ON A POTENTIAL EUROPEAN PROGRAMME TO ACCELERATE AND OPTIMISE A DEMO REACTOR STAGE OF THE FAST TRACK

D Stork

Euratom/CCFE Fusion Association, Culham Science Centre, Abingdon, Oxfordshire OX14 3DB, UK.
corresponding author: derek.stork@ccfe.ac.uk

DEMO will be the last 'research fusion machine' before deployment of a first-of-a-kind Fusion Power Plant (FOAK FPP), and must finally validate and qualify all the component subsystems of a FOAK FPP. In particular, DEMO must perform nuclear lifetime-testing of in-vessel components up to reactor-relevant levels and demonstrate tritium self-sufficiency by the testing of full-size breeding blankets in a reactor-like 14 MeV neutron flux, and their integration into a full tritium fuel cycle plant. These requirements, plus the validation of all associated operational and remote handling maintenance plant, place a heavy technology mission on DEMO. Moreover reaching nuclear testing limits with minimum time delay implies a high level of reliability and availability of component subsystems. Comparison of the ITER baseline physics scenarios with the requirements of reactor concepts, eg. the European Power Plant Conceptual Studies (PPCS)[1], shows that FPP economics depend on achieving plasmas with higher normalised β and densities above the Greenwald limit (N_G) compared to ITER's targets, adding a requirement for some physics scenario development at the 'DEMO stage'. DEMO must also demonstrate solutions to issues on the plasma physics and technology interface in conditions beyond ITER, such as divertor performance at much higher power loadings (including operation with scenarios where the plasma radiation power fraction is very high) and feedback control of plasma instability and burn with the sparse dataset from the allowable reactor diagnostics. Finally, DEMO must be able to supply electricity by connection to the grid.

Recent European studies are discussed, aimed at defining the relevant issues and trade-offs in deployment of a DEMO with sufficient relevant mission capabilities and the minimum of risk, at the earliest possible time. The relevant mission capabilities are assessed in terms of the drivers of reduction of cost of electricity (coe) from fusion, given by the PROCESS [2] code to be: high availability; high 'steam cycle' thermodynamic efficiency; high nett power generated from the FPP; high plasma β; and high density operation. Issues discussed are:

- the trade-off between materials development and the coe from DEMO;
- the trade-offs between coe and development duration from operating the DEMO plasma in pulsed mode rather steady-state (in terms of machine size, fatigue lifetime, size, re-circulating power of heating and current drive systems, and energy storage in the balance of plant), whilst electricity generated from the FPP remains true steady-state;
- the minimum steps in machine size and plasma performance from ITER to DEMO; and
- the leverage in overall fusion development schedule, via optimising the time to complete a DEMO mission, from R&D programmes to improve DEMO subsystems' reliability, availability and (if relevant) energy efficiency.

Against this background, progress of recent European DEMO technology R&D is surveyed.

The potential is discussed for risk reduction and DEMO schedule optimisation coming from: systems tests which could be added to the currently foreseen phase 2 of ITER; early deployment of a Components Test Facility, for nuclear testing/qualification of medium-scale prototypes of DEMO's in-vessel components in a tokamak environment; and a DEMO-relevant programme on a 'satellite tokamak' operating during the DEMO design phase. Finally we suggest studies needed to define an integrated European DEMO programme.

Work funded by the UK EPSRC under grant EP/G003955 and by the European Communities under contract of Association between EURATOM and CCFE. Views and opinions expressed herein do not necessarily reflect those of the European Commission.

[1] D Maissonier et al, Nuclear Fusion 47(2007)1524
[2] D J Ward et al, 18th IAEA, FEC (2000), paper IAEA-CN-77-FTP2/20.