Evaluation of CFETR as a Fusion Nuclear Science Facility using multiple system codes

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Abstract. This paper presents the results of a multi-system codes benchmarking study of the recently published China Fusion Engineering Test Reactor (CFETR) pre-conceptual design [B.N. Wan, et al, IEEE Transactions on Plasma Science **42**, 495 (2014)]. Two system codes, General Atomics System Code (GASC) and Tokamak Energy System Code (TESC), using different methodologies to arrive at CFETR performance parameters under the same CFETR constraints show that the correlation between the physics performance and the fusion performance is consistent, and the computed parameters are in good agreement. Optimization of the first wall surface for tritium breeding and the minimization of the machine size are highly compatible. Variations of the plasma currents and profiles lead to changes in the required normalized physics performance, however, they do not significantly affect the optimized size of the machine. GASC and TESC have also been used to explore a lower aspect ratio, larger volume plasma taking advantage of the engineering flexibility in the CFETR design. Assuming the ITER steady-state scenario physics, the larger plasma together with a moderately higher B_T and I_p can result in a high gain $Q_{fus} \sim 12$, $P_{fus} \sim 1$ GW machine approaching DEMO-like performance. It is concluded that the CFETR baseline mode can meet the minimum goal of the Fusion Nuclear Science Facility (FNSF) mission and advanced physics will enable it to address comprehensively the outstanding critical technology gaps on the path to a demonstration reactor (DEMO). Before proceeding with CFETR construction steady-state operation has to be demonstrated, further development is needed to solve the divertor heat load issue, and blankets have to be designed with tritium breeding ratio (TBR) > 1 as a target.

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