Foreword

Selected papers from the 2022 International High-Level Radioactive Waste Management Conference

Guest Editors

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We are pleased to present this special issue of *Nuclear Technology* showcasing papers from the 2022 International High-Level Radioactive Waste Management Conference (IHLRWM 2022).

IHLRWM 2022 once again made apparent that the management and disposition of spent nuclear fuel and high-level radioactive waste is an ongoing task in every country that possesses these materials. While permanent deep geologic disposal is the end point of both open and closed fuel cycles, the long-term management of spent nuclear fuel and high-level radioactive waste presents multiple challenges preceding permanent disposal, including the possibility of extended storage, the potential introduction of advanced reactor spent nuclear fuel and waste, and the sociopolitical challenges of siting facilities. The papers in this issue highlight the breadth of work being conducted in multiple countries to advance the technical basis for safety and address the nontechnical challenges associated with disposal, storage, and transportation of spent nuclear fuel and high-level radioactive waste.

Since the first commercial nuclear reactors began producing electricity in the 1950s, they have generated approximately 400,000 metric tons heavy metal of spent nuclear fuel.[1] Today, nuclear energy provides about 10% of the world's electricity.[2] It is a significant component of many nations' strategies to lower carbon emissions and improve energy security—at the 2023 United Nations Climate Change Conference (commonly known as COP28), more than 20 nations declared an intention to triple global nuclear energy by 2050.[3]

Spent nuclear fuel, or the high-level radioactive waste from reprocessing it, requires isolation from people and the environment over time spans greatly exceeding the time any human society or institution can be expected to persist. Permanent disposal in stable geologic formations can provide passive safety over regulatory periods that may be as long as 1 million years. Various lines of evidence serve to build the case for safety—the papers in this issue touch on some of these, including disposal system safety assessment,[4,5] detailed process modeling,[6] underground research,[7] and natural analogues.[8] Appropriate regulatory standards help define "safe." At IHLRWM 2022, the American Nuclear Society debuted draft recommendations for new generic safety standards for deep geologic disposal in the United States. These recommendations were finalized in August 2023.[9]

In many countries progress toward permanent deep geologic disposal has been delayed such that spent nuclear fuel may be in dry storage for many decades beyond initial licensing periods for storage facilities. Understanding aging processes can increase confidence that spent nuclear fuel can be transported, retrieved, and meet the waste acceptance criteria of a deep geologic disposal facility after a period of extended storage. Research and development efforts include investigation of degradation mechanisms affecting canisters, fuel cladding, and neutron absorbers; development of methods for inspection, mitigation, and repair; and consequence analyses. Several papers in this issue address these topics.[10–13]

As countries turn to nuclear energy to meet carbon emission and energy security goals, many are pursuing deployment of advanced, non–light water reactors. An understanding of the spent fuel forms—whether metallic, coated-particle, or molten salt—and the high-level waste forms[14] that may result from advanced fuel cycles will be needed to develop strategies for disposal, storage, and

transportation of these materials. Anticipating the challenges of waste management while still in the design and development stage will improve long-term management strategies for advanced reactor spent nuclear fuel and high-level radioactive waste.[15,16] Approaching deployment of new technologies, including those for managing wastes, as a socio-technical process, rather than a purely technical process, would increase the likelihood that the technologies developed will be desirable.[17]

Demonstration that a proposed disposal or storage facility for spent nuclear fuel and/or high-level radioactive waste can be implemented safely is not enough to achieve success in siting such a facility. Three papers in this issue discuss public perceptions surrounding nuclear waste management in the United States.[18–20] A fourth proposes a package performance demonstration as a means of building stakeholder confidence in transportation of spent nuclear fuel.[21] Results of a national survey suggest that the public overwhelmingly supports the principle of consent-based siting, preferring a model that seeks broad-based consent from many actors while prioritizing the consent of local communities.[18]

IHLRWM 2022 highlighted the significant progress made in radioactive waste management since the previous iteration of the conference in 2019. In Finland, the first disposal tunnels for a deep geologic repository were excavated,[22] while in Sweden, the government approved construction of a repository.[23] The French radioactive waste management organization submitted its application for a license to construct a repository.[24] The Swiss radioactive waste management organization selected the most suitable site for a repository.[25] In countries including Canada, the United Kingdom, Germany, and Japan, progress in repository siting has been made. In the United States, the Department of Energy initiated consent-based siting for federal consolidated interim storage.[26]

The next International High-Level Radioactive Waste Management Conference will be in 2025, where we are sure to learn about new progress toward safe, permanent disposal of high-level radioactive waste and spent nuclear fuel.

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