SUPER3C – Superconducting Coated Conductor Cable
Completion of a Project Supported by the European Commission*

March 10, 2009 (HP18). The development of High Temperature Superconducting (HTS) wires during the last two decades allows one to envision large scale energy applications. Among them, power cables constitute a straightforward way to take advantage of the very high current densities achieved in HTS materials.

The basic feature of HTS cables is their ability to transport power at a lower voltage than conventional cables, which drastically diminishes the reactive power and the energy losses. Moreover, their low impedance makes possible the direct linking of substations, thus saving transformers and simplifying the grid. Larger amounts of power can be transmitted more efficiently with lower losses. The HTS cables are also inert for the environment. They do not generate any external magnetic field, thanks to a superconducting shield, and their excellent thermal insulation eliminates any temperature impact on the cable surroundings and any heat exhaust constraint. As a consequence, HTS cables need a minimized space and can be installed by retrofitting in existing right-of-way ducts.

Multiple HTS cable prototypes have been manufactured around the world with HTS bismuth-based multifilamentary wires as current carrying elements. This technology is now moving towards the pre-commercial stage. However, as the technology is maturing, in the near future these multifilamentary wires are expected to be superseded by a 2^{nd} generation of less expensive HTS wire alternative: the Coated Conductor (CC) tapes.

Several CC-based HTS cable projects have been or are being carried out around the world. Among them, the EU-funded project SUPER3C, now completed, allowed thirteen European partners to develop a medium-voltage cable using coated conductors.

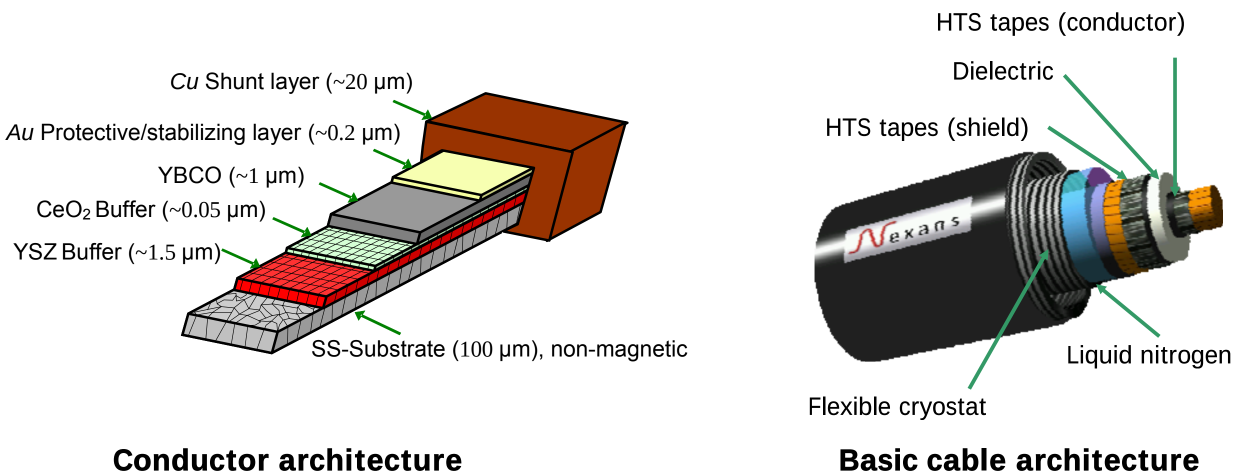

Fig. 1. The SUPER 3C conductor architecture (left) and the cable architecture (right).

The SUPER3C project aimed at establishing the feasibility of a low-loss HTS energy cable using CC tapes. It comprised the development, manufacturing and testing of a functional model consisting of a one-phase, 30-meter long, 17 MVA (10 kV, 1 kA) cable with its terminations.

The project, carried out from June 2004 to December 2008, involved thirteen partners from six countries and was coordinated by Nexans France. The Tampere University of Technology (Finland) led the cable modelling task with the support of the Bratislava Institute of Electrical Engineering from the Slovak Academy of Sciences in Slovakia, which was in particular in charge of fabricating the short cable models. The Göttingen Center for Applied Materials Development (ZFW gem. GmbH, Germany) was responsible for CC tape architecture and characterization. European High Temperature Superconductors (Bruker HTS, Germany) led the CC tape development and manufacturing task, with support from Nexans SuperConductors (Germany) and from the Barcelona

Institute of Materials Sciences (ICMAB, Spain). The functional cable model manufacturing task was led by Nexans Deutschland (Germany). Nexans Norway fabricated the cable core which was introduced in the flexible cryogenic envelope. Cable terminations were provided by Nexans France. Labein Tecnalia (Spain) was in charge of the cable testing and the network integration task, with support from E.on Engineering. Air Liquide (France) supplied the liquid nitrogen cooling system allowing the CC tape to maintain its superconducting state around 73 K (–200°C). The energy company E.on Energie (Germany) performed the technical, economical and social assessments.

The project resulted in a one-phase 30-meter cable system, which was submitted to a full characterization program including 24 kV class dielectric tests and short-circuit tests up to 40 kA for 1 second. Due to an improved design of internal cable architecture, the targeted transmitted power of 17 MVA was demonstrated by lower number of CC tapes as in alternative configurations.

Fig. 2. Installation of the HTS cable at LABEIN TECNALIA for short-circuit and dielectric tests. Left: 30 m long functional model cable. Right: Overview of terminations and connections for the dielectric tests.

Through several case studies, the project also addressed the integration of HTS cables into power grids as well as their social and economical impact. The study allowed the partners to identify the most promising scenarios for integrating HTS cable systems into power grids.

In spite of being an extraordinary technological challenge, the project laid a foundation for the future development of superconducting applications in European power grids. It has achieved most of its technical objectives and showed a high degree of cooperative interaction between all the partners.

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