Wendelstein 7-X in the European Roadmap to fusion electricity

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The Roadmap to fusion electricity is the European plan to demonstrate fusion electricity by 2050. The plan is implemented by the Consortium of European Fusion laboratories (EUROfusion). The Roadmap consists of eight missions, all of which address key elements en-route to DEMO and follow a success oriented mitigation of potential development risks by the implementation of appropriate countermeasures and the development of key technologies. The stellarator mission explores the most promising alternative line to the tokamak and aims to bring the stellarator line to maturity.
Stellarators offer magnetic confinement concepts with potentially inherent quiescent, steady-state operation. Classical stellarators, however, suffer from unfavorable confinement properties for both the thermal plasma and fast, fusion-born particles. Wendelstein 7-X is designed to overcome potential drawbacks by the intentional optimization of the magnetic field structure; specifically it is optimized to reduce neoclassical losses and to improve the confinement of fast particles at economically attractive plasma beta values. One key-element is the reduction of trapped-particle drift losses by a field guided poloidal precession on confined drift surfaces. The specific shaping of the low-shear magnetic configurations offers to employ an island structure outside the last-closed flux surface to implement a feasible divertor concept. W7-X, in the line of Helical Axis Advanced Stellarators (HELIAS), has to demonstrate this advanced stellarator concept to be an attractive candidate for reactor extrapolation.
Wendelstein 7-X is a five-fold symmetric, high-aspect ratio device with an average major radius of 5.5m and a plasma volume of about 30m^3. The magnetic field of around 2.5 T is generated by a set of superconducting modular coils and will be equipped with CW plasma heating (preferentially ECRH, up to 8MW in the first phase). The long-term perspective for steady-state operation is to install actively cooled in-vessel components (IVC) with heating upgrades ready after 2019. In the first phase, on the way to steady-state operation, an uncooled but robust carbon divertor will be used to develop in the first years steady-state operation schemes. The guiding principle in this test-divertor phase is to increase the plasma density and to take benefit from the flexibility of the magnet system, predominantly to develop appropriate divertor scenarios. Even earlier, a brief initial, limiter-equipped plasma phase will be conducted after the technical commissioning presently going on. To start up the device, fuelling and heating systems (7 gyrotrons at individual power of 800kW) are commissioned with their control at pulse energies limited to 2 MJ by the uncooled IVCs. The first operation will focus on reliable plasma breakdown and build-up and the commissioning of interlocks to ensure safe prolongation of pulse lengths. This will also include the monitoring of ECRH deposition and impurity influx. In line with the EU priorities, a physics plan to focus on ECH physics and initial SOL investigations is prepared for the first 12 weeks of initial operation.