Update on world's first superconducting cable and fault current limiter installation in a German city center

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ABSTRACT

In recent years significant progress has been made in the development of high temperature superconducting (HTS) power devices. Several field tests of large scale prototypes especially for cable and fault current limiter applications have been successfully realized and the technologies are getting closer to commercialization.

This paper will give an update on the German AmpaCity project. The overall system design will be introduced and the type test results of the cable and accessories will be reported. Furthermore, the installation of the complete HTS system on site in Essen as well as its commissioning will be highlighted.

KEYWORDS

AmpaCity Project, Fault Current Limiter, High Temperature Superconductivity, High Temperature Superconductor System, Power Cable, Urban Area Power Supply

INTRODUCTION

In most European countries the power supply within cities is predominantly ensured through high, medium and low voltage power cables. A large fraction of these cable systems as well as the associated substations are approaching the end of their lifetime and therefore need to be refurbished in the upcoming years. Usually, old power devices will be simply replaced by new ones, and if there are major load changes, substations will be adapted by up- or downgrading.

The application of medium voltage HTS systems consisting of a concentric three phase HTS cable connected in series with an HTS fault current limiter (FCL) offers attractive alternatives to conventional systems. Replacing conventional high voltage cable systems by medium voltage HTS systems exhibiting the same power rating enables a considerable reduction of the number of inner city substations. Since HTS cables are in general more compact than conventional cables, the required right of way is much smaller and the installation is easier. Moreover, there are many other advantages of HTS cables. Besides the increased power density there is no thermal impact on the environment. In addition, HTS cables do not exhibit outer magnetic fields during normal operation and in combination with HTS fault current limiters the operating safety in the grid is increased as a result of reduced fault current levels.

Over the last few years, high temperature superconductors have matured, especially due to the technical progress achieved in manufacturing these materials, and they are getting closer to industrial scale production. Furthermore, several superconducting cable systems [1-5] as well as superconducting fault current limiters [6-8] for power systems have been tested in real grid applications worldwide and the transition to commercial projects is in progress. The experience gathered in the field tests shows that all technical requirements are fulfilled so far, and a high reliability of these new power devices can be achieved. At present, the main reason preventing wider use of the HTS technology is the higher capital cost compared to conventional devices. However, already today an economic advantage of the HTS technology can be realized wherever positive secondary effects are present. Regarding the design of electricity distribution networks, this would mainly include higher power density and space savings especially in congested urban areas.

Between December 2009 and December 2010 a feasibility study had been conducted under guidance of the Karlsruhe Institute of Technology (KIT) on behalf of the German utility RWE [9,10]. Together with superconductor cable and fault current limiter specialists from Nexans as well as other partners, it was investigated whether the electric power supply with medium voltage superconductor systems in city centers offers technical and economical advantages compared to conventional high voltage technology. The German city Essen was chosen for the study and the key result is, that four out of ten 110/10 kV transformer substations become dispensable in the downtown area by using 10 kV cable systems. Conventional 10 kV cables do not constitute a viable alternative because of the large routing requirements and the high losses involved. In comparison to 110 kV cables, 10 kV HTS systems allow a much simpler grid structure, which requires less space for cable routing and smaller areas for equipment installations. In addition, the grid with 10 kV HTS systems exhibits lower overall costs than the grid with conventional 110 kV systems.

Subsequent to the positive results of the feasibility study RWE, Nexans and KIT started a pilot project, also referred to as "AmpaCity", with the objective to install an HTS system in the downtown area of a German city to demonstrate the technology under technical and economical aspects [11].

AMPACITY PROJECT

Due to the innovative character of the AmpaCity project an application for funding was submitted to the German Federal Ministry of Economics and Technology by the consortium consisting of RWE, Nexans and KIT. After being approved by the ministry, the demonstration project started in September 2011.

As for the feasibility study the downtown area of the city Essen was chosen for the installation of the HTS system consisting of a concentric three phase cable and a fault current limiter. The system was introduced as a connection between the medium voltage busses of two substations replacing a conventional high voltage system. The