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Technological readiness of alternative reactor concepts

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Abstract. Some alternative reactor concepts are frequently discussed in the literature as relevant for the disposal of high-level radioactive waste. We present results on the technological readiness of and research and development on those reactor concepts from a project commissioned by the Federal Office for the Safety of Nuclear Waste Management on novel reactors (Pistner et al., 2023). The focus is on 7 technology lines and 10 specific reactor concepts within those lines. These are sodium-cooled fast reactors (SFRs), lead-cooled fast reactors (LFRs), gas-cooled fast reactors (GFRs), very high-temperature reactors (VHTRs), super-critical water-cooled reactors (SCWRs), molten-salt reactors (MSRs) and accelerator-driven systems (ADSs). For all technology lines considered, extensive research and development work has been taking place for several decades and in some cases since the middle of the last century. Depending on the technology line, technical test stands for individual phenomena have been built and operated and so have smaller experimental reactors and larger demonstration reactors. Nevertheless, until today no commercially competitive reactor concept exists in the field of alternative reactor concepts. The most extensive technical experience is available for the SFR and VHTR technology lines. However, proof of reliable operation under economic boundary conditions is still required for SFRs and VHTRs. For other technology lines, neither has technical feasibility in the form of a demonstration reactor been demonstrated so far (LFR, MSR) nor are more extensive findings from smaller experimental reactors available (GFR, SCWR, ADS). To plan, license, construct and operate such experimental and demonstration reactors, a period of at least 1 to 2 decades must be assumed for each reactor project and probably substantially more based on historical experience. It has been shown that developers' schedules are often characterized by overly optimistic assumptions, that developments are delayed by years or even decades, and that in many cases specific approaches are discontinued completely because the underlying technological difficulties could not be overcome. Thus, the time still required for the development of alternative reactor concepts is probably in the range of several decades. Against this background, it cannot be assumed that such reactor concepts will be used on a relevant scale by the middle of this century.

Additionally we will present general results of this study regarding criteria such as safety, fuel supply and waste disposal, proliferation, and costs and point out advantages and disadvantages of those systems over light-water reactors.

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