In order to connect renewable energy to the electric power network, and to run the network under such conditions, a set of DC grids is planned across Europe. To protect these new DC superhighways, new fast-acting DC protection is needed.

Manchester University is at the forefront of research into the operation of such DC circuit breaker protection and the implementation of such systems on to future DC networks.

The European Union Renewable Energy Directive has committed the UK to the development of large amounts of offshore wind, through its so-called 20/20/20 targets. In real-terms this means the UK to must generate more than 20% of electricity from renewable sources by 2020. A key plank of this strategy is a large expansion of offshore wind, as outlined in the plans for Round 3 wind farms. This expansion is being mirrored across most of Northern Europe.

A variety of studies have suggested that a 'DC grid' rather than individual point-to-point connections offer the most cost-effective option. For example, the North Seas Countries' Offshore Grid Initiative indicate savings of 18% by 2030 for a meshed design using Voltage-Source High Voltage DC Transmission (VSC-HVDC). This has been recognised in National Grid’s Electricity Ten Year Statement and the European Network of Transmission System Operators for Electricity’s Ten Year Network Development Plan. In addition an integrated HVDC network further has the potential to improve reliability through redundancy, avoiding cable idling costs and the danger of under-utilised assets.

However, to realize such HVDC networks, DC circuit breakers are necessary to isolate faulted DC sections. The unacceptable alternative would be to temporarily de-energise the whole DC network to then allow isolation of the faulted section. This is unacceptable because the resulting simultaneous loss of supply to the AC system would radically exceed onshore present network design limits and would lead at least to severe disruption among consumers. For larger DC grids and power loss it could even cause widespread black-outs.
**Project:** DC Breakers

DC current breaking is much more difficult than AC current breaking; in AC the natural current zero points can be used – in DC, no such zeroes exist. Early work on HVDC breakers has tried several technologies. Traditional HVDC circuit breakers, such as the Metallic Return Transfer Breaker (MTRB), were used to switch DC current between parts of a circuit during a faulted condition. However, they were not required to break fault current at full DC line voltage, merely to transfer normal current from one part of the circuit to another after the fault had been dealt with by AC circuit breakers. As such, they are too slow for application in VSC-HVDC. In addition, they only break current at a reduced voltage of a few 10s of kV.

Initial work in HVDC on high-voltage DC circuit breakers, focused on using the oscillating impedance of the arc, together with passive circuit elements, to create zero-crossings to provide extinguishing points. The main breaker opens, and then oscillating current and voltage create zero current points at which current in the mechanical switch can block. A pseudo-AC system was created. As well as the complexity and additional voltage and current stresses resulting, this still led to relatively slow operating times (ca. 35ms). An advancement in technology was required. Entirely solid state solutions, using a single switch in series with the cable to break current, have been proposed. However, losses associated with such devices are comparable to those of a single leg of a converter – the device is thus just too expensive to run.

Recently, DC circuit breaker designs are starting to become available: ABB’s active HVDC circuit breaker and Alstom Grid’s prototype demonstrated under the EU Twenties research programme, are good examples. However, these are large, especially when the series inductor they require to operate is considered.

Research at Manchester is focusing on faster, smaller, and cheaper solutions, using superconducting technology and advances from the aerospace industry. These are being tested in EPSRC funded research (EP/I021552/1). In parallel, research funded by National Grid is being undertaken to help understand requirements for breaker specification and testing.

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