Short-Circuit Current Limitation Through 2G YBCO Resistive-Type SFCL Devices: Technical and Economic Comparison with Traditional Air-Core Reactors

G. Angeli, M. Bocchi, L. Serri and L. Martini
RSE – Milano (IT)

Introduction
The main goal consists in comparing two different technologies of FCL from a techno-economic point of view:

i) Limiting air-core Reactors (LRs)
ii) Resistive-type Superconducting Fault Current Limiters (SFCLs) with each phase shunted by an air-core reactor.

General approach
1) Steady-state regime (load flow) and short-circuit calculation.
2) Design of the LR devices and shunt reactor, as a function of the desired value of reactance.
3) New load flow and short-circuit calculation considering the LRs installed in the grid.
4) Design of the SFCL devices: superconducting components and cryogenic system.
5) Cost comparison on the basis of the design parameters, considering the same grid and the same Limiting Factor for the following three scenarios: baseline (no FCL installed); innovative (SFCL installed); traditional air-core reactors installed.

Design of the SFCL device

Techno-Economic Analysis Results

Fig. 1. Maximum temperature and limiting factor reached by SFCL after a 100 ms fault as function of shunt impedance (T_{max} is parameterized on HTS tape length L from L = 40 m to L = 300 m, the red arrow is oriented towards the increasing Z).

Fig. 2. Behavior of minimum HTS length L_{min HTS} per phase as a function of maximum temperature T_{max} at the end of fault, parameterized over shunt air-core reactors impedance Z (from Z = 0.1 Ω until Z = 1.5 Ω, the red arrow is directed towards the increasing Z).

Fig. 3. Capital and operating costs of SFCL and LRs as functions of limiting factor.

Fig. 4. Return on Investment and cost variation between SFCL and LRs as functions of LF.

Conclusions
Limiting air-core Reactors (LRs) and resistive-type Superconducting Fault Current Limiters (SFCLs) have been compared from a techno-economic point of view. The main outcome is that, for a given tariff plan and grid initial power factor, a wide range of LF values guarantees that the installation of SFCLs instead of LRs gives a time of return on investment shorter than 10 years.