e-News for power industry leaders
Edition 43 – May 2026

Application Of VSC HVDC In A System Black Start Restoration

Blackouts, although infrequent, can cause widespread disruption to infrastructure, economic activity, and public safety. Because of these risks, transmission system operators must establish robust Black Start Restoration (BSR) procedures to recover generation and restore electricity supply as quickly and safely as possible. Working Group B4.94 has produced Technical Brochure (TB) 981, *Application of VSC HVDC in a System Black Start Restoration*. This examines how Voltage Source Converter High Voltage Direct Current (VSC HVDC) technology can support the restoration of electrical power systems following a major blackout.

The TB focuses on the growing role of VSC HVDC systems in modern power networks. HVDC technology is increasingly used to connect asynchronous grids, support long-distance transmission, and integrate renewable energy sources such as offshore wind farms. Due to its flexibility and controllability, VSC HVDC is becoming an attractive option for black start applications.

The TB explains the concept of black start restoration and the planning required to implement it successfully. A black start unit is defined as a power source capable of restarting parts of the grid without relying on an external power supply. Restoration plans are typically prepared in advance and involve dividing the network into segments, defining restoration paths, and carefully managing load pickup to maintain system stability. The report also references ten recent large-scale blackouts, including South Australia in 2016, to illustrate the importance of effective restoration planning.

The report compares Line-Commutated Converter (LCC) HVDC technology with VSC HVDC technology. LCC systems are unable to independently control voltage and frequency and therefore cannot initiate black start operations on their own. In contrast, VSC technology, particularly when operated in Grid Forming mode, can independently establish and regulate voltage and frequency without requiring synchronization to an existing grid. This capability makes VSC HVDC suitable for black start applications.

The TB then examines the design considerations associated with using VSC HVDC for black start restoration. Successful operation depends on the availability of a “healthy” energy source at one end of the HVDC link. The report discusses factors such as converter ratings, transformer design, auxiliary power systems, DC system energization, protection systems, and commissioning requirements. It emphasizes that VSC systems must be specifically designed with black start functionality in mind, as different restoration scenarios can impose different technical demands on the converter system.

Another important topic is the modelling and simulation requirements necessary to validate black start capability. Electromagnetic transient studies and real-time simulation are identified as essential tools for verifying converter controls, protection systems, and system interactions during restoration. Accurate representation of control systems is critical to identifying resonance issues and ensuring stable operation during energization sequences.

The TB also investigates operational interactions that can arise during black start restoration. Every time a transmission line, transformer, or other network component is energized, the electrical characteristics of the network change. These changes can create phenomena such as ferroresonance, harmonic distortion, overvoltages, and control instability. Coordination between

VSC controls, protection systems, synchronous generators, and inverter-based resources is therefore essential. The report highlights the need to clearly define the roles of all AC/DC converters during restoration in order to avoid stability concerns.

Finally, the report explores the use of offshore wind farms as black start resources. As renewable energy penetration increases, inverter-based renewable sources may play a larger role in future restoration strategies. However, renewable generation introduces challenges such as variable power availability and uncertainty in output. Preliminary feasibility studies indicate that offshore wind farms equipped with grid-forming capability may be able to support black start operations and energize HVDC systems from offshore installations.

Overall, the TB concludes that VSC HVDC technology can support modern black start restoration due to its flexibility, controllability, and compatibility with renewable energy integration. However, successful implementation requires careful planning, specialized design considerations, detailed simulation studies, and coordinated control strategies to ensure stable and reliable restoration of the power system.

The TB is free for members and 170€ for non-members.