The long way to steady state fusion plasmas - the superconducting stellarator device Wendelstein 7-X

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The stable generation of high temperature Hydrogen plasmas (ion and electron temperature in the range 10-20 keV) is the basis for the use of nuclear fusion to generate heat and thereby electric power. The most promising path is to use strong, toroidal, twisted magnetic fields to confine the electrically charged plasma particles in order to avoid heat losses to the cold, solid wall elements. Two magnetic confinement concepts have been proven to be most suitable: (a) the tokamak and (b) the stellarator. The stellarator creates the magnetic field by external coils only, the tokamak by combining the externally created field with the magnetic field generated by a strong current in the plasma. “Wendelstein 7-X” is the name of a large superconducting stellarator that goes into operation after 15 years of construction. With 30 m^3 plasma volume, 3 T magnetic field on axis, and 10 MW micro wave heating power, Hydrogen plasmas are generated that allow one to establish a scientific basis for the extrapolation to a future fusion power plant. It is a unique feature of Wendelstein 7-X to be able to operate high-power Hydrogen plasmas under steady-state conditions, more specifically for 1800 s (note that the world standard is now in the 10 s ballpark). This talk provides a review of the principles of nuclear fusion and discusses the key physics subjects of optimized stellarators. The sometimes adventurous undertaking to construct such a first-of-a-kind device is summarized as well. We finish with an outlook towards the fusion power station and address the most important remaining issues to be addressed in the framework of the world-wide fusion research endeavor.