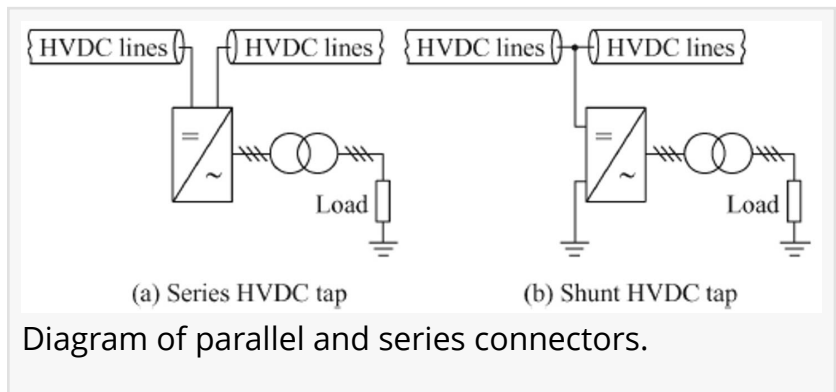


Tapping the power highways of the clean-energy grid

GA, UNITED STATES, September 21, 2026 /EINPresswire.com/ -- High-voltage direct current (HVDC) lines are often described as the power highways of the clean-energy era, carrying large amounts of electricity across long distances with high efficiency. Yet a highway is most useful when it has safe, practical exits. A new review examines HVDC tap technology, which allows electricity to be drawn from existing HVDC lines for local loads, remote communities, industrial users or renewable-energy resources. By comparing tap topologies, converter designs and control strategies, the review shows how these access points could make future direct current (DC) grids more flexible, reliable and scalable without always requiring new transmission corridors or major grid reconstruction.



As offshore wind, distributed generation and cross-border electricity exchange expand, modern grids must move power over longer distances while serving more varied local needs. Conventional alternating current (AC) transmission can be uneconomical or inefficient for some remote or high-capacity applications, while many High-voltage direct current (HVDC) links were originally built for point-to-point delivery rather than multiple access points. Adding taps to these lines is attractive, but technically demanding: small taps may still face full line voltage, strict insulation requirements, stability risks and high component costs. Because of these challenges, deeper research is needed into compact HVDC tap designs, advanced converter technology and coordinated control for hybrid AC/DC grids.

The review was conducted by a research team from the Department of Engineering, King's College London, London WC2R 2LS, United Kingdom. Published ([10.23919/CJEE.2025.000110](https://doi.org/10.23919/CJEE.2025.000110)) on March 31, 2025, in the Chinese Journal of Electrical Engineering, the article surveys the state of HVDC tap technology for renewable-energy integration, rural electrification and hybrid alternating current/direct current (AC/DC) power systems. It also discusses modular multilevel converters (MMCs), DC/DC converters, power-flow optimization, HVDC grid substation design and future research directions for more scalable power networks.

The review groups HVDC taps into three main families: series, parallel and hybrid taps. Series taps are placed directly in the HVDC line, carrying the full current while taking only part of the voltage, making them promising for smaller power extraction. Parallel taps are connected across the line, handling full voltage but limited current, which can be more suitable for larger tap ratings. Hybrid taps combine elements of both approaches to improve flexibility and system adaptability. A central thread is the growing importance of MMCs, whose modular structure, scalability and low harmonic distortion make them strong candidates for HVDC tapping. The authors also examine control strategies, including model predictive control (MPC), proportional-integral-derivative (PID) control, MMC energy control and power synchronous control for voltage source converter HVDC (VSC-HVDC) systems. These approaches are especially important in weak grids, fault ride-through, reactive-power support and coordination among multiple HVDC links, including line-commutated converter HVDC (LCC-HVDC) systems. The review further connects tap design with power-flow optimization, converter architecture and substation planning, making clear that future HVDC access points will depend on both device-level innovation and whole-system coordination. It also highlights lessons from earlier HVDC tap projects, where feasibility was demonstrated but protection, voltage stability and cost remained decisive engineering constraints.

The authors said the review points to a broader change in transmission planning: HVDC links should not only move bulk power from one terminal to another, but also provide controlled access for communities, industries and renewable generators along the route. They said future progress will depend on whether engineers can make taps smaller, cheaper and more fault-tolerant, while ensuring that their control systems remain stable in complex networks, weak AC grids and fast-changing operating conditions, especially as renewable generation becomes more variable.

Practical HVDC taps could help power systems use existing transmission assets more efficiently, connect isolated communities, support offshore wind delivery and strengthen future multiterminal HVDC (MTDC) networks. They may also reduce the need for separate new lines in some settings by allowing local loads or distributed energy resources to connect to nearby HVDC infrastructure. The review cautions that major barriers remain, including cost, high-voltage insulation, voltage stability, fault management and regulatory complexity. Solving these issues could make HVDC taps an enabling technology for cleaner, more resilient and more accessible power systems as electricity networks become increasingly renewable, distributed and interconnected, and as planners seek flexible ways to expand capacity without overbuilding.

References

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