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The Advanced Tokamak Path to a Compact Net Electric Pilot Plant

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Physics based simulations using a new integrated 1.5D core-edge approach for a whole device modeling capability project a compact net electric fusion pilot plant is possible at modest scale based on the advanced tokamak concept, and identify the key parameters for its optimization. These first of a kind reactor simulations provide new insights cf. previous "systems code"projections by self-consistently applying transport, pedestal and current drive physics models to converge fully non-inductive stationary solutions without any significant free parameters. The approach provides new insights into reactor optimization with increasing plasma density, pressure and toroidal field found to lower auxiliary heating and current drive demands, and thus required fusion performance and recirculating power. Solutions at the ˜4m major radius scale are identified with margins and trade-offs possible in achievable parameters. Remaining current drive is projected from neutral beam and helicon ultra-high harmonic fast wave, though other advanced current drive approaches presently being developed may also be useful. The resulting low recirculating power and double null configuration leads to a divertor heat flux challenge that is comparable to ITER Neutron wall loadings also appear tolerable. Strong H-mode access (factor >2 margin over transition scaling) is maintained with ˜30-60% core radiation. The approach would benefit from high temperature demountable superconductors to provide performance margin at elevated field, and to aid in a nuclear testing mission. However, solutions are possible with conventional superconductors. An advanced load sharing and reactive bucking approach in the main field and solenoid coils has been developed and would facilitate handling of mechanical stresses. Nevertheless, the prospect of an affordable test device which could close the loop on net-electricity production is compelling, motivating research to prove the techniques projected here.

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