NOVEL GRID CONCEPTS FOR URBAN AREA POWER SUPPLY

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ABSTRACT

This paper presents results of a study investigating a possible permanent grid deployment of medium voltage superconductor cables within a typical urban area power system. A complete new grid concept, which only becomes feasible through the use of superconductor cables, is shown. Further, several different cable options, including superconducting and conventional cables, are compared.

KEYWORDS

Superconductivity; HTS cables; medium voltage superconductor cables; inner city power supply.

INTRODUCTION

In Germany and also other European countries the power supply within cities is predominantly ensured through high, medium and low voltage power cables. Many of these cables as well as associated substations are approaching the end of their lifetime and therefore need to be refurbished in the short and medium term. Usually, old power devices will be simply replaced by new ones, and if there are major load changes substations will be adapted accordingly by up- or downgrading.

Employing high temperature superconducting (HTS) power cables as replacement for conventional cables could be an interesting option. For a few years now, several superconductor cables have been tested in real grid applications worldwide [1,2,3]. The experience gathered in these tests shows, that all technical requirements are fulfilled so far, and a high reliability can be assured. Overall, HTS cables are on the verge of commercialization, which however will essentially depend on the price development for the HTS material as well as further technological developments.

This paper is based on a study conducted by the Karlsruhe Institute of Technology on behalf of the German utility RWE [4]. Together with superconductor cable specialists from Nexans as well as other partners, it was investigated whether the electric power supply with medium voltage superconductor cables in city centers offers technical and economical advantages compared to conventional high voltage technology.

URBAN AREA GRID CONCEPTS

The German city of Essen, which is situated within RWEs supply area, was chosen as example for the study. Based on RWEs load forecast for the year 2020 and already existing high voltage (HV) to medium voltage (MV) substations the concept for the grid with conventional technologies is shown in figure 1. In this concept ten major substations are located within the urban area of Essen, each equipped with two 40 MVA, 110/10 kV transformers. The connection of the substations is mostly realized with 110 kV underground cables (UGC), and a few overhead line (OHL) links. The electrical parameters for the links are provided in table 1. Through balancing the total system load equally between substations a maximum load of 40 MVA with a power factor of 0.9 lagging is achieved for each substation.

Further, the surrounding grid is represented through the generation infeed in the substations B, G and J. With respect to the gird structure G is identified as slack bus whereas B and J are generator busses with an infeed of 140 MW and 100 MW at the maximum system load. In order to keep short circuit currents in the 10 kV system at an acceptable level the 10 kV busses are divided within each substation. In the system, all substations comply with the n-1 criterion with respect to transformer capacity and also with respect to the 110 kV links connecting each substation.

	110 kV UGC (conventional)	110 kV OHL (conventional)	10 kV UGC (conventional)	10 kV UGC (HTS)
Type	N2XS(FL)2Y RM/35 1×300 mm2	Al/St 265/35	NA2XS2Y RM/35 1×630 mm^2	Nexans HTS 10/40
Number of systems	1	1	5	1
Nominal voltage (kV)	110	110	10	10
Continuous current (A)	591	680	2310	2310
Continuous power (MVA)	113	130	40	40
Resistivity (mΩ/km)	95.5	118.3	12.0	0
Reactance (mΩ/km)	188.7	296.3	17.1	11.4
Capacitance (nF/km)	149.1	8.0	3635.0	2880.6
Conductance (nS/km)	46.8	40.0	4568.0	1086.0

Table 1: Electrical line parameters for the urban area power system