

IMPACT OF ADVANCED PHYSICS AND TECHNOLOGY ON THE ATTRACTIVENESS OF TOKAMAK FUSION POWER PLANTS

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During the past ten years, the ARIES Team has studied a variety of tokamak power plants with different degrees of extrapolation in plasma physics and technology from present database. Continuation of research has allowed us to apply lessons learned from each ARIES design to the next. The results of ARIES tokamak power plant studies provide a large body of data that highlight the contribution, tradeoffs, and relative leverage of advanced plasma physics and fusion technology directions. Our results indicate that for the same plasma physics (e.g., first-stability) and technology extrapolation, steady state operation is more attractive than pulsed-tokamak operation. Dramatic improvement over first-stability operation can be obtained through either utilization of high-field magnets (e.g., high-temperature superconductors) or operation in advanced-tokamak modes (e.g., reversed-shear). In particular, if full benefits of reversed-shear operation are realized, as is assumed in ARIES-AT, tokamak power plants will have a cost of electricity competitive with other sources of electricity. In technology area, emerging technologies such as advanced Baryon cycle, high-temperature superconductor, and advanced manufacturing techniques can improve the cost and attractiveness of fusion plants. For blankets, liquid coolants are most attractive because most of neutron power is directly deposited in the coolant. This property can be exploited to arrive at blanket design with a coolant outlet temperature higher than structure temperature in the radiation zone leading to a high thermal conversion efficiency (as in ARIES-ST and ARIES-AT blankets). The dual-cooled (He and LiPb) ARIES-ST blanket using ferritic steel structural material represents a near-term option for fusion systems and achieves a thermal efficiency of 45%. Development of high-performance SiC composites leads to the high-performance ARIES-AT blanket (SiC composite/LiPb coolant) that achieves 60% thermal conversion efficiency and may achieve the full potential safety and environmental features of fusion power.

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