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Optimization of cryogenic mixed-refrigerant cascades for intermediate cooling stations of the long-distance superconducting power cable SuperLink

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In Munich, Germany, a 15 km long superconducting power cable is planned to provide a high-power connection within the 110 kV network. To ensure safe and economic operation, efficient liquid nitrogen re-cooling stations are needed at several points along the cable. Within the SuperLink research project, next generation cooling systems for such operations are being developed.
As an alternative to Brayton coolers operated with helium or neon, cryogenic mixed-refrigerant cycles (CMRC) are being investigated as a compact and economic cooling option for this application. The wide-boiling refrigerant mixture can be tuned to efficiently match the cooling needs of the superconducting power cable. Since the use of high-boilers increases performance, but also poses the risk of freeze-out at the very low temperatures needed, a cascade process is proposed. While the precooling stage is using a mixture of nitrogen and flammable refrigerants, the main cooling stage is running on a mixture of nitrogen, oxygen and neon. In this contribution, a Differential Evolution algorithm is used to optimize the operating conditions of such a cascade, i.e. mixture compositions, pressures and precooling temperature, within the large parameter space.

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