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PS1 – HVDC systems and their applications & PS2 – DC for Distribution Systems
PS1-1 – HVDC Planning, Control, Protection, Operation, Design & Performance
Question 1.3: In the last decade, VSC technology has advanced considerably, and it has now become the predominant technology selected for new HVDC projects, especially to interconnect and transmit renewable energy. VSC is even starting to be evaluated as an alternative to the refurbishment of existing LCC HVDC links as the power rating of VSC converters trends up.
• What are the main considerations on technology selection for new and refurbishment HVDC projects?

Main Considerations for Selection of VSC or LCC in New HVDC Systems
VSC delivers inherent flexibility with MW and Mvar control within the converter, without AC Shunt Banks, but looking at the differences….

DC Conductor Circuit: From an investment p.o.v. selection of technology is made on the basis of both the converters and the DC conductor. Regardless of which technology is more cost effective the fact that VSC can utilize lower cost extruded cables as against MIND cable for LCC simplifies the decision. If the transmission medium is insulated cable, and it is within the VSC rating, then a VSC solution will most likely be lower cost.
New Technology Risk: the perceived new technology risk associated with VSC is receding - Increasing maturity of VSC means that utilities and developers are leaning towards VSC by default.
Converter Ratings: Increasing Rating capabilities of VSC converters means that the majority of HVDC systems being proposed globally up to ~2000 MW are VSC. Even up to 3000 MW and beyond, there is a trend towards VSC being preferred, even though these are at the extreme high end of the ratings capabilities at 525 kV.
Engineering Complexity: There is a lot of experience in designing and constructing LCC HVDC, considering their strong dependence on the interconnected AC systems, working within the basic constraints of p.f., SCL, AC voltage and frequency, AC and DC harmonics, and many other factors including converter station footprint. However, the basic converter equipment is relatively simple, well understood, and the complexity lies mainly in the project-specific design, and the customization of the HVDC system to meet the performance needs of the operational link. This means that LCC systems may give the appearance of being more constrained, and therefore present more risk to potential owners. VSC is somewhat the reverse, the basic converter equipment is inherently more complex, (managing the retained energy within the converter elements to ensure an even distribution of duty cycle, efficient performance, etc.). Once the converter basic operation is mastered, the beneficial impacts of MW and MVar control, radically reduced dependence on the AC networks, and other inherent functional benefits, give the overall impression of the VSC systems bringing lower risk. The prospects for late-stage modification to an LCC system will be more likely to impact both the physical hardware and the software, whereas in the VSC, the impact of late-stage modification will most likely be seen in the software. The small exception to this is the potential need for a high frequency filter in some VSC systems.
Operational Flexibility: Many network operators view the controllability of MW injection through HVDC as a benefit compared to AC, but as VSC has the inherent ability to dynamically control MVar, and to operate into very weak AC systems, or even with a load-only AC system, makes VSC so attractive that grid codes are being written around them.
Future Expandability: The constant voltage operation of VSC HVDC, regardless of power direction, brings the prospect of future expansion into HVDC multi-terminal or even HVDC grid systems. The autonomous nature of the individual converters (working on the basis of the DC terminal voltage to control MW and MVar exchange on its AC terminals), means that adding more terminals to an existing DC link becomes a more manageable prospect, the limitation perhaps being more in the DC conductor circuit rating rather than the individual converters.
Converter Equipment Dimensions: The lower power density of the IGBT compared to the Thyristor means that more semiconductor devices are needed to meet the same MW rating. Therefore, VSC converter valve structures are larger than those of LCC systems.
Converter Station Footprint: LCC converter stations are overall larger footprint than a VSC converter station with equivalent rating, since LCC systems require a great deal of AC Harmonic Filters and Reactive Power shunt elements to achieve the necessary performance limits.

……. For these and other reasons, the future trend is a preference for, even insistence on, VSC for new installations.

Main Considerations for Selection of VSC or LCC in Refurbishment of Existing HVDC Systems

Refurbishment takes different factors into account, but largely driven by Owner budget considerations and ambitions for future HVDC system utilization….

Common Scope Options include: Controls, Valves + Cooling + Controls (with or without retaining the valve hall building), or total converter replacement.

Outage Duration Permitted: When an existing HVDC is being refurbished, the changeover from the old equipment to the new takes a finite amount of time. The physical replacement of equipment must be carried out safely and expediently. The down-time period without power transfer may be critical, especially if the link is crucial to the reliable operation of the interconnected AC networks. This may restrict the duration of the changeover outage to a few hours, or allow it to be extended over several days, weeks or even months. If a longer outage is permitted, a new building may occupy the space previously occupied by the AC harmonic filters, therefore, if budget permits, this may allow VSC through a replacement program.

Retention of the Existing Building: Valve hall dimensions as originally constructed would normally have been optimized to be as small as possible to accommodate the Thyristor valves, therefore the larger IGBT valves may not easily fit. If budget is limited, and the owner wishes to remain within the existing building, this often forces staying with LCC converters, due to larger VSC valve dimensions.

Total Replacement Option: If budget allows, and there is adjacent land available, or if the system is highly utilized to the extent that the HVDC power transfer (or the standby availability), is crucial to the reliable operation of the AC networks, this may drive the refurbishment towards total replacement, building a new HVDC link alongside the existing, which adds potentially new VSC functionality.

……Until IGBT MMC-based Valves achieve a power density similar to that of the Thyristor Valves, it is unlikely that a limited Valves + Cooling + Controls refurbishment of an existing LCC system will be possible using VSC, staying within the same buildings.

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