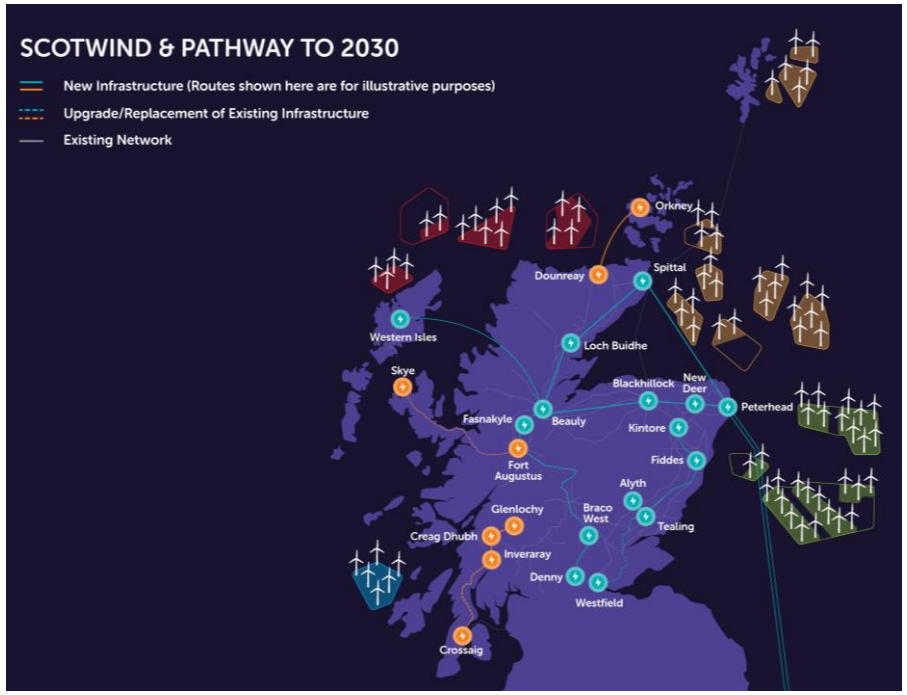
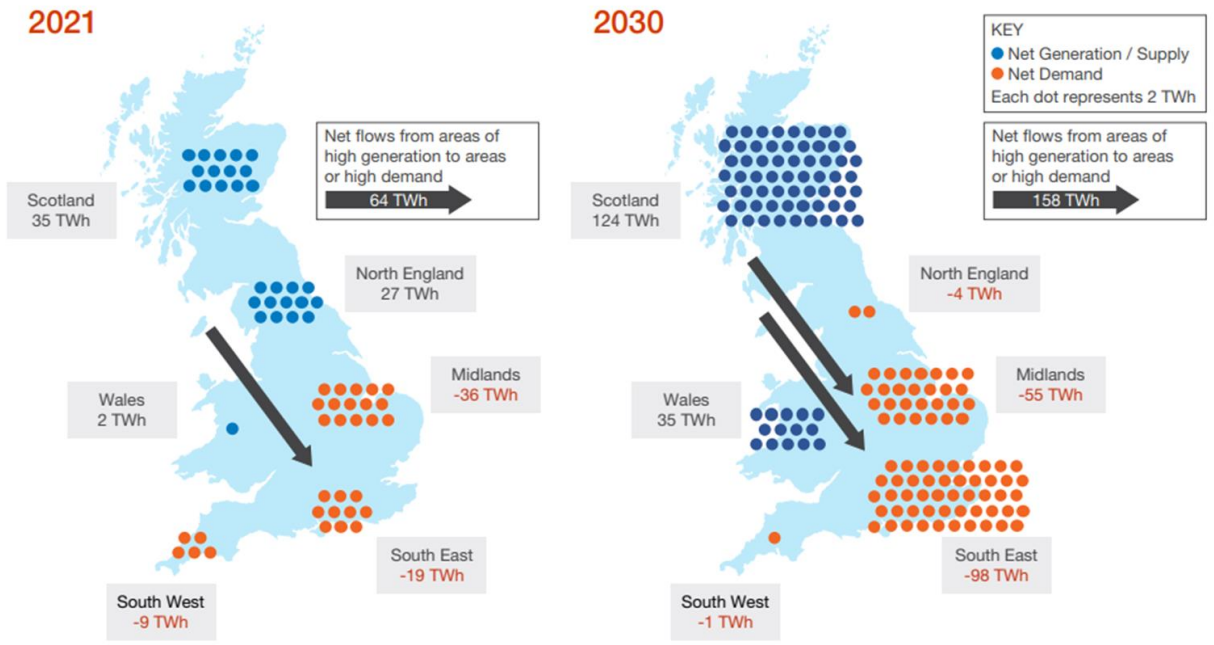
Introduction – the need for HVDC

- The transition to low carbon electricity in GB will require HVDC systems:
  - ✓ **GW scale offshore wind deployed at increasing distances from grid connections**
  - ✓ **Distance between generation and demand centres**



Credit: SSEN Transmission



Credit: NGESO Future Energy Scenarios 2022

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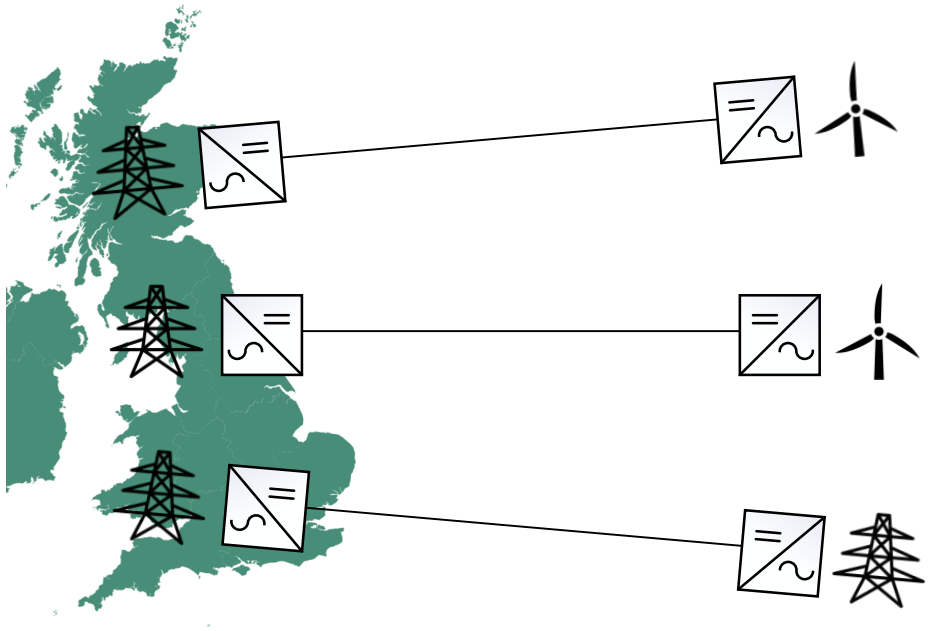
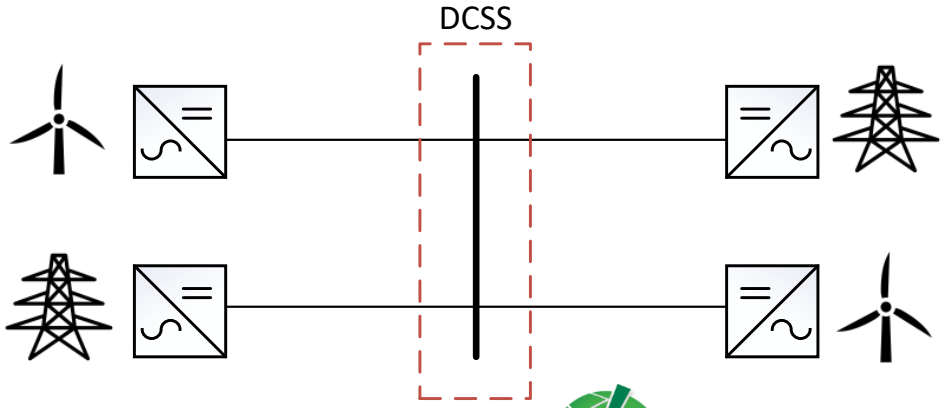
Development of Multi Terminal HVDC (MTDC) Systems

- Historically, HVDC systems have been point-to-point (two terminals)
- More projects creates unsustainable land/coastal pressures and costs
- Next step: develop MTDC systems
  - ✓ **Connect otherwise separate projects**
  - ✓ **Reduction in converters**
  - ✓ **First steps toward HVDC grids**





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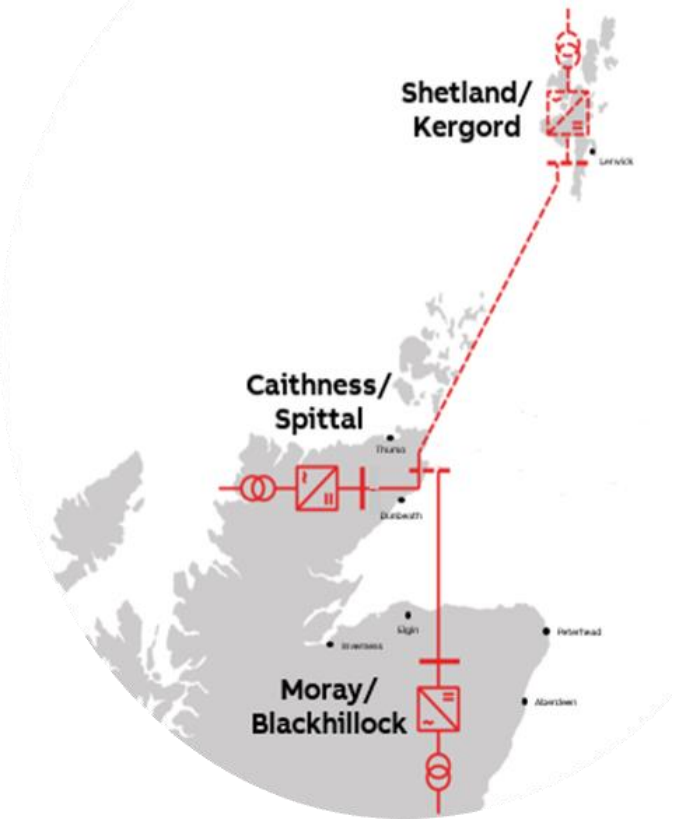
A DC Switching Station (DCSS) for MTDC

- A DCSS enables MTDC – Europe's (320kV VSC) first MTDC commissions 2024
- A new, double busbar DCSS has been proposed through Project Aquila – to facilitate 525kV MTDC, multi-vendor interoperability, and expansion



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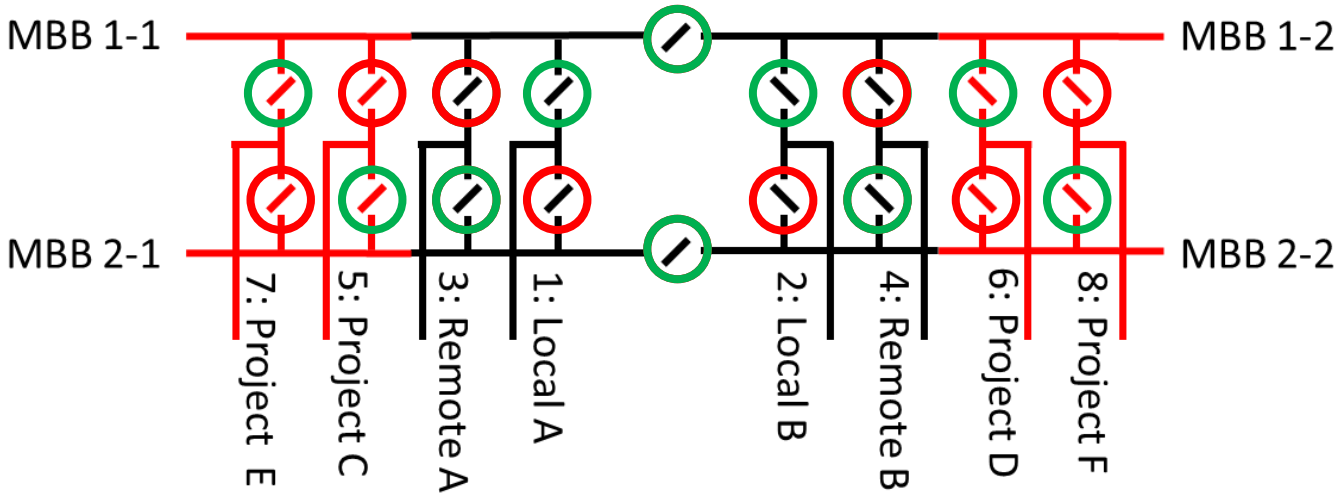

Open

Closed

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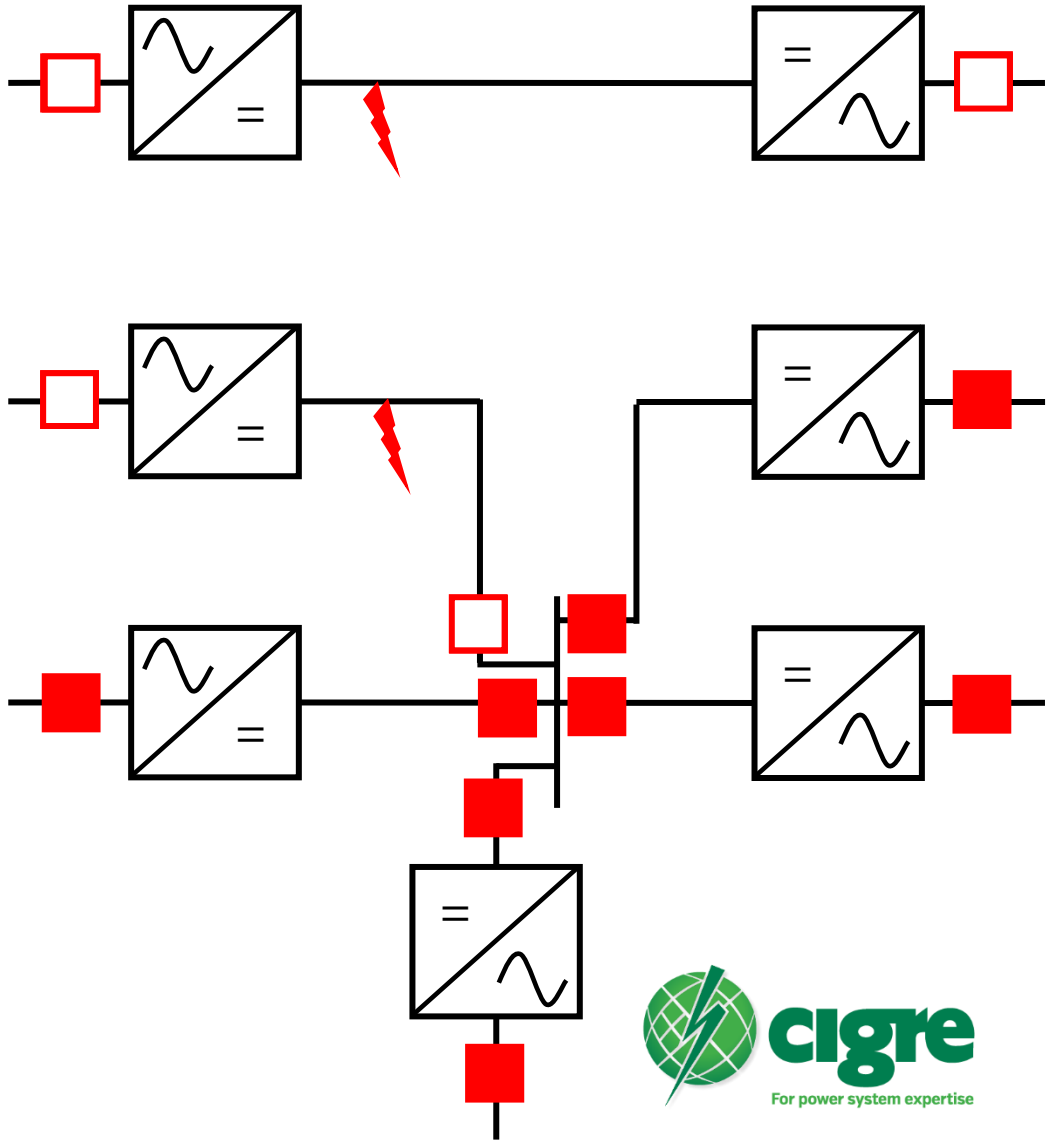
Fault Clearing in HVDC Systems

- In P2P systems, commonly clear faults using AC circuit-breakers (ACCBs)

- In MTDC, ACCB clearing would:
  - ✓ **interrupt power flow on the entire system for seconds/minutes**
  - ✓ **significantly disturb the connected onshore HVAC networks**

- Therefore, in MTDC systems with large generation in-feed:
  - ✓ **ACCB fault clearing is less acceptable**
  - ✓ **DCCBs are preferred**



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Including DCCBs in a MTDC System

- Ideal scenario: fully selective protection with DCCBs dedicated to each circuit

- Challenges for including DCCBs today:
  - ✓ **Technology readiness**
  - ✓ **Product uncertainty (e.g., scale, cost, integration) leading to design risk**
  - ✓ **Risks may be unacceptable for project promotors**

- Integrating DCCBs in today's HVDC systems:
  - ✓ **Delay delivery until DCCBs are available, or**
  - ✓ **Limit scale of system now, but plan to retrofit DCCBs** ⟵

- Preferred solution: Limit scale, expand later
  - ✓ **Deliver a MTDC system in the short term, limited appropriately**
  - ✓ **Include some expansion capability if/when DCCBs arrive**
  - ✓ **Partially selective protection could reduce number of DCCBs**

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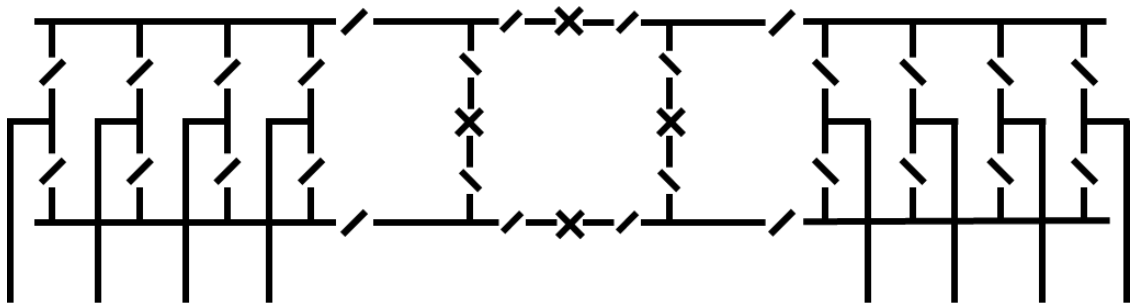
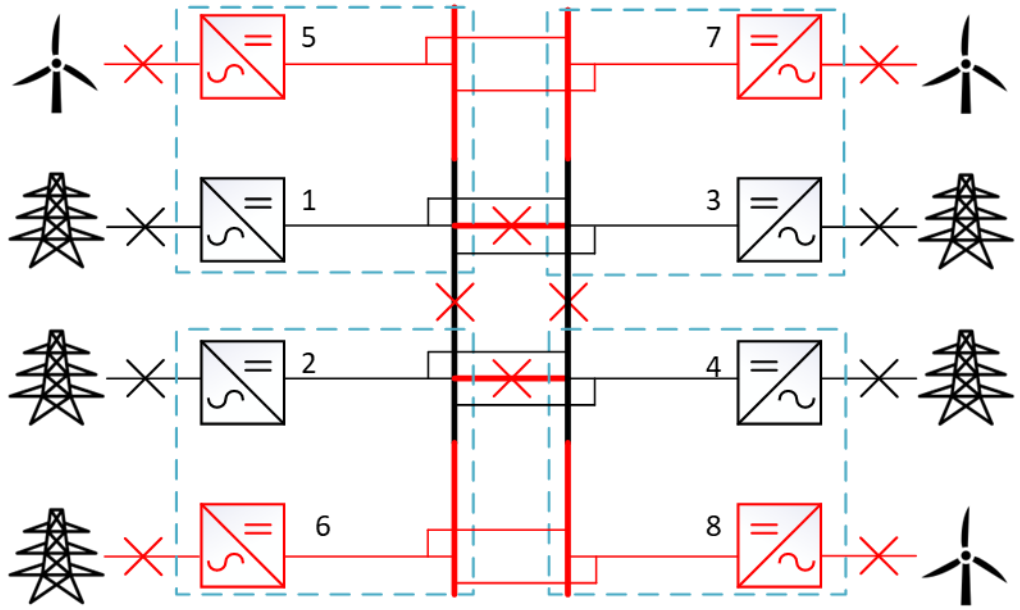
Mesh Corner DCSS

- This paper proposes a partially selective solution based on the Mesh Corner
- Selectivity is sacrificed as multiple circuits are connected to a corner, but the reduction in number of CBs reduces cost and footprint of the substation.





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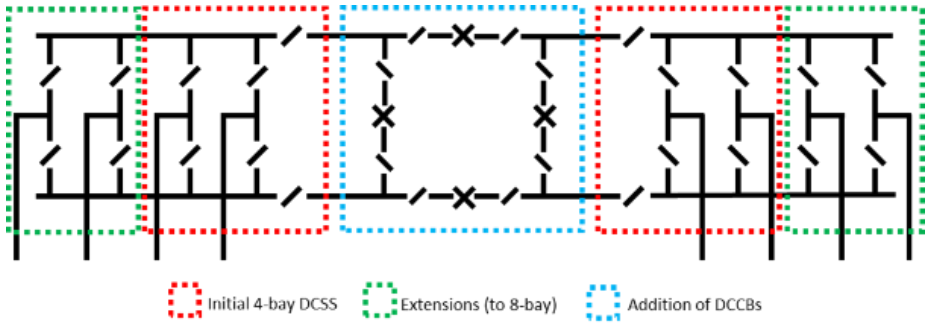
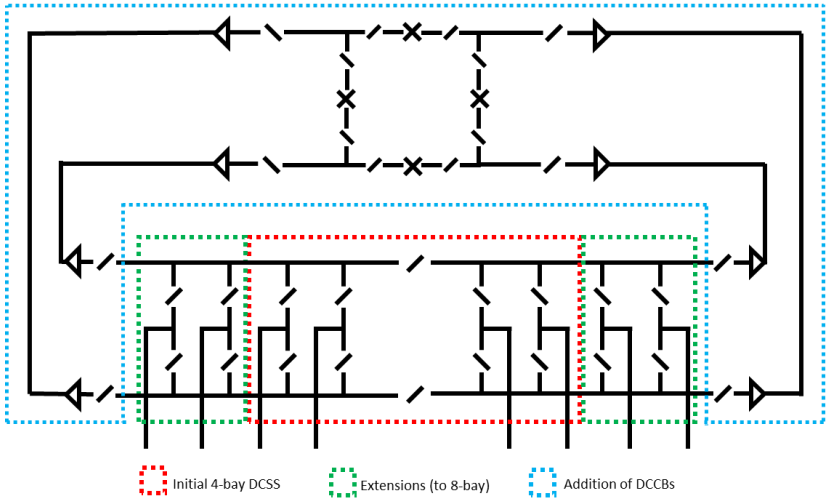
Mesh Corner – Retrofit Options

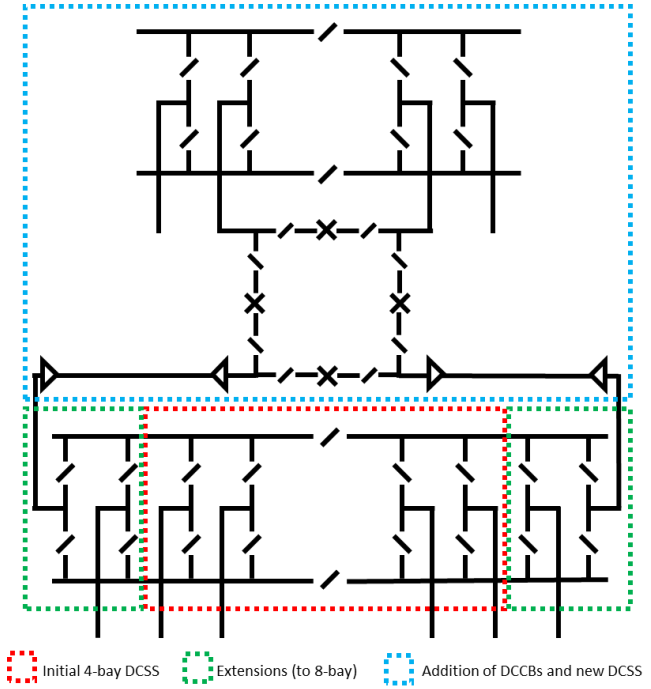
Option A



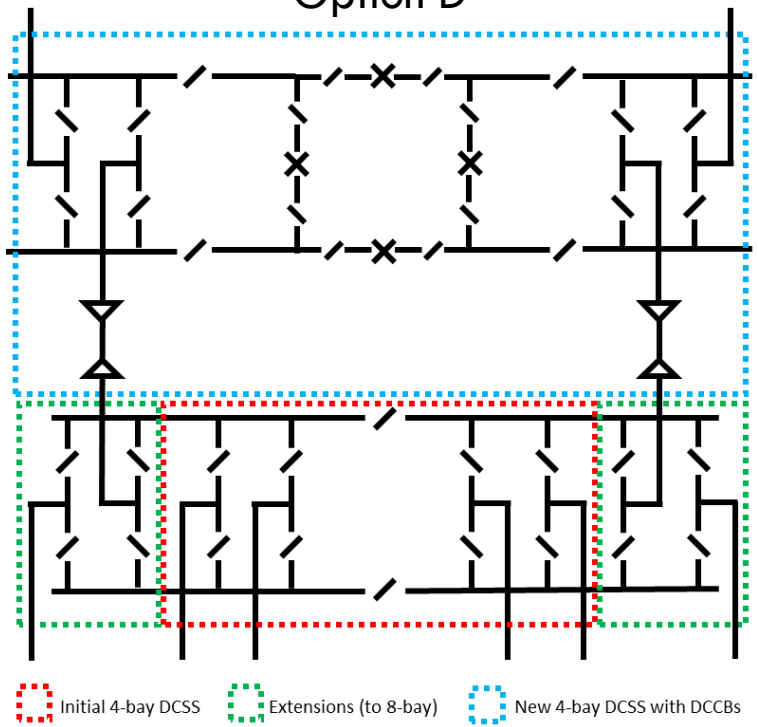
Option B



Option C



Option D



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Mesh Corner – Options Assessment

	Criteria	A	B	C	D
High Level Design	Electrical Interface	↑	↓	↓	↓
	Spatial and Enviro. Impact	↑	–	↓	↓
	Expansion	–	↑	↑	↑
	Stakeholders	–	–	–	–
Operability	Safety	↑	–	↓	↓
	Protection	↑	↑	↓	↓
	R.A.M	–	–	↑	↑
Cost	CAPEX	↑	–	↓	↓
	OPEX	↑	–	–	–

- Though A appears strongest, the design is difficult to implement today
- To deliver MTDC, multi-vendor operation now, projects must progress without DCCBs
- B, C, D offer options for later expansion

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Conclusions

- Demand for HVDC will drive development of MTDC
- DCCBs will be a key enabler of large MTDC systems and, eventually, DC grids
- Uncertainty on DCCB technology/commercial readiness limits developers
- It may be possible to integrate DCCBs later with a suitable DCSS design
- The Mesh Corner offers a potential solution
  - ✓ **DCCBs could be added later – avoiding need to commit today**
  - ✓ **Partially selective – appropriate for scale**
  - ✓ **Minimal DCCBs – saving cost and footprint**
  - ✓ **Options explored could be building blocks for DC grids**

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