**FUSION REACTOR DESIGN RESEARCH**

**AT GEORGIA TECH**

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1. **EPR and INTOR leading to ITER**

BACKGROUND: Professor Stacey organized and led one of the pioneering design studies for a tokamak Experimental Power Reactor (EPR) at Argonne National Laboratory in the mid-1970’s [1], before coming to Georgia Tech, on the basis of which he was asked by DoE to organize and lead the US participation in what became the IAEA International Tokamak Reactor (INTOR) Workshop[2,3]. The INTOR Workshop involved hundreds of fusion physicists and engineers in each the USA, USSR, Japan and Europe in assessing the feasibility of constructing and operating an EPR, defining the design concept and identifying and prioritizing the required R&D. Much of the coordination of the US input to INTOR was coordinated and reviewed at Georgia Tech and involved Professors Abdou, Bateman and Thomas and Georgia Tech NE students, as well as hundreds of US fusion physicists and engineers under the guidance of Professor Stacey, who also played a major role in the international leadership of the INTOR Workshop. The success of the INTOR Workshop led to Secretary Gorbachev suggesting to President Reagan at the 1985 Geneva Summit Meeting the joint construction and operation of INTOR, which led to formation of the ITER Project in 1988 to carry out the R&D and develop an engineering design.

1. **ITER and after ITER—DEMO and FUSION-FISSION HYBRIDS**

BACKGROUND: Georgia Tech faculty and students participated as members of the distributed ITER design team prior to the formation of the central ITER team, working on design of radiative power exhaust [5] and thermonuclear burn control [6]. Prof. Stacey served as chair of the ITER Steering Committee—US (ISCUS) in the 1990s, which advised the government on all aspects of the US participation in ITER. The multibillion $ ITER [4] is now under construction in France by a consortium involving Europe, Japan, China, South Korea, India, Russia and the USA, with operation scheduled to begin in the 2020s.

 The conventional wisdom of fusion development is that after the operation of the EPR (ITER), the next major reactor would be a DEMO, then followed by “commercial fusion power reactors”. Based on his experience in the INTOR Workshop, Prof. Stacey developed one of the earliest evaluations of possible DEMO parameters [5].

 Georgia Tech researcher advanced the idea that, although the ITER level of fusion development would not enable economically competitive fusion power reactors, the copious fusion neutron source provided by the ITER level of fusion development could be useful for other purposes than pure fusion reactor electricity production[6], thus allowing fusion to contribute to carbon-free energy production at an earlier stage. A series of faculty-student designs were carried out at Georgia Tech of fusion-fission hybrids—an ITER-like tokamak as a neutron source with the plasma surrounded by an annular nuclear reactor for either i) weapons tritium production[7], ii) the “disposition” (by neutron transmutation to other isotopes) of weapons-grade plutonium [8] or iii) the transmutation (fission) of the transuranics in spent nuclear fuel that had been removed from conventional nuclear reactors [9-13].

This last option, the transmutation of transuranics in spent nuclear fuel, is particularly attractive because it could reduce the capacity required for high-level radioactivity waste repositories (HLWRs) by an order of magnitude or more, thus eliminating a major impediment to the expansion of nuclear power, while at the same time extracting additional energy from the nuclear fuel. Fuel cycle analyses[14] indicate that one 3000MWth FFH Subcritical Advanced “Burner” Reactor (SABR) with 75% availability could fission all the transuranics produced annually by three 3000MWth LWRs. Preliminary safety analyses did not identify any problems[15]. The present version of SABR consists of ITER technology and a slightly smaller tokamak plasma surrounded by a “nuclear annulus” consisting of 10 modular sodium pools each containing a 300 MWth transuranics metal fueled fast reactor.

Short TIGR para

ONGOING WORK: Two PhD thesis are investigating the inherent safety and burn stability of the SABR concept. A 10-node neutron and primary coolant system plus secondary coolant system dynamics model is being developed by Andrew Bopp to investigate whether negative reactivity feedback mechanisms would shut the reactor down in the event of any loss of primary or secondary coolant flow, and the operational dynamics and stability of the tokamak plasma when subjected to an inadvertent off-normal condition is being investigated by Max Hill. This latter work is also of direct relevance for ITER operation.

FUTURE WORK: We anticipate theses investigating i) the nuclear fuel cycle and reduction in high-level radioactive waste repository requirements, ii) tritium self-sufficiency, and iii) the removal and replacement of fuel in the modular reactors. Finally, we anticipate a future iv) upgrade of the SABR design concept based upon what has been learned.

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