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P2.011 A conceptual system design study for an NBI beamline for the European DEMO

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Neutral Beam Injection (NBI) is a robust, established heating and current drive method in fusion experiments. Among its strengths is high current drive efficiency that may pave the path for steady state operation of a tokamak reactor with an economically viable recirculating power fraction. For large tokamaks like ITER and DEMO the use of negative ions is mandatory due to the vanishing neutralisation efficiency of positive ions at the required approx. 1 MeV beam energy. While the design of ITER's NBI has long been finalized and the prototype is under construction, NBI for DEMO poses new challenges that go far beyond those of ITER and require new approaches. Besides the demand for very-long-pulse or continuous operation, compatibility with much higher neutron fluences, and higher availability, a significant increase in energy efficiency is required to render NBI a viable option. Currently, the wall plug efficiency is limited to about 27 % on ITER, mostly due to the low neutralisation efficiency in beam–gas collisions. New concepts such as photo-neutralisation promise to overcome this limitation, but their practical feasibility has not yet been demonstrated.

Within the work package Heating and Current Drive of EUROfusion's Power Plant Physics and Technology division a systematic and comprehensive system design study of a DEMO NBI beamline was launched this year in order to explore a broad range of options for each beamline component and mutual dependences. The components' design is mostly constrained by the chosen principle of the neutraliser, e.g. whether there is a need for residual ion energy recovery (ER) that may save the energy efficiency of the beamline even if the particle neutralisation efficiency is far from 100 %. We have chosen this as starting point and present first concepts for ER integration as well as our general approach to a comprehensive system design study.

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