Paris Session 2022

Integration of Energy Storage into High-Capacity Power Converters for Provision of Ancillary Services

SCB4 PS1 & PS3 – Grid Forming Applications (Special category) Question S.2

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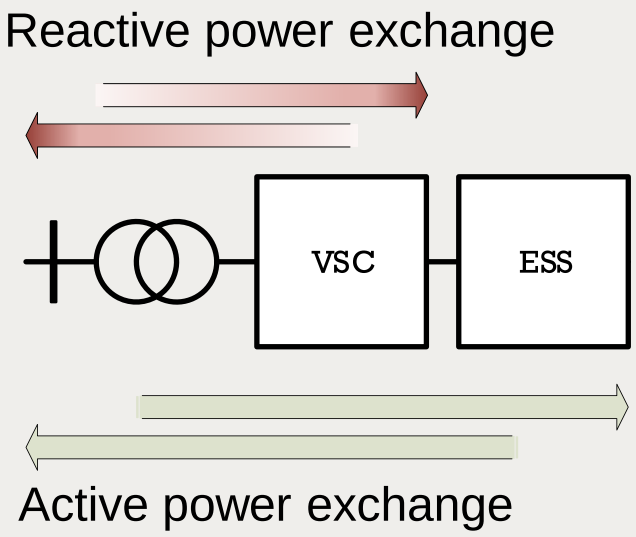
Question S.2

Is there any practical experience around the world with the construction of supercapacitor banks and associated protection? Are there pilot projects to demonstrate the supercapacitor-enhanced STATCOMs?

Integration of Energy Storage Systems with High-Capacity Converters



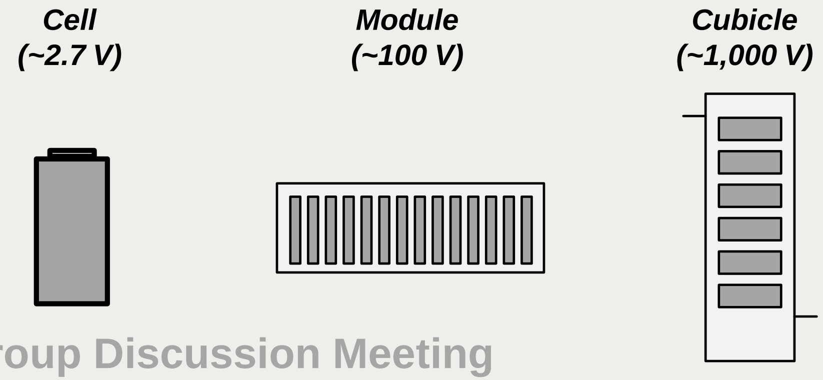
Future system stabilisation equipment will require integrated energy storage systems for both short and medium-term active power support. This will allow an increased range of functionalities, such as synthetic inertia, fast-frequency response and energy balance services.

Coupling the energy storage system with the power converter is one of the challenges, with increasingly higher capacity systems being demanded. Key considerations include ***safety, reliability/redundancy, maintenance, footprint, development hurdles and risks***, etc.

GFM	Grid Forming Control
ESS	Energy Storage System

Energy Storage Voltage Ratings

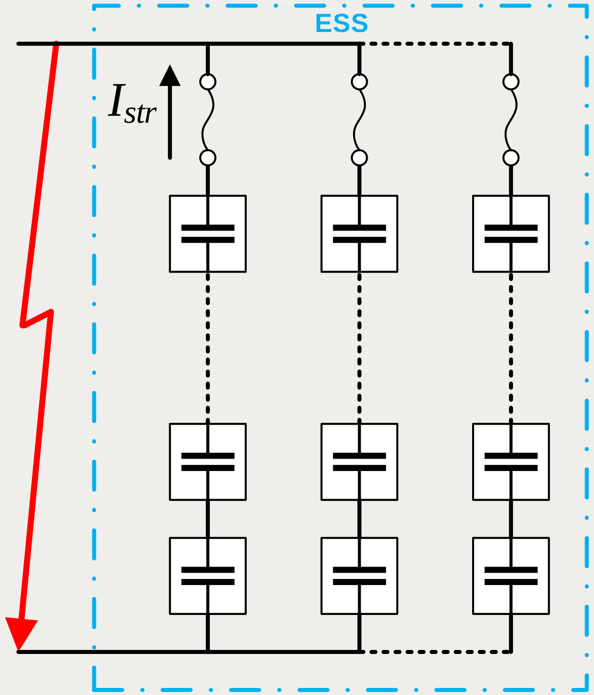
- Super-capacitor and lithium-ion based energy storage systems are typically built-up in three levels of increasing voltage: cell, module and cubicle.
- Due to the large number of cells, modules typically contain active balancing control as well as communication and monitoring systems.
- Current stage-of-the-art designs are based around cubicle designs in the range of ***1,000~2,000 V***; and equivalent ratings for associated equipment.
- Increasing this voltage significantly is expected to require significant redesign of these components and systems.

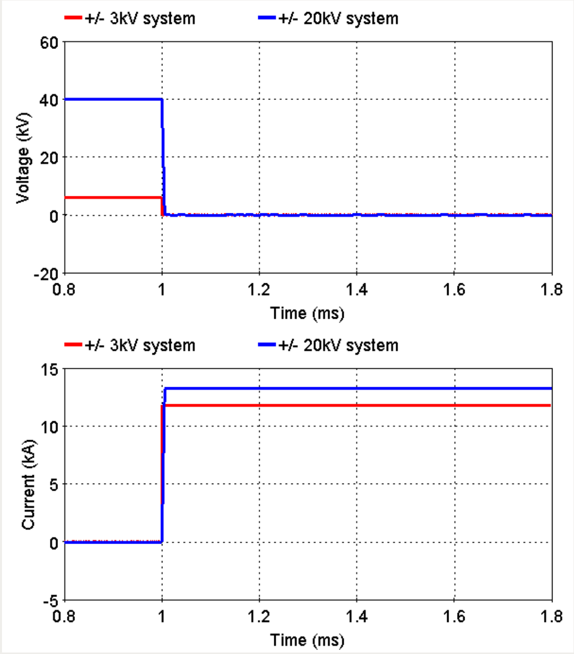


Group Discussion Meeting

DC Protection

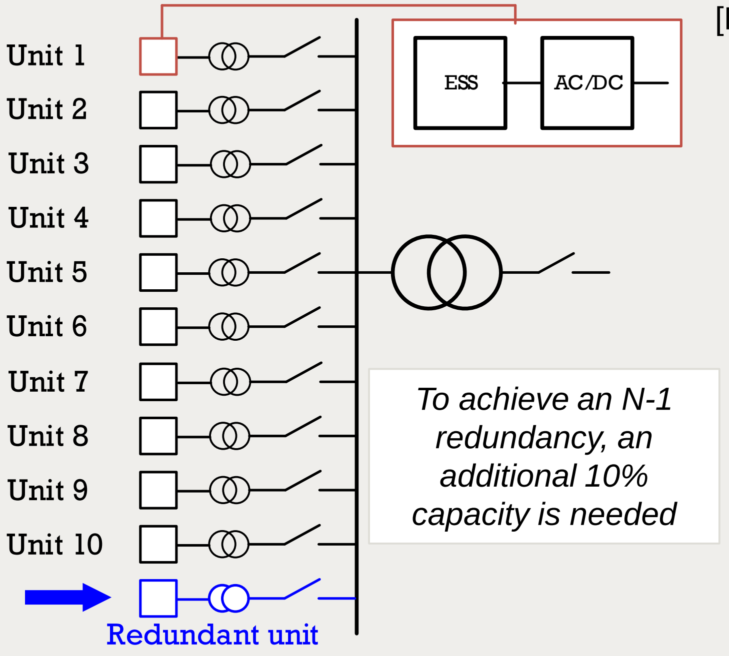
- Supercapacitors have low ESR, resulting in large fault currents
- Protection equipment requirements (e.g. circuit breaker or fuse) becomes very severe when the ESS consists of high-voltage and large capacity units.



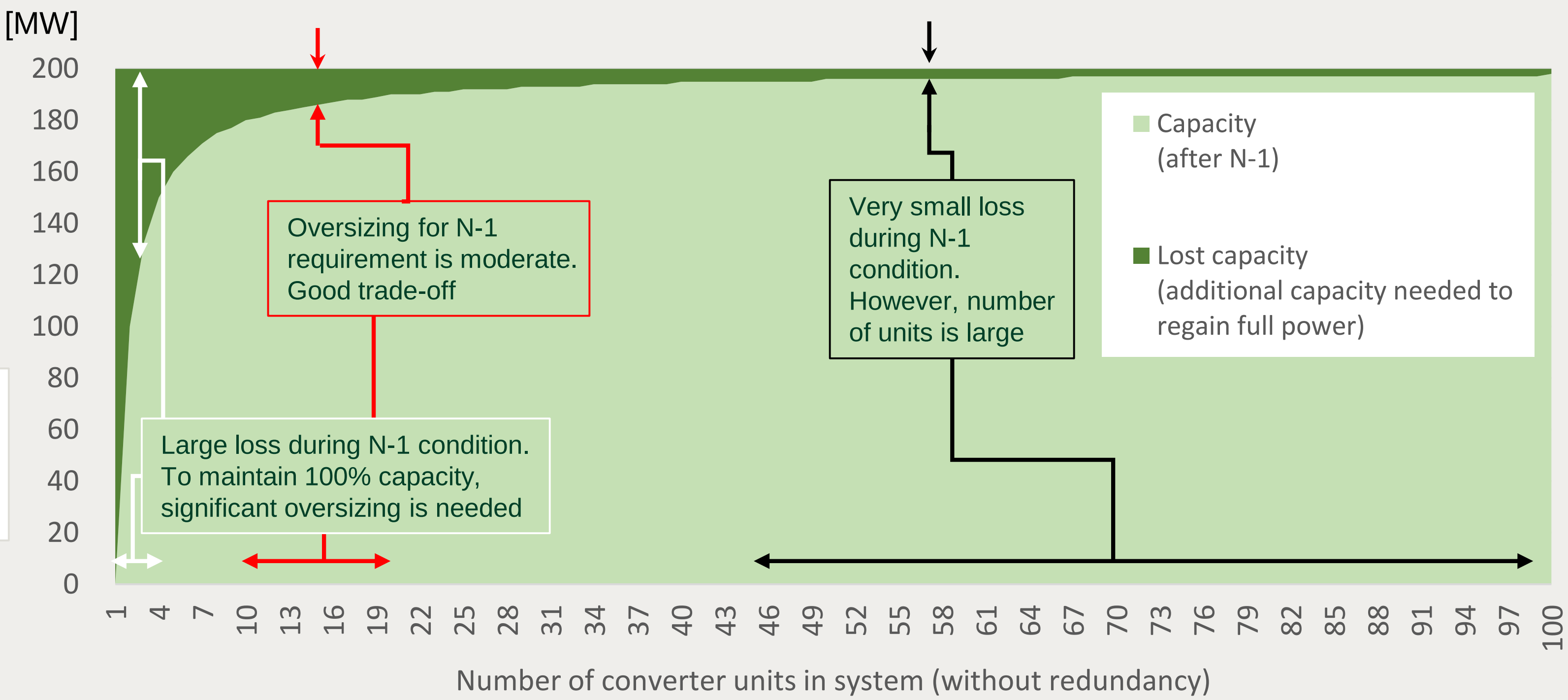


Impact of converter capacity on redundancy

- The ESS impacts overall availability. The overdesign required to achieve N-1 redundancy is directly related to converter unit capacity, which influences cost/footprint.
- A small capacity is attractive from the point of view of readily providing redundancy. However, it is unattractive for very-large scale systems, where the number of converters and associated secondary equipment will increase.
- Considering target system capacities 150~300MVA, a unit capacity of 10~20 MVA is seen as a good trade-off

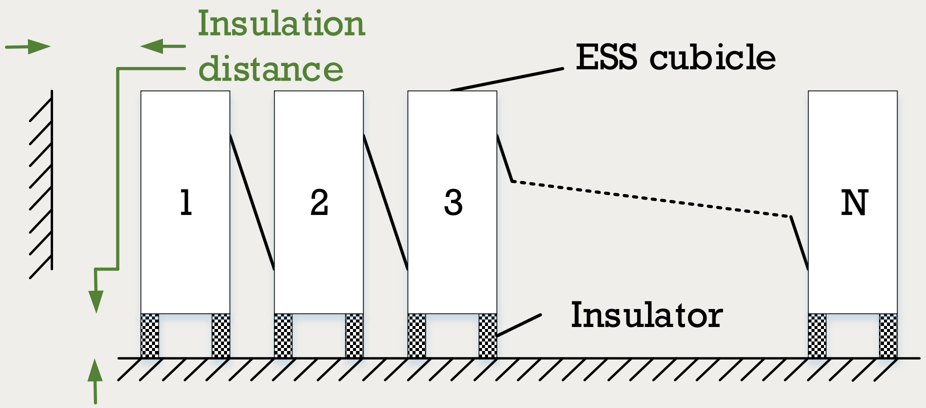


200 MW System (20 MW Unit Capacity)



DC Voltage: Footprint Impact

- DC voltages of several tens of kV is expected to increase clearance distances significantly, and thus increasing footprint, both between cubicles in different strings and to ground (floor, walls, etc.)
- With a lower dc voltage, a standardised cubicles can be used, and placed closely together, leading to a compact footprint.



Conclusion

Optimising converter capacity (redundancy)

- The addition of energy storage within the power converter has an impact on overall redundancy and availability, which favours a medium sized converter capacity.

Matching energy storage devices with the converter

- Increasing dc voltage significantly from the current state of the art (1,000~2,000 V) will require development of higher voltage energy storage modules and cubicles.

Protection considerations

- Faults within the ESS can lead to significant short-circuit current, and adequate protection systems are critical.