Designing for nuclear safety, security and sustainability: a philosophical discourse of the nuclear reactor

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Values – i.e. how societies perceive of “the good” – are at the heart of engineering design. In this presentation we will focus on four main values that have played a role in nuclear design, namely safety, security, sustainability and economic viability. We will first elaborate on how each of these values has been perceived in the six decades old history of nuclear power. We will then operationalize these values by specifying how they relate to a specific step in nuclear fuel cycles. In so doing we can assess the existing nuclear fuel cycles.

Such assessment is helpful in ex-post analysis of the technologies and understanding the intricate choice that policy-makers need to make. At least equally important is to incorporate these values in an ex-ante analysis of what we deem to be a desirable future technology. This approach accounts for human values through the design process and it is referred to as Value Sensitive Design (Friedman 1996). Such thinking in terms of values has motivated the development of new fuel cycles, for instance Partitioning & Transmutation (P&T) in order to reduce the waste life-time, but it has also affected the design of the nuclear reactor.

Historically, the notion of safety has been one of the important driving forces behind serious changes in the reactor design philosophy. Particularly, major nuclear accidents seem to have affected the thinking about reactor safety. We will review the evolution of safety regimes from active to passive and ultimately to inherently safe reactors. Indeed, security, sustainability and economic viability also play a role in design. Since we cannot meet all these criteria simultaneously choices and trade-offs need to be made. We will highlight these choices by discussing three promising future reactors, namely High Temperature Reactor Pebble-bed Module (HTR-PM), Gas-cooled Fast Reactors (GFR) and Molten Salt-cooled Reactors (MSR).

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