DEVELOPMENT PATH OF LOW ASPECT RATIO TOKAMAK POWER PLANTS*

R.D. Stambaugh, VS. Chan, R.L. Miller, P.M. Anderson, C.B. Baxi, R.W. Callis, H.K. Chiu, S.C. Chiu, C.B. Forest, R. Hong, T.H. Jensen, L.L. Lao, J.A. Leuer, Y.R. Lin-Liu, M.A. Mahdavi A. Nerem, R. Prater, P.A. Politzer, M.J. Schaffer, D.L. Sevier, T.S. Taylor, A.D. Turnbull, and C.P.C. Wong

General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA

Recent advances in tokamak physics indicate the spherical tokamak may offer a magnetic fusion development path that can be started with a small size pilot plant and progress smoothly to larger power plants. Full calculations of stability to kink and ballooning modes show the possibility of greater than 50% beta toroidal with the normalized beta ($\beta_N=\beta_T/(I/ab)$) as high as 10 and fully aligned 100% bootstrap current. Such beta values coupled with 2–3 T toroidal fields imply a pilot plant about the size of the present DIII–D tokamak could produce ~800 MW thermal, 160 MW net electric, and would have a ratio of gross electric power over recirculating power (Q_{PLANT}) of 1.7. The high beta values in the ST mean that E×B shear stabilization of turbulence will be 10 times more effective in the ST than in present tokamaks, implying that the required high quality of confinement needed to support such high beta values will be obtained. The anticipated beta values are so high that the allowable neutron flux at the blanket sets the device size, not the physics constraints. The ST has a favorable size scaling so that at 2–3 times the pilot plant size the Q_{PLANT} rises to 4–5, an economic range and 4 GW thermal power plants result. Current drive power requirements for 10% of the plasma current are consistent with the plant efficiencies quoted. Helicity injection current drive appears very attractive for the broad, high beta, ST profiles. The unshielded copper centerpost should have an adequate lifetime against nuclear transmutation induced resistance change and the low voltage, high current power supplies needed for the 12 turn TF coil appear reasonable. The favorable size scaling of the ST and the high beta mean that in large sizes, if the copper TF coil is replaced with a superconducting TF coil and a shield, the advanced fuel D-He^3 could be burned in a device with $Q_{PLANT} \sim 4$. If the anticipated physics of the ST regime can be proven in near term experiments, then the ST offers the possibility of a magnetic fusion development path with a minimal cost initial step and exciting further possibilities.

*Work supported in part by U.S. Department of Energy under Grant No. DE-FG03-95ER54309 and by General Atomics.