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Exploration of long-pulse and steady-state operations in ITER

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The ITER long-pulse and steady-state operations, foreseen in the ITER Research Plan [IRP, 2018 ITER technical report, ITR-18-03], are important steps towards exploration of reactor relevant tokamak operation and research. A few key research areas, such as the operational space with heating mixes and external current drive, access to target plasma states with profile tailoring and control, and plasma MHD stability, will be studied first in the Pre-Fusion Power Operation (PFPO) phase, minimizing impacts on the lifetime of the CS coils. The operational space, scenario recipes, and control techniques will be re-established with high performance fusion plasmas in the Fusion Power Operation (FPO) phase, which includes long-pulse operational aspects, such as the heat loads on the plasma facing components and continuous operation of various tokamak components. In this work, the operational space of PFPO long-pulse plasmas has been explored including scans of plasma density and heating mixes, and then extended for FPO long-pulse and steady-state operations including options for a heating and current drive (H&CD) upgrade. The foreseen options for an H&CD upgrade do not include a Lower Hybrid current drive system, and are therefore without strong far off-axis current drive. The optimization of the ideal MHD stability has been performed using the potential upgrade H&CD options. Operational recipes for accessing target plasma states and achieving a long pulse duration have been explored using integrated scenario modelling. The heat loads onto the plasma facing components have also been assessed using the SOLPS-ITER code, including potential mitigation using Neon impurity seeding. The analyses carried out in this work demonstrate the feasibility of achieving long-pulse H/He operation in PFPO and steady-state DT operation in FPO, in accordance with the ITER Research Plan objectives.

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