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DEMO Reactor Design by the New Modular System Code SYCOMORE

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Demonstration power plant is the next step for fusion energy following ITER. Key questions remain before a design is selected. Some of these questions can be addressed by simulation through system codes. System codes aim at modeling the whole plant with all its subsystems and identifying their interactions and their impact on the design choice. The SYCOMORE code is a modular system code developed to address key questions relevant for tokamak fusion reactor design. SYCOMORE is developed within the European Integrated Tokamak Modelling framework (ITM) and provides a global view of the plant, from technological elements to physics-oriented issues. It contains modules for plasma, divertor, blankets, shields, magnets, power conversion and global plant power balance. The modules are connected in a calculation chain to ensure self-consistency of the design.

The code has recently shown that increasing the minor radius of a reactor is much more beneficial from the net electric power output than increaser the major radius, even at similar plasma volumes. The major radius effect on confinement is a trade-off between larger plasma volume and lower plasma current due to fixed q95. On the contrary, increasing the minor radius increases the plasma volume and keeps a high enough plasma current resulting in a linear increase of net electric output with the minor radius. Similarly, small minor radius (below 2.5 m for 9.4 m major radius R=9.4 m) lead to high amounts of heating power required to compensate for thermal losses and subsequently high argon seeding fraction to protect the divertor and low fusion power. This shows the critical importance of the radial build on the reactor performances as well as the necessity to compute all subsystems sizes and characteristics in a self-consistent way.

Benchmark activities with international system codes are also led to confirm these results. They show a good general agreement with other international codes and highlight some critical differences in the way some physics or technological processes are treated (radiation power, shielding thickness⋯).

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Author: Mr SAOUTIC, Bernard (CEA-IRFM)

Co-authors: Dr LI PUMA, Antonella (CEA-DM2S); Dr FAUSSER, Clément (CEA-DER); Dr REUX, Cédric (IRFM-CEA); Dr GALASSI, Davide (CEA-IRFM); Dr IMBEAUX, Frederic (CEA-IRFM); Dr CIRAOLO, Guido (CEA-IRFM); Dr JABOULAY, Jean-Charles (CEA-DM2S); Dr ARTAUD, Jean-Francois (CEA-IRFM); Dr DUCHATEAU, Jean-Luc (CEA-IRFM); Dr BUCALOSSI, Jerome (CEA-IRFM); Dr ZANI, Louis (CEA-IRFM); Dr DI GALLO, Luc (CEA-IRFM); Dr HERTOUT, Patrick (CEA-IRFM); Dr BERNARDI, Pierre (CEA-IRFM)

Presenter: Mr SAOUTIC, Bernard (CEA-IRFM)

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