On the Possibility of Using High-Temperature Superconductor Cable Lines in Creation of Long-Length Interconnections

V. Ye. Sytnikov, T. V. Ryabin, S. Ye. Bemert
Joint-stock company Research and Development Center at Federal Grid Company of Unified Energy System
Russia
e-mail: sytnikov_ve@ntc-power.ru

S. Yamaguchi, Yu. V. Ivanov
Chubu University
Japan

The increasing demand of the humankind for energy and uneven distribution of its sources on the Earth imply the necessity to consider the issues of transportation of large volumes of energy between countries and continents. As a result, such giant projects as the project of creating the Asian Energy Super Grid or plans for transferring energy from the north of the African continent through the Mediterranean to Europe are discussed. On the other hand, specific character of the location of electric power sources (nuclear power plants, hydroelectric power stations, wind farms) at great distances from large cities and electric power consumers also leads to the need to transport large energy flows over long distances. At the same time, the power delivery scheme assumes the use of high-voltage cable or overhead transmission lines (220–750 kV), to minimize energy losses during its transportation. This leads to the creation of high-voltage step up and step down substations and to alienation of large areas of land. The use of superconducting cable lines will significantly improve the efficiency, reliability and environmental friendliness of long-distance transmissions. With the current level of superconducting and cryogenic technology development, it is possible to create long superconducting cable lines for transportation of energy over distances of tens and hundreds of kilometers. The power of a single line can reach several gigawatts at a voltage of 100–200 kV, and the energy losses in it will be significantly lower than in traditional cable or overhead power lines. In our assessment of long cable lines, we will consider DC transmission lines, since any AC cable lines have a length limitation due to the charging currents that lead to a decrease in power at the far end of the line.

The report will briefly present the results of the world's two largest projects for creating superconducting DC lines cooled by liquid nitrogen. It is a project of creation of a 1.0 km long line in Hokkaido (Japan) and a project of creation of a 2.5 km line for the electrical network of St. Petersburg (Russia). Both projects are designed for a transmitted power of

50 MW at a voltage of 20 kV. Within the framework of these projects, scientific and technical cooperation of high-tech companies and research organizations was organized in both countries. Based on the experimental and theoretical results obtained by the research groups of these two projects, the possibility of building power bridges using superconducting technologies both in the ground and in underwater versions of cable placement was shown. Assessment of the transmission power, total length of the line and maximum distance between the cryogenic stations, energy losses and required power of the cryogenic plant will also be presented. As a result, it will be shown that, at the current level of development of superconducting and cryogenic technology, it is possible to create superconducting transmission lines with a power of about 10 GW in almost any length. At the same time, cryogenic stations should be located along the line with a maximum step of 45 to 75 km. The possibility of increasing the distance between cryogenic stations by improving the thermal insulation of cryostats is under discussion.

Key words: Superconducting cable line, power bridge, transmitted power, cryogenic station, critical current, gigawatt.