

## STRATEGIC DEPLOYMENT OF LEAD-COOLED FAST REACTORS (LFRS) IN EUROPE: ADVANCING WASTE REDUCTION AND RADIOTOXICITY MANAGEMENT BY 2035

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Europe's current nuclear energy infrastructure faces significant challenges in waste management, fuel efficiency, and long-term sustainability. Conventional reactors generate large quantities of long-lived radioactive waste, requiring storage for over 100,000 years, and use only 1%–2% of the available energy in uranium fuel. Additionally, the fragmented approach to spent fuel processing across different countries leads to inefficiencies in waste disposal and resource utilization. To address these issues, this study focuses on the deployment of Lead-Cooled Fast Reactors (LFRs) in Europe with a centralized facility for spent fuel and waste management, considering infrastructure requirements, policy alignment, and economic viability. LFRs operate within a closed fuel cycle, enabling near-complete utilization of fissile materials and drastically reducing waste production. Compared to current reactors, they achieve a 20-fold reduction in used fuel per unit of energy and shorten radiotoxicity decay times to just a few hundred years instead of millennia. Unlike previous studies focusing solely on LFR technology, this work integrates a centralized facility for spent fuel and waste management, offering a comprehensive strategy tailored to fit European energy needs. By systematically reprocessing spent fuel at a dedicated European facility, only short-lived fission products require final disposal, while the remaining fuel is recycled with natural or depleted uranium, extending uranium resource availability from hundreds to thousands of years. This strategy enhances nuclear fuel efficiency, reduces long-term storage costs, and strengthens European energy security by decreasing dependence on uranium enrichment and imports. The establishment of a coordinated infrastructure and policy framework for LFR deployment by 2035 is critical. This study intends to identify and highlight the foundations for the LFR nuclear energy system deployment that effectively addresses spent fuel and waste management, for the long-term sustainability energy challenges in Europe.

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