In today’s fusion experiments impurities are often considered a nuisance, levels of $Z_{\text{eff}}$ are minimized and the radiated power is considered missing power when stability and performance of a plasma discharge are evaluated. At the same time it is well known that in a reactor impurities are needed in order to radiate the power rather than guiding it into the divertor. Both views are justified and for a reactor the right balance between beneficial and detrimental effects is required, thus, an ‘optimal’ impurity level exists. The idea of an optimal impurity level in a reactor will be elaborated and some basic features of impurities in a reactor are discussed, while the main focus is put on the role of impurities inside of the separatrix. Note that radiative cooling in the scrape-off layer is important for a reactor, but it is not addressed in detail by the present work.

Various ways of evaluating the optimal impurity levels in a reactor are presented. In order to do so, one crucial ingredient is high quality atomic data, which can be used to evaluate the cooling efficiency, i.e. the cooling factor $L_Z$, of an impurity. In the course of this work, the cooling factors of 35 elements from hydrogen ($Z=1$) to bismuth ($Z=83$) have been evaluated using up to date atomic codes. This ensemble of cooling factors is unique as all the necessary data, i.e. ionization and recombination rates and coefficients which quantify the line and continuum radiation have been calculated using the same codes and approximations for all elements. On these grounds the ensemble may be labelled ‘consistent’.

The optimal impurity level is evaluated using a very simple 0D-model, an extended 0D-model with basic profiles and a detailed 1D-model using ASTRA as basis for considering profile effects of radiation and transport. The basic conclusion from this comparison yields following findings:

- The consideration of profiles always reduces the concentration of the optimal impurity level as compared to a 0D-evaluation of the power balance (Lawson criterium).
- The radial profiles of impurities and electrons including the divertor compression are crucial for the performance of a reactor.
- Low-Z impurities should be avoided as seeded impurities as the related dilution is clearly visible in the performance of a power plant. For temperatures above 15keV, the cooling factors of high-Z radiators decreases strongly, which leads to better compatibility with high performance reactor plasmas at strong radiative cooling levels.
- The transport and confinement of helium has the potential to strongly reduce the fusion yield of a reactor plasma and thus, requires attention.