Heating and Current Drive systems in the ITER research plan

M. Schneider, D. Boilson, M. Henderson, S.-H. Kim, P. Lamalle, A. Loarte, A. Polevoi

ITER Organization, Route de Vinon / Verdon, CS 90 046, 13067 St Paul-lez-Durance, France

Reaching ITER's mission goals of exploring burning plasma physics and achieving high fusion gain will depend on the efficiency and robustness of its ancillary heating and current drive (H&CD) systems for a routine access to high performance plasmas. In view of the many roles foreseen for the H&CD systems, ITER's baseline capability consists of neutral beam injection (NBI), electron cyclotron heating (ECH) and ion cyclotron resonance heating (ICRH). Their complementary capabilities will address the challenges anticipated in establishing and sustaining burning plasmas with high fusion power for various operating scenarios. This flexibility will also be key to the development of scenarios in hydrogen and helium plasmas during the pre-fusion power operation phase. High power heating is essential to ensure H-mode access for high fusion gain, relying on the most advanced built to date systems, utilizing several aspects of novel technology. They must ensure routine stationary or modulated operation for 3600 s to support the development of long-pulse plasmas, particularly in predominantly non-inductive operation.

NBI will deliver 33 MW through vertically steerable beamlines to provide radial variation of H&CD profiles. It is the main source of bulk current drive in ITER. As in most fusion devices, the main operational constraint is the plasma density, which must be sufficiently high to prevent excessive 'shinethrough' heat loads on in-vessel components. ECH system can launch 20 MW via a single equatorial launcher combining co- and counter-current injection, or through 4 upper ports, enabling plasma breakdown EC-assist, MHD control, current profile shaping and core tungsten control. Its local H&CD deposition over a substantial radial range provides high flexibility for both inductive and non-inductive scenarios. ICRH antennas will deliver 20 MW providing high flexibility ion and electron heating, through the appropriate choice of frequency and heating scheme to support scenarios over a significant range in toroidal field, current, density and fuel species. They also provide sawtooth and core tungsten control capabilities. Outstanding issues are related to ITER edge plasma profiles that influence coupling efficiency and RF sheath effects.

This paper will discuss recent developments of the ITER project and specific roles of ITER H&CD systems in meeting the challenges associated with the successful implementation of the ITER Research Plan, making use of physics modelling and supporting experiments to evaluate their expected performance in ITER. Options available to the ITER project for longer term upgrades of the H&CD systems will also be discussed.