BENEFITS FROM MVDC AND LVDC CABLE SYSTEMS

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The climate change and the energy transition lead to a shift in the energy production from conventional power plants, e.g. fossil fuels, which are located close to consumer centres to power plants based on renewable energies. These renewable power plants are often placed in rural areas, e.g. wind parks. Furthermore, the necessity of CO_2 neutrality and the ever-increasing energy demand make the increased use and expansion of renewable energy power plants indispensable. These emerging changes of recent years and decades have presented numerous challenges and innovations, which have an impact on the energy market and the requirements for a reliable energy supply. However, the existing transmission and distribution grid is not designed for the rising amounts of energy from mainly renewable energy power plants. Therefore, the transmission and distribution grid has to be extended and uprated in future. However, the expansion of energy infrastructure is often confronted with resistance from the general public, which often rejects the construction of new transmission systems. In this regard, the direct current (DC) transmission is a part of the solution to solve the problems of the energy transmission and distribution due to the, e.g. higher possible transmission capacity over an in comparison similar alternating current (AC) cable system.

Nowadays, high-voltage (HV) DC cable systems are already implemented into the existing grid. Furthermore, a large number of DC cable systems will start to operate in the upcoming years, e.g. the corridor projects in Germany. Until now, HVDC is mostly used as a point-to-point connection to transmit energy from renewable power plants, e.g. off-shore wind farms, to consumer centres. In the case of high voltage cable systems however, the insulation material must be modified with, e.g. nanofillers to, for example, increase the specific resistance of the insulation material or reduce the accumulation of space charges in the insulation material. However, the additional treatment of the insulation material makes the production of DC cables often more complex and more expensive in comparison to standard and well-established AC cables [1]. To solve the challenges coming from the energy transition an alternative approach is the medium-voltage (MV) DC transmission via cables. Through investigations regarding MVDC cable systems it was already shown that standard AC cables with the corresponding accessories can be used in MVDC cable systems. The nominal DC voltage can be increased significantly [2]. By using MVAC cable systems for MVDC operation the big advantage of a transmission capacity, which is 5.7-fold in comparison to an MVAC cable system by using identical cables, is obtained [3].

As a result, an MVDC as well as a low-voltage (LV) DC distribution system can be introduced to the existing grid in future besides HVDC transmission systems (Fig. 1). For example, the project “Angle DC”, located in Wales, UK, proves that standard AC cable systems can be converted to MVDC cable systems. Furthermore, the transmission capacity was increased by 23% despite the conservative approach of the nominal DC voltage in the “Angle DC” project [4]. In addition, the use of LVDC systems will increase in future, which is related to the advantages in specific use cases in comparison to LVAC systems as, cost reduction or energy reduction. For instance, the company “Schaltbau” already built a manufacturing facility, where LVDC is used for the logistics in the company. In future, the main energy system of the company will be changed to an LVDC system. Furthermore, half of the energy produced by the photovoltaic system, located on the property of the company, will be connected to the LVDC system. In comparison to an energy concept with fossil energy sources, the energy costs will be reduced by up to 35% [6].

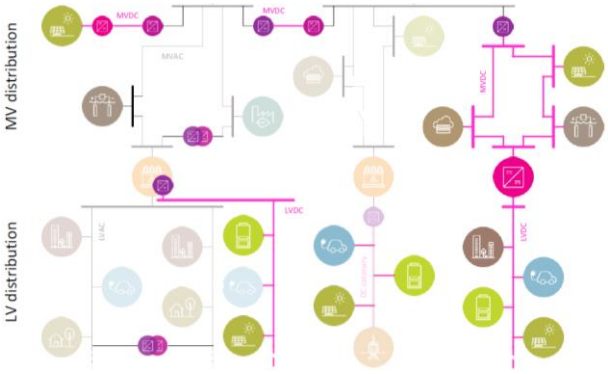

Fig. 1: MVDC and LVDC transmission grid [5]

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In this contribution, the benefits of MVDC and LVDC cable systems are shown and discussed in detail. In addition, the application of MVDC and LVDC systems is described in depth. For this purpose, investigations regarding an MVDC and LVDC cable system are introduced. In the case of MV and LVDC cable systems, the research deals with the conversion of AC to DC cable systems to increase the transmission capacity and reduce the costs in comparison to AC cable systems. To further investigate the conversion of new LVAC cables to LVDC cables, the insulation material of a standard 4x50SM LVAC cable for up to 1000 V AC is investigated under various DC stresses. The insulation material of the investigated LVAC cables is polyvinyl chloride (PVC), which is a typical insulation material used in LVAC systems. To investigate this insulation material for DC application, breakdown tests and long-term tests under DC stress are carried out. These investigations indicate that standard LVAC cables can be used for LVDC without a modification of the used insulation material.

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