Roadmap to a heliotron reactor.

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One or more demonstration plants for electricity production (DEMOs) will be constructed after ITER. They are expected to be the first fusion power plants with generating electric power at a level of several hundreds MWs. The DEMO plants should prove the capability of reliable operation of fusion power plants. In order to realize commercial use of fusion energy in the second half of this century, the first DEMO reactor should start operation in 2030s [1, 2]. Fusion Energy Forum of Japan reported "A Roadmap and Technological Strategy toward the Commercial Use of Fusion Energy" in June 2008 [2]. It contains work breakdown structures for the first tokamak DEMO plant and the proposal on indispensable R&Ds in addition to ITER and the Broader Approach (international cooperation project carried out by Japan and EURATOM on a time frame compatible with the ITER construction phase, which deals with important subjects together with ITER project).
In order to realize advanced steady state fusion power plants, stellarator research has been proceeded with international collaborations. Stellarator reactors have several features suitable for a fusion power plant, such as no need for current drive, no plasma current disruptions and suitability for steady state operation. One disadvantage was considered a necessarily large major radius to attain self-ignition condition with a sufficient space for blankets. According to recent reactor studies based on the experimental results in LHD, the plasma major radius of a heliotron reactor is set to 14 to 18 m in order to install shielding and breeding blankets with total thickness of about 1.1 m [3]. The central toroidal field is 5 to 6 T, and the stored magnetic energy is estimated to be 120 to 140 GJ. Although the major radius is two to three times as large as a recent design of tokamak reactors, the magnetic stored energy is comparable. It means that the amount of superconducting wires and necessary supporting structures can be comparable with those of a tokamak reactor. In addition, its large helical windings can be realized by small extension from the ITER technology with using cable-in-conduit conductors similar to those for ITER-TF coils [4].
Since stellarators are candidates for advanced fusion power plants, their roadmap to a DEMO should be discussed. Fortunately, most of required technology is similar to that for tokamak reactors. The particular R&Ds are clarified, and the strategy to a heliotron DEMO is discussed.

[1] IEA/GB/RD(2006□)4/2, From ITER to Power Plants - The Roadmap to Fusion Power, available from <www.iea.org/textbase/techno/technologies/fusion/FUSION.PDF>.
[2] Fusion Energy Forum of Japan: ITER・BA Technical Promotion Committee's Report "A Roadmap and Technological Strategy toward the Commercial Use of Fusion Energy," June 2008, available from <http://www.naka.jaea.go.jp/fusion-energy-forum/>.
[3] A. Sagara, S. Imagawa, O. Mitarai, et al., Nuclear Fusion, **45** (2005) 258.
[4] S. Imagawa, A. Sagara, and Y. Kozaki, Plasma and Fusion Research **3** (2008) S1050.