European Fusion Power Plant Studies

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From 1990 to 2000 studies within the European fusion program examined the safety, environmental and economic potential of fusion power. Since the establishment of the main features of the conceptual designs upon which those studies were based there have been substantial advances in the understanding of fusion plasma physics and plasma operating regimes in tokamaks, and progress in the development of materials and technology. Moreover, the safety and environmental studies were based on designs that were not economically optimized, and the various studies were not intended to be fully consistent with one another in detail. Accordingly, a more comprehensive and integrated study, updated in the light of our current know-how and understanding, was launched, to serve as a better guide for the future evolution of the fusion development program. This was the Power Plant Conceptual Study (PPCS), which reported in the summer of 2004.

Several conceptual designs ("Models") for commercial fusion power plants were developed, spanning a range from relatively near term to more substantial extrapolations. All are based on the mainstream tokamak concept. All have an electrical output of 1.5 GWe. However, because of differences in their plasma physics and materials basis, they differ substantially in their fusion power, size and re-circulating power fraction. The parameters of the Models were chosen by systems analysis to be economically optimal, given the specifically assigned constraints on plasma and technology performance. Those analyses also show which plasma, materials and engineering parameters are keys to further improving the economics. The conceptual designs were developed in some detail, including innovative aspects: a helium-cooled divertor able to withstand 10 MW/m2 steady heat load and a maintenance concept resulting in 75% availability. Key features will be described in this paper. Analyses were made of the safety, environmental impacts and economic performance of the Models.

The calculated cost of generating electricity from the Models is in the range of published estimates for the future costs from other sources. Even the near-term Models are economically viable. Drawing on more extensive work in the European Socio-Economic Research in Fusion program, the "external" costs were also calculated. External costs are those associated with any environmental damage or adverse effects upon health. These costs were very low, for all the Models: similar to wind power and much less than fossil fuels. Economic optimization of the designs did not jeopardize their safety and environmental performance. All the Models proved to have the attractive and substantial safety and environmental advantages shown in earlier studies, now established with greater confidence.

The results for the near-term Models suggest that a first generation of fusion power plants – those that would be accessible by a fast track route of fusion development, going through ITER and not entailing major materials advances – will be economically acceptable with major safety and environmental advantages. The remaining results illustrate the potential for more advanced power plants. It is concluded from the PPCS results that the main thrusts of the European fusion development program are on the right lines.