Superconducting Cables for Europe's Energy Transition

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ABSTRACT

SCARLET, "Superconducting CAbles foR sustainabLe Energy Transition", is a new Horizon Europe project funded for a duration of 4.5 years. The goal of the project is to develop and industrially manufacture superconducting cable systems at the gigawatt level, bringing them all the way to the type test. SCARLET will be carried out by 15 partners in the fields of material sciences, cryogenics, energy systems and electrical engineering. This paper will give an overview of the main topics in SCARLET, highlighting the innovations and challenges.

KEYWORDS

superconductivity, MVDC cables, high-power transmission, gigawatt cables, HTS, MgB_2

INTRODUCTION

Due to their compact size and ability to transmit high electric powers with great efficiency and reduced environmental impact, superconducting cables represent a promising option for the upgrading and extension of the European grids. In particular, superconducting cables will enable more efficient and less costly power transmission from remote renewable electricity generation sites to busy consumption centres.

In the past decade, a growing number of projects related to superconducting cables of various lengths and capacities have been constructed or become operational worldwide [1,2]. A prominent example of a superconducting cable installed in the grid is the AmpaCity project in downtown Essen, Germany [3]. The 1 km long AC cable is based on high-temperature superconducting (HTS) materials and is cooled using liquid nitrogen, operating under a voltage of 10 kV and a current of 2.4 kA rms. The cable system energized a full district close to the city center and was in operation for more than 8 years.

The promise of superconducting cables for the future grid was recognized by the European Commission with the funding of the Best Paths project from 2014 to 2018. This project demonstrated a full-scale 3-GW-class DC superconducting cable system operating at 320 kV and 10 kA and meeting the requirements for grid integration [4].

The new Horizon Europe project SCARLET (acronym for "Superconducting cables for sustainable energy transition") builds on the previous development and demonstration work on high-power superconducting links, focusing on two main technologies and on the medium-voltage instead of high-voltage range. The project started in September 2022 and will run for 4.5 years with the aim of bringing the developed superconducting cable systems to the last qualification step before commercialization. The main demonstration topics in SCARLET and their complementarity within a transmission grid are depicted in Fig. 1. The application spectrum is quite broad and includes onshore HTS cables connecting land-based renewable generation sites to the grid, offshore HTS cables serving as export cables bringing the energy to the shore from offshore windfarms, and MgB_2 cables in combination with liquid hydrogen transport connecting renewable energy sources with ports, ground transport and industries in need of both electricity and hydrogen. In conjunction with the developed cables, the protection of the cable systems and the grid is also investigated in the project.

In the following, an overview of these main demonstration topics will be given, emphasizing the innovations and challenges ahead.

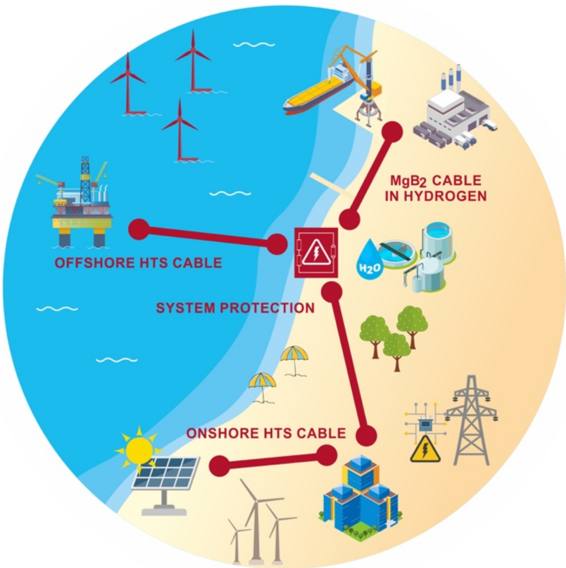

Fig. 1: Complementarity of the SCARLET demonstrators within a pan-European transmission network from remote renewable electricity production to high-load consumption centres

SCOPE AND STRUCTURE

SCARLET brings together 15 industry and research partners from 7 countries, spanning the fields of material sciences, cryogenics, energy systems and electrical engineering. The project is coordinated by SINTEF Energy Research and additionally includes the following partners: Absolut System, ASG Superconductors, ESPCI, IEE Slovak Academy of Sciences, Nexans France, Nexans Germany, RIFS Potsdam, RINA Consulting, RSE, SuperGrid Institute, SuperNode, University of Bologna, Vision Electric Super Conductors, and WavEC.