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Integrated power and particle exhaust scenarios

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Benign power exhaust in a tokamak relies on the injection of radiating impurities (plasma enhancement gases), to be controlled for the achievement of the desired power crossing the separatrix and sufficient divertor radiation. At least partial divertor detachment is required, reducing the heat flux impinging the divertor target at the separatrix below about 5 MW/m^2. Candidate gases for divertor radiation are N, Ne and Ar, while potential core radiators are Ar, Kr and Xe. A high throughput of D+T (gas puffing, pellet injection) is generally required to obtain a high compression of impurities in the divertor, avoiding too strong core fuel dilution. This applies as well to the He atoms generated by the fusion reaction.
The talk will explain the general relationships between fueling, radiative losses, divertor compression and pumping, using integrated scenarios in the ASDEX Upgrade tokamak as examples which combine core and divertor radiation and no-ELM conditions. The measured impurity and fuel distributions are described by a simple particle balance model, which provides the size dependent extrapolation to reactor conditions and defines the open physics parameters. Here, the impurity divertor enrichment is the most important quantity, describing the ratio of impurity and fuel divertor compression. Much longer time scales are expected for reactor conditions compared to those observed ASDEX Upgrade, due to much larger relevant volumes but a similar pumping speed. The fuel particle throughput, which is connected to the separatrix density, appears as important optimization quantity: while a cleaner core plasma and easier divertor detachment are obtained at high gas throughput, a reduction of core energy confinement has generally been observed.

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