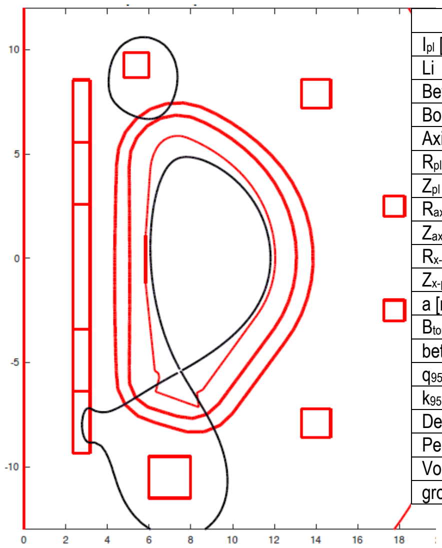
2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

# Overview of DEMO Technology and Scenario Design activities in Europe

F.Maviglia[1], G.Federici[1], M.Siccinio[1], R.Albanese[2], R.Ambrosino[2], C.Bachmann[1],T.Barrett[3], A. Castaldo[2],V.P.Lo schiavo[2],C.Day[4], M.Mattei[2], D. Ricci[5], G.Granucci[5].

[1]EUROFusion PMU
[2]University of Naples Federico II and CREATE consortium
[3]CCFE Culham Science Centre
[4]Karlsruhe Institute of Technology
[5] Istituto di Fisica del Plasma "Piero Caldirola" - CNR
francesco.maviglia@euro-fusion.org

This paper describes the progress of the pre-conceptual design activities for the European DEMOnstration fusion power plant (DEMO) [1], including both the technology challenges beyond the ITER design, and the development of a performing and yet stable plasma scenario.
While it is expected that the technology design and R&D will benefit largely from the ITER design and operation, some fundamental gaps remains due to the unique DEMO requirements [2], *e.g.* the tritium breeding self-sufficiency, the electricity power conversion systems (PCS), and the use of materials which can withstand a high neutron irradiation while maintaining a sufficient mechanical resistance and thermal conductivity.




| | SOF |
|---|---|
| $I_{pl}$ [MA] | 19.1 |
| Li | 1.14 |
| Betapol | 0.8 |
| Boundary flux [Vs] | 150 |
| Axis flux [Vs] | 296 |
| $R_{pl}$ [m] | 9.19 |
| $Z_{pl}$ [m] | 0.08 |
| $R_{axis}$ [m] | 9.39 |
| $Z_{axis}$ [m] | 0.03 |
| $R_{x\text{-}point}$ [m] | 7.48 |
| $Z_{x\text{-}point}$ [m] | -5.42 |
| a [m] | 2.88 |
| $B_{tor}$ [T] | 4.89 |
| betan | 0.03 |
| $q_{95}$ | 2.93 |
| $k_{95}$ | 1.64 |
| $Delta_{95}$ | 0.33 |
| Perimeter [m] | 25.4 |
| Volume [$m^3$] | 2355 |
| growth rate [$s^{-1}$] | 2.44 |

Fig. 1 DEMO optimized geometry and main parameters for the Start Of Flatop (SOF) phase, based on 2017 baseline.

The implications of these differences are, for instance, the need of developing a new strategy for the protection of the first wall from plasma transients [3], different from ITER conformal wall limiter, with the proposal to use discrete high heat flux limiters in specific locations of the machine. Another issue presented is the minimization of the inter pulse dwell time, in order to maximize the electricity output and simplify the PCS system, avoiding cycling of the generators and the need of large energy storage systems, which is dictated by the central solenoid charging time, and pump down time required to achieve the next radio frequency assisted breakdown [4]. A number of analysis and design choices are being carried out for the plasma scenario development, regarding the tradeoff between having performing plasma, in terms of fusion power, while guaranteeing a reasonably stable scenario to ensure the integrity of the plasma facing components [5]. An increase on plasma elongation at 95% of the separatrix, $\kappa_{95\%}$ from 1.59 to 1.65, corresponding to an increase on fusion performances [6], has been achieved due to the optimization of the vertical stability (VS). In Fig. 1 is presented the optimized equilibrium and main plasma parameters based on the 2017 DEMO baseline model. This was obtained with the optimization of the plasma magnetic equilibria, and the design of the surrounding electrical conductive structures geometry, both of which allowed achieving plasma more resilient to the coupling between perturbations and vertical displacements. In this respect, we have also compared the VS control performances of the magnetic single null (SN) configurations, used in ITER, with double null (DN) configurations. The comparison was extended with regards to the capability of protecting the wall from plasma transients.

References:

[1] A.J.H. Donné, et al., "Scientific and technical challenges on the road towards fusion electricity"Journal of Instrumentation 12(10),C10008 (2017).
[2] F. Maviglia, et al., “Wall protection strategies for DEMO plasma transients”, FED (2018), https://doi.org/10.1016/j.fusengdes.2018.02.064.
[3] G. Federici, et al., “DEMO Design Activity in Europe: Progress and Updates”, Int. Symp. on Fusion Nuclear Technology (ISFNT), Sept. 2017, Kyoto, Japan.
[4] D. Ricci et al.,” Discharge recovery by means of EC assisted start-up”, to be presented at the European Physical Society conference 2018.
[5] R. Wenninger et al., “Advances in the physics basis for the European DEMO design” Nucl. Fusion 55 063003 (2015)
[6] ITER Physics Design Guidelines: 1989, N.A. Uckan and the ITER Physics Group, ITER Documentation Series No. 10, IAEA, Vienna 1990, IAEA/ITER/DS/10.