



The Challenges of Small Fusion Power Plants

Of the many competing requirements to realise viable fusion energy, capital cost has become a significant concern following the experience with the experimental ITER reactor. The difficulty of raising multi-billion dollar capital funding suggests that the fusion community should examine the prospects for smaller sized power plant designs on the basis that this will lead to lower capital costs. For a commercial fleet of fusion power plants capital cost is only one aspect of power plant design that must be considered, operational and decommissioning costs are also matters for consideration in addition to the cost per unit of electricity. The requirements of the grid that the plant is to connect into are also key factors in the specification of a power plant including net electrical output and whether the plant is base or peak load.

Additional limitations to performance imposed by engineering and physics in both the tokamak and its supporting infrastructure narrow the window of available design space. As an example, scoping studies using fusion reactor system codes have indicated that plant availability is the key driver of cost of electricity and maintenance strategy is a major contributor to this. The maintenance strategy and frequency depend upon accessibility, tokamak component design (particularly mass and dimensions) and material degradation rate, factors that are also influenced by the limitations of materials and coolant under high power densities.

The challenges emerging from a holistic view of small power plant design are discussed from the perspectives of the present design base and future advances in the field. Identifying the interfaces between different design demands informs the R&D programme required to deliver fusion from small power plants, which, with more options available, is potentially more complex than for large fusion devices. The present status of the international fusion programme will be discussed to identify areas of specific concern to small power plant design.