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# Spherical Tokamak path to Fusion – History and the Next Step

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The Spherical Tokamak (ST) path to Fusion offers key elements needed to enable magnetic confinement fusion to make the transition from pure government-funded research programs to the commercial marketplace and attract commercial cost sharing at an affordable level and with low financial risk: a low-cost, low-power, small-size market entry vehicle and a strong economy of scale in larger next step devices. This ST path has certain specifics that makes it different from the conventional JET-ITER-DEMO path: 1) The ST approach can progress from the pilot plant to the power plant just by increasing the linear dimensions of the device without significant changes in technology [1]; 2) The use of High Temperature Superconductors (HTS) in an ST allows both high field and compact size. The high beta potential of the ST is so great that the physics of this device will not determine its size; 3) The development path to a Power Plant based on ST can be faster and cheaper than the conventional JET-ITER-DEMO path, so attractive to the private investors. According to the report published by the Fusion Industry Association, private investments into fusion development have already exceeded $4.7 billion in total, spread over several alternative to the mainstream approaches.

It was found that the physics and technical demands of the ST approach diminish with device size. It was shown [2] that the power efficiency of a Fusion reactor, Q, depends mainly on the Fusion power produced, but not on the device size. That is why at Tokamak Energy Ltd, a private company in Oxfordshire, UK, we started our path to Fusion with a very compact but high field prototype, ST40, which has already demonstrated Fusion relevant plasma temperatures exceeding 100 M degrees [3] confirming a significant improvement of performance with the increase in the toroidal field in STs. The use of HTS in tokamak magnets, the possibility of which was demonstrated by TE.Ltd in the full-HTS tokamak, and by achieving magnetic fields of up to 24T in tokamak magnet relevant magnet prototypes, allows reduction in the size of the tokamak central post allowing more space for neutron protecting shielding and smaller size overall.

Most of recent DEMO and reactor designs assume pulsed operations. Advantages of pulsed reactors, including economics, have been discussed recently in detail ([4,5] for conventional tokamaks, [6] for STs). ST reactors have even more advantages due to possibility of high bootstrap current, stronger increase in the confinement with the toroidal field, good stability, and lower requirements on the volt-second capability of the central solenoid for the plasma current sustainment. These advantages will be discussed in detail.

In this talk, the history of Spherical Tokamaks and of the ST path to Fusion, as well as advances in the ST physics and technology R&D will be also overviewed.

References

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