EC assisted start-up experiment and predictions for the next generation fusion experiments

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For an efficient and robust use of Electron Cyclotron (EC) to assist the start-up phase of the plasma in large tokamaks with superconductive coils, it is necessary to develop appropriate models capable of predicting from present experiments to future scenarios (as for ITER, JT-60SA and DEMO). Experience gained on TCV and FTU tokamaks has highlighted the relevance of a correct and consistent evaluation of the EC absorbed power together with the role of impurity and magnetic configuration in the early stage of the discharge. The code BKD0, one of the existing codes for start-up study, is a predictive 0D model for the burn-through phase, which includes the calculation of the EC absorption computed by the beam-tracing code GRAY and an impurity model. A benchmark activity between BKD0 and DYON codes was successfully carried out for the simplified ITER case (ohmic). BKD0 validation has been based on experiments performed on FTU (circular, full metallic wall) and characterized by the injection of 400kW in first ordinary (OM1) and in second harmonic extraordinary (XM2) modes, similarly to what is foreseen in ITER. BKD0 reproduces successfully the FTU operational window at low toroidal electric field, showing that a factor 5 in neutral prefill can be sustained by a low level of EC power, injected as OM1. More recently, experiments on TCV (with carbon wall) have been carried out to test the BKD0 impurity model in presence of Ar. The EC assisted start-up experiments were focused on reproducing the JT-60SA configuration (82.7 GHz, XM2, toroidal electric field of 0.7 V/m). BKD0 reproduces the 400kW threshold of EC power needed for plasma initiation, that increases with addition of Ar in D2 prefill, and infers the impurity content at startup, thus confirming the validity of the model included in the code. An iterative procedure has been implemented which couples BKD0 with the CREATE-BD magnetic model for JT-60SA, integrating and optimizing the active circuit currents and considering eddy currents in the passive structures for developing the plasma breakdown scenario. Based on these results, BKD0 is able to extrapolate the operational parameters for the next generation fusion experiments like ITER, JT-60SA and DEMO, providing values of, e.g. the required EC power or neutral gas composition and pressure, for the optimization of the ECRH in different experimental conditions.