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

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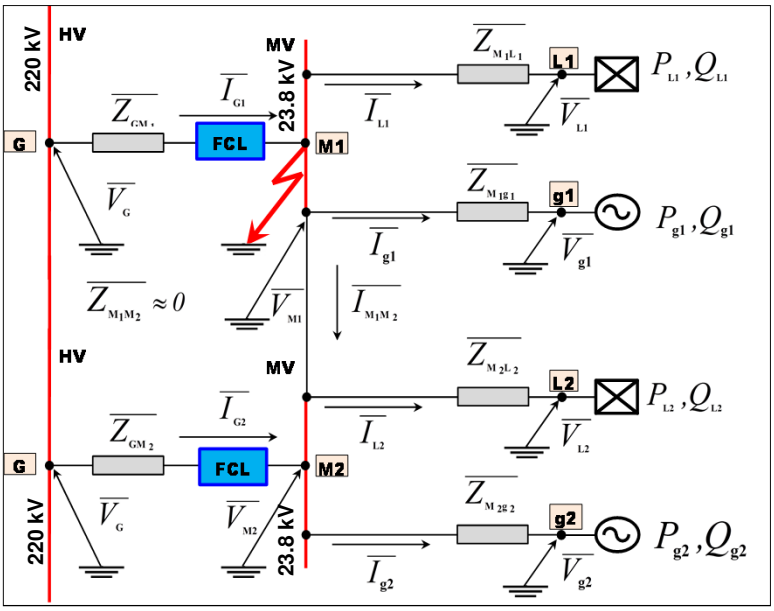
Introduction

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 device's**: 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

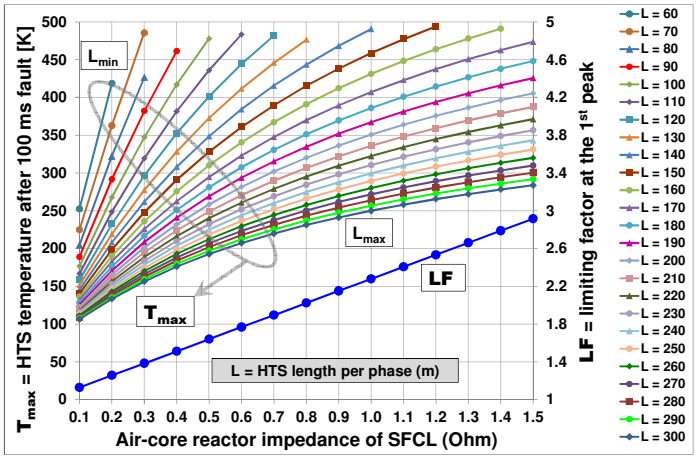


Fig. 1. Maximum temperature and limiting factor reached by SFCL after a 100 ms fault as function of shunt impedance (T_{max} is parameterized on HTS tape length L from L = 40 m to L = 300 m, the red arrow is oriented towards the increasing Z).

nom = nominal
PSC = Prospective Short-Circuit
WITH NO FCL

$I_{G1\ nom} = I_{G2\ nom} = 841\ A_{rms}$
$I_{G1\ PSC} = I_{G2\ PSC} = 17.7\ kA_{rms}$

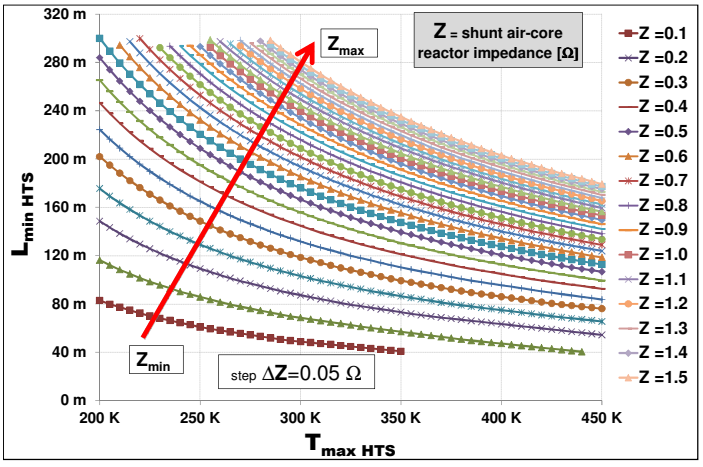


Fig. 2. Behavior of minimum HTS length L_{minHTS} per phase as a function of maximum temperature T_{maxHTS} at the end of fault, parameterized over shunt air-core reactors impedance Z (from Z = 0.1 Ω until Z = 1.5 Ω, the red arrow is directed towards the increasing Z).

Techno-Economic Analysis Results

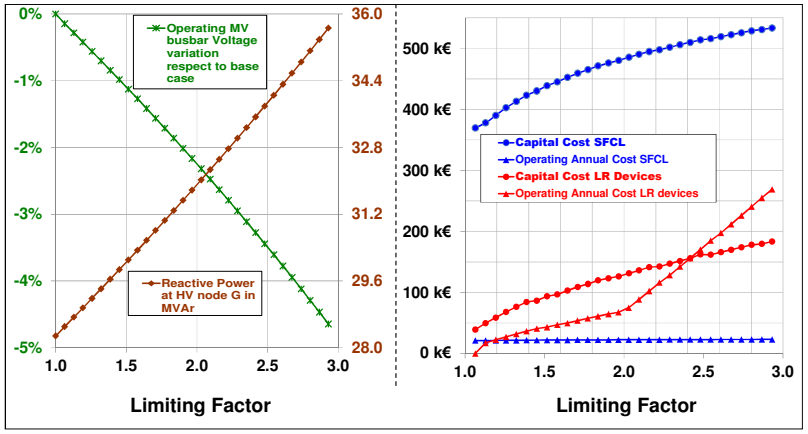


Fig. 3. Capital and operating costs of SFCL and LRs as functions of limiting factor

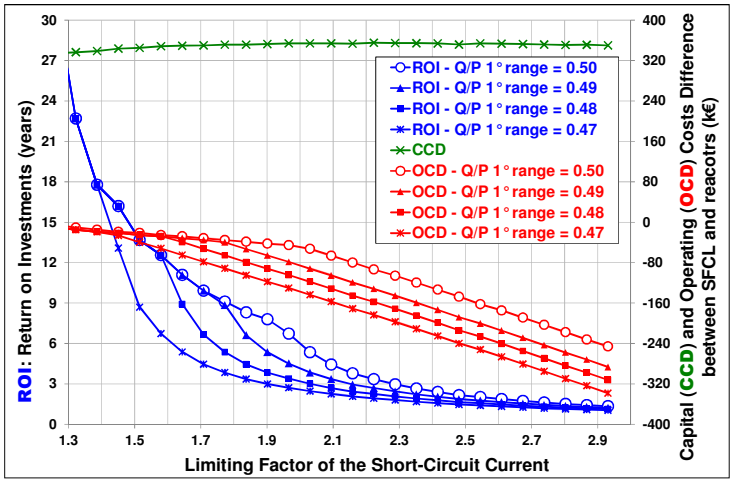


Fig. 4. Return on Investment and cost variation between SFCL and LRs as functions of LF

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.