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Conceptual design of the DEMO EC-system: main developments and R&D achievements

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For the development of a DEMOnstration Fusion Power Plant the design of auxiliary heating systems is a key activity to achieve a controlled burning plasma. The present heating mix considers Electron Cyclotron Resonance Heating (ECRH), Neutral Beam Injection (NBI) and Ion Cyclotron Resonance Heating (ICRH) with a target power to the plasma of about 50 MW for each system. The main tasks assigned to the EC system are plasma startup assist, heating to L-H transition and current ramp up to burn, MHD stability and current ramp down control. These requirements are used as input for the conceptual design of the EC system, with an extensive R&D program focusing on relevant technologies to be developed. Gyrotron: the R&D and Advanced Developments on RF generators are targeted on gyrotrons operating at 240 GHz, considered as optimum EC Current Drive frequency in case of higher magnetic field than for the 2015 DEMO1 baseline. Multi-purpose (multi-frequency) and frequency step-tunable gyrotrons are under investigation to increase the flexibility of the system. The principle feasibility of a 236 GHz, 1 MW CW conventional-cavity and, alternatively, of a 238 GHz, 2 MW CW coaxial-cavity gyrotron is under investigation together with the development of a Brewster-angle window. Transmission Line (TL): Different options are under investigation and a preliminary study of an evacuated quasi-optical multiple-beam TL is presented and discussed in terms of layout, dimensions and theoretical losses. A list of the required components for broadband/double frequency and of a RF load is defined. Launcher: Remote Steering Antennas and truncated waveguides have been considered under the constraints of a high neutron flux and to avoid movable mirrors close to the plasma. The deposition locations coverage and the wave absorption efficiency have been investigated, for a selection of frequencies, injection angles and launch points. A preliminary evaluation of the blanket apertures together with launching configurations and waveguide routing have been proposed. The proposed EC system is structured in cluster, in order to allow the necessary redundancy and flexibility to guarantee the required EC power in the different phases of the plasma pulse. Number and composition of the clusters are analyzed to have high availability and therefore maximum reliability with a minimum number of components.

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