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A smart architecture for the DEMO fuel cycle

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In the framework of the EUROfusion DEMO Programme the EU has elaborated a completely novel and most innovative fuel cycle architecture, driven by the need to reduce the tritium inventory to an absolute minimum.

To achieve this goal, batchwise processes used in the fusion fuel cycle so far were replaced by continuous processes wherever possible. This includes the change from discontinuous cryopumping to mercury based continuous vacuum pumping with practically zero demand on cryoplant power, and the introduction of thermal cycling ab- and adsorption processes for isotope rebalancing in the tritium plant instead of large cryogenic distillation columns with tritiated liquid hold-ups. To further reduce inventory, the well-known approach to route all exhaust gas through the tritium plant has been abandoned in favor of a three-loop architecture. There, superpermeable metal foils are introduced in the divertor ports to separate a pure DT stream which is then immediately recycled to feed the pellet injection systems. To increase the core fueling efficiency, optimization potentials in the design of the high field side pellet injection systems are being exploited. Finally, a unified fuel cycle simulator is under development on a commercial software platform in order to identify optimization potentials within the fuel cycle, to allow impact studies, and on a long term to support the development of tailored control and operational strategies.

The talk will present the first integrated and consolidated design point of the fuel cycle based on the 2017 European DEMO baseline. It is shown how the DEMO requirements are picked up and affect system level performance. Examples are given for integration issues and how they were solved (remote handling, divertor integration, plasma control). Finally, a roadmap is delineated which illustrates the remaining R&D efforts needed to achieve at a validated and complete conceptual design until the mid 2020s.

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