A combined 0D-1.5D approach for efficient prediction of K-DEMO plasma scenarios

J.C. Rivas[1], J. Seo[1], C. Lee[1], R. Choi[1], and Y.-S. Na[1]
[1] Department of Nuclear Engineering, Seoul National University, Seoul, Korea
e-mail (speaker): rivas@snu.ac.kr

The use of higher detail simulations for validating the results of a 0D plasma systems code is an approach used for DEMO conceptual design since some years ago[1].
A method based on this approach[2] is being developed at the Plasma Laboratory for Advanced Research of SNU that uses a fast 0D plasma core balance optimization as a guess solution for a transport solver[3].
In this method, a 0D plasma code is used as an objective function by an evolutionary optimization algorithm to optimize figures of merit deemed of interest by changing some input parameters and constraining the solution with physics and technological limits.
The obtained solution is then used as a guess solution for a transport solver, which provides a more reliable and self-consistent solution based on the 0D optimization.
The solution from the transport solver is in turn used to estimate some parameters of the 0D plasma code and subsequently produce a new iteration[3].
The results currently produce solutions with main characteristics ranging from current K-DEMO to EUROfusion DEMO1, depending on parameter assumptions, and also strongly dependent on the physics models used for the calculations.

Together with the physics models, the technological constraints are the defining factor of the main characteristics of the solution. If conservative assumptions are taken, the plasma solution will show lower performance.
Figure 1 illustrates a solution obtained with the transport solver starting from the set of inputs of the 0D plasma optimized solution. The heuristic solution is not granted to be optimal, but it fulfills performance requirements of K-DEMO. It exhibits higher value of Q, and lower values of $B_{t,max}$ and P_{sep}/R than the current K-DEMO design. On the other hand, <NWL> is lower, which decreases the breeding ratio but increases the plant availability[3].

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References

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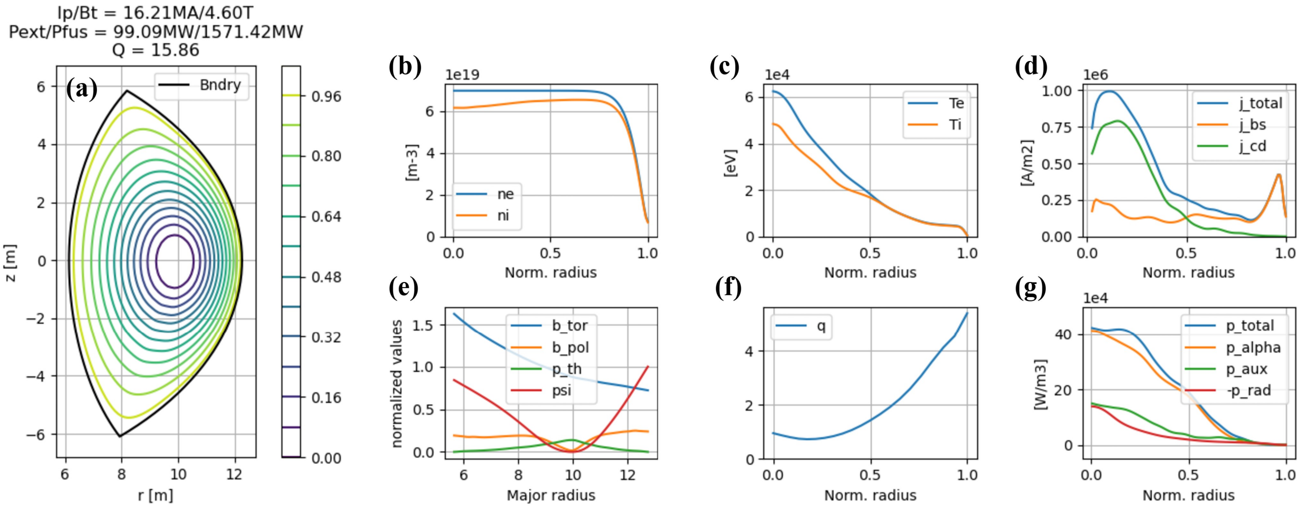

Figure 1. *Some figures from the 1.5D transport solver solution: (a) poloidal flux contours, (b,c) electron and ion densities and temperatures, (d) current densities, (e) toroidal and poloidal field (B/B_0 normalization), thermal pressure ($2\mu_0 p_{th}/B_0$ normalization) and poloidal flux ($(\Psi-\Psi_0)/(\Psi_b-\Psi_0)$ normalization) (f) safety factor and (g) power balance. (b,c,d,f,g) show radial profiles, while (e) shows the midplane profile.*