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PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

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# Interconnection of Adjacent Point-to-Point HVDC Links as an Enabling Step towards Deployment of Multiterminal HVDC Systems


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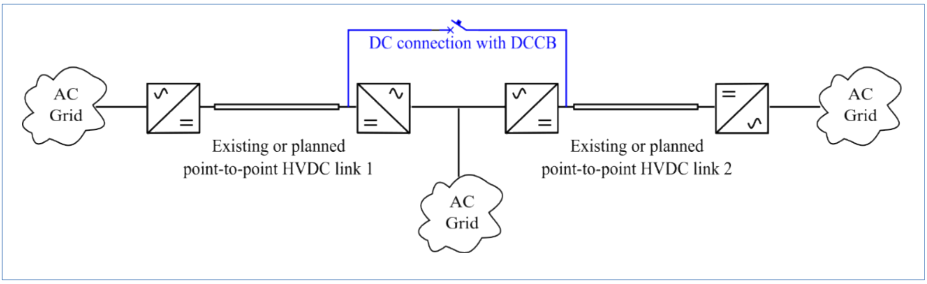


## Motivation

The transition to a decarbonised electricity supply system calls for increased use of **HVDC power transmission**. As HVDC links become more prevalent, it will become beneficial to connect them into **multiterminal connections**, which may eventually evolve into a DC grid. Thereby, many benefits are possible:

- **investment cost is saved**, since the number of costly converter stations can be reduced,
- **security of supply is improved** since power can be routed in alternative paths,
- **converter losses** and unavailability are reduced,
- **environmental and visual impact** as well as the planning and permitting issues are reduced.

However, deployment is extremely slow as experience is lacking. Experience cannot be gained because no installations are made.

**To solve this catch-22-like situation we propose to create a DC bypass between two adjacent HVDC links.**

## Object of investigation

- Devise technical concept for DC-side connection of existing point-to-point connections
- Verify the technical feasibiity of the proposed solution
- Make a thorough  cost/benefit analysis of the proposed solution.

## Study case

To have a realistic and feasible study case, the two HVDC point-to-point links *SouthWest link* and *Hansa Power Bridge* were chosen. They both have one terminal in Hurva in Southern Sweden and operate at the same DC voltage.

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## Technical concept

A technical concept for the control and protection of the combined three-terminal systems has been conceived. This involves:

- **main circuit** modifications, adding the DC bypass with a DC circuit breaker and di/dt inductors,
- **selective protection** scheme,
- **power flow control** by droop functions,
- **seamless transition** between point-to-point and multiterminal operation,
- **insulation coordination.**

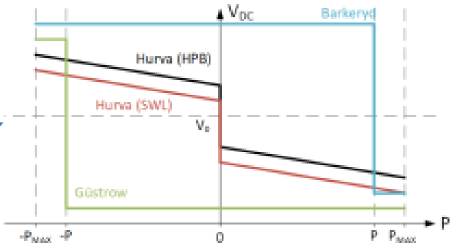
## Control

- Droop control ($P - V_{DC}$) scheme to enable **seamless transition between** P2P and MTDC operation
- **No adaptations needed** to switch DC connection in or out

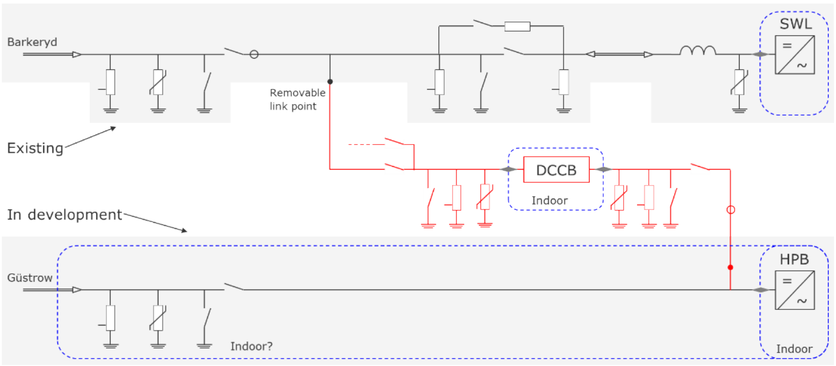
## Protection

A selective DC-side protection scheme was developed

- A fault on either link should **not affect the other link** and not cause blocking of its converters
- DCCBs with **2 ms** (hybrid or VARC) and **8 ms** (mechanical) opening time were investigated
- A third option was using **two redundant hybrid DCCBs**

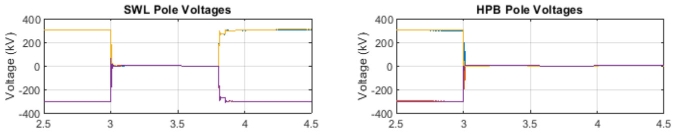



## *Main circuit modifications for the DC bypass, in red*

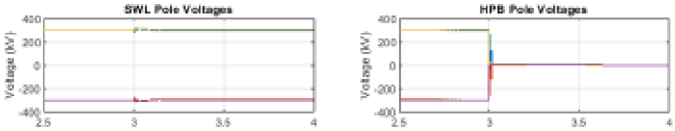



## *Simulation of the impact of a fault on the Hansa Power Bridge Part:*

*AC CB protection (reference case)*




*DC-side protection with DCCB*

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## Economic evaluation

A detailed cost/benefit analysis of the project, considering three different implementations of the DCCB was made. It takes into account all significant items:

- the **capital expenditure** of purchasing and installing the DCCBs and other needed parts,
- the **maintenance cost of** added components**,**
- the cost of power losses in the added **DC reactors,**
- the benefit of **power loss savings** owing to bypassing the converters,
- the **gain in socio-economic welfare** (SEW) thanks to increased availability of the, link from Barkeryd to Güstrov,
- **re-dispatch savings**, due to less frequent unplanned outages of the transfer capacity from Barkeryd to Güstrov.

## Acknowledgement

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## Conclusion

- There is a need to gain **operational experience** of multiterminal HVDC to accelerate its deployment
- The proposed DC connection allows for **risk-free derisking** of HVDC grid technology incl. DCCBs
- Given the **significant power loss savings**, the DC connection can even be profitable
- Still bigger benefits will be reaped with **native multiterminal HVDC systems**, thanks to the reduction in the number of costly converter stations

*DCCB alternatives investigated for the selective DC-side protection*

**Hybrid DCCB**

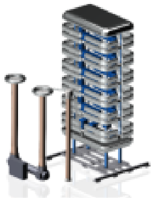

Illustration: 350 kV 16 kA
Indoor
2 ms breaker operation time
Tested up to 350 kV, 20 kA
Dimensions: 7 x 5 x 11 m

**Mechanical DCCB with active current injection**

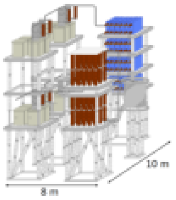


Illustration: 320 kV 16 kA
Both in- and outdoor
8 ms breaker operation time
Tested up to 160 kV, 16 kA
Dimensions: 8 x 10 x 9 m

**Voltage source converter assisted resonance DCCB**

Illustration: 320 kV 10 kA
Indoor
2 ms breaker operation time
Tested up to 80 kV, 12 kA
Dimensions: 2 x 7 x 8 m

*NPV comparison of different DCCB alternatives (mln EUR)*

| | Cost / Benefit Element | Mechanical DCCB | Hybrid DCCB | Redundant DCCB |
|---|---|---|---|---|
| 1 | CAPEX | − 14.7 | − 43.2 | − 21.2 |
| 2 | OPEX (maintenance) | − 2.1 | − 14.7 | − 3.0 |
| 3 | DC Reactor losses | − 3.7 | − 2.0 | − 2.0 |
| 4 | Power loss savings | 42.2 | 42.2 | 42.2 |
| 5 | SEW gain | 1.0 | 1.0 | 1.0 |
| 6 | Re-dispatch savings | 11.2 | 11.2 | 11.2 |
| **7** | **Total Lifetime Project Value (NPV)** | **34.0** | **− 5.4** | **28.3** |