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Scoping study for compact high-field superconducting net energy tokamaks R. T. MUMGAARD, M. GREENWALD, J. P. FREIDBERG, S. M. WOLFE, Z. S. HARTWIG, D. BRUNNER, B. N. SORBOM, D. G. WHYTE, MIT PSFC — The continued development and commercialization of high temperature superconductors (HTS) may enable the construction of compact, net-energy tokamaks. HTS, in contrast to present generation low temperature superconductors, offers improved performance in high magnetic fields, higher current density, stronger materials, higher temperature operation, and simplified assembly. Using HTS along with community-consensus confinement physics (H98=1) may make it possible to achieve net-energy (Q>1) or burning plasma conditions (Q>5) in DIII-D or ASDEX-U sized, conventional aspect ratio tokamaks. It is shown that, by operating at high plasma current and density enabled by the high magnetic field (B>10T), the required triple products may be achieved at plasma volumes under 20m^3, major radii under 2m, with external heating powers under 40MW. This is at the scale of existing devices operated by laboratories, universities and companies. The trade-offs in the core heating, divertor heat exhaust, sustainment, stability, and proximity to known plasma physics limits are discussed in the context of the present tokamak experience base and the requirements for future devices. The resulting HTS-based design space is compared and contrasted to previous studies on high-field copper experiments with similar missions. The physics exploration conducted with such HTS devices could decrease the real and perceived risks of ITER exploitation, and aid in quickly developing commercially-applicable tokamak pilot plants and reactors.

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