EFFICIENT UPGRADING OF DISTRIBUTION NETWORKS WITH HTS CABLES

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ABSTRACT

The characteristics of the latest generation High Temperature Superconducting (HTS) cables make them very attractive for utilities. Thanks to the technical advantages, HTS cables can solve network bottlenecks and upgrade distribution networks in a very efficient way.

Today’s distribution networks face enormous challenges. The continuous growth in electricity consumption leads to transmission of more electric energy over the networks. The increasing penetration of renewable energy sources and other distributed sources in the energy supply in distribution networks leads to numerous technical bottlenecks.

The advantages to be enjoyed by applying HTS cables are: transport of much more power at a lower voltage level, very low energy losses, fault current limitation (FCL) and no negative thermal and Electro Magnetic (EM) influence on other infrastructures. Besides that, HTS technology is very environmental friendly. HTS cables produce almost no EM-emissions, a significant reduction in CO₂ emission can be achieved due to the low energy losses and there is no risk of leakage of harmful materials, like SF₆ or oil.

Nowadays the costs of superconducting material, which are dominating in the cost structure of HTS cables, are rather high. But, with the development of the technology and a growing market, considerable price reduction can be expected already in the near future.

The Dutch DSO Alliander, in combined effort with Ultera, has found HTS technology to be ideal to reach the challenges of the future in modern and existing grids.

INTRODUCTION

Present distribution networks face nowadays two main challenges. Continuous improvement of common welfare and integration of new technologies (among others the new environmental friendly technologies like e.g. the introduction of Plug-In Hybrid Cars) lead to an increase of electrical power demand. Other aspects of the modern society are the reduction of acceptance of overhead lines, the growth of urban areas and limited space, available for the installation of underground cable connections. This all leads to overloading of existing infrastructures.

The latest generation of HTS cables has improved non linear voltage-current characteristics (figure 1). This means low impedance during normal operation and large impedance at increasing current. Smart HTS cables, designed with this property (FCL), behave intelligently by adapting their impedance to the actual needs in the network. That’s why smart HTS cables also contribute to a stable voltage profile in grids, while reducing short circuit currents.

Figure 1. Voltage-current characteristics of FCL HTS cable

These excellent characteristics of HTS cables provide the opportunity to upgrade existing distribution networks and to
integrate dispersed generation and renewables in an efficient and flexible way.

**Small footprint of HTS cables**

A traditional way to extend and to strengthen networks by the installation of new overhead lines is becoming straitened. The trend towards decreased acceptance of overhead lines is now universal. Electromagnetic field emission requirements are becoming more and more strict. Furthermore landscape impact of overhead lines and their visual effect in built-up areas is not tolerated anymore. Therefore, more infrastructures will be built underground. In it’s turn this will cause challenges such as limited space underground and impact of different infrastructures to each other (figure 2).

**REDUCTION OF ENVIRONMENTAL IMPACT**

HTS cables are environmental friendly because of their characteristics, as listed above, like no electromagnetic and heat emissions. Besides this, no harmful materials, as SF₆ and oil, are used. Furthermore, thanks to the very low energy losses in HTS cables, a significant reduction of CO₂-emission can be achieved. Calculations show, that a reduction in CO₂-emission of more than 50% can be achieved with the HTS technology.

**IN SHORT TERM ECONOMICALLY ATTRACTIVE**

The prices of superconducting materials dominate in the cost structure of HTS cables. Nowadays these costs are rather high. But, with the development of technologies and market, one can expect a considerable price reduction in near future. Already in a few years prices of superconducting materials can beat the prices of copper.

**6 KM HTS CABLE IN A REAL NETWORK**

The Dutch DSO Alliander is working together with Ultera on the installation of a 6 km long HTS cable in downtown Amsterdam (figure 4).

An existing high voltage circuit will be retrofitted by replacing the 150 kV Gas Pressure Cable with a 50 kV HTS cable. This will strengthen the backbone grid of the City of Amsterdam. The capacity of the cable will grow from 100 MVA to 250 MVA. After pulling the gas pressure cable out of the steel pipe, the HTS cable will be pulled into it (figure 5). Re-using the existing steel duct avoids significant civil works.
CONCLUSION

Compared with the traditional technologies, HTS cables have enormous technical and environmental advantages.

The technical characteristics of new generation of HTS cables make them very attractive for the utilities. Due to the technical advantages, HTS cables can solve grid bottlenecks and upgrade distribution networks in a very efficient way.

The pilot project in the city of Amsterdam shall open the doors for a real commercial market for HTS cables.

REFERENCES


