Comparison of Superconducting Fault Current Limiters against Traditionally Employed Practices in the Management of Fault Levels in the South African National Grid

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Abstract — Much research has been done in the field of applied superconductivity towards the development of a superconducting fault current limiter for large scale power system application. This has now culminated in the establishment of long term pilot installations wherein superconducting fault current limiters were commissioned on existing power grids for testing or installed on test grids to prove operability and performance. Fault levels are reported to be increasing on most networks due to a combination of increasing network interconnectivity and the popular rise of embedded renewable generation projects. When utilities are confronted with the scenario where fault levels rise above those specified by installed equipment, they traditionally considered one of two options: (i) replace the installed equipment with suitably rated equipment or (ii) install a 'series reactor' to the busbar in an effort to reduce the fault level. The superconducting fault current limiter has now evolved to a position wherein it too may also be considered as an effective means of fault level management and extend the lifetime of a substation. Utilising fault level data from the South African power pool (ESKOM, the largest utility in Africa with a nominal generating grid capacity of 41.9 GW), this paper aims to first contextualize the risk present today and quantify the number of breakers that are presently overstressed/underrated and in need of an intervention to prevent both a safety and/or operational risk, for example, data indicates that 8% of the existing substations have circuit breakers that are overstressed/ underrated in the Gauteng Province of South Africa. The three alternatives (series reactor, upgrade of equipment or superconducting fault current limiter), available to the utility will be considered for implementation taking into account factors not limited to only the capital cost of installation. Some of these factors will include energy costs (as found with a 'series reactor') and the cost of 'reduction in service life', for example, when operational switchgear is replaced after 10 years although it has an installed service life of 25 years. This paper will quantify when superconducting fault current limiters are a viable option for fault level management from a utility perspective and must be compared to the busbar voltage degradation and continuous energy wastage of a 'series reactor' or the financial expense of upgrading equipment sooner than intended.

Keywords (Index Terms) — fault level management, power system management, superconducting fault current limiters