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Feasibility of Borehole Co-Location with Advanced Reactors for Onsite Management of Spent Nuclear Fuel

2020 TECHNICAL REPORT

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The following organizations, under contract to the Electric Power Research Institute (EPRI), prepared this report:

Deep Isolation
2120 University Ave., Ste. 609
Berkeley, CA 94704

Principal Investigators
R. Balzer
J. Hamilton

Auburn University
1161 West Samford Avenue
Auburn, AL 36849

Principal Investigator
D. King

J Kessler and Associates, LLC
416 East Park Avenue
Charlotte, NC 28203

Principal Investigator
J. Kessler

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- Nuclear Energy Institute (NEI): Rod McCullum
- EPRI: Dan Moneghan and Jeremy Renshaw

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ABSTRACT

Ongoing delays and uncertainty for the implementation of geologic disposal for commercial spent nuclear fuel (SNF) and high-level radioactive waste (HLW) continues to impact the current operating nuclear fleet. In the United States and other countries, many utilities must regularly move SNF from spent fuel pools to dry storage in order to maintain full core offload capacity. For future deployment of advanced reactors (ARs), having an answer to the "What about the waste?" question is widely considered a fundamental building block for establishing and maintaining public confidence and support.

Deep borehole disposal has long been recognized as a credible alternative to mined repositories since the science-based consensus on land-based disposal for commercial SNF and HLW was established in the 1950s. A collaborative, multi-disciplinary review of major technical, regulatory, and stakeholder issues for a generic site and AR technology, indicates that commercially deployable deep horizontal borehole technology could offer utilities and other AR owner-operators a viable and beneficial alternative path for managing the backend fuel cycle.

In this study, EPRI identifies and evaluates key elements for planning, siting, licensing, and implementing deep borehole storage and disposal co-located with an operating advanced nuclear power plant. The opportunity to bundle AR operation with onsite permanent disposal provides a unique answer to the nuclear waste question and flexibility not available under the existing SNF management regime. This flexibility includes near-term integrated, retrievable, subsurface storage paired with the option for conversion to a licensed permanent disposal facility or retrieval for traditional offsite disposal. Important barriers and gaps, such as the lack of suitable risk-informed, performance-based disposal regulation for the United States, do exist but are not insurmountable given the lead times available and the experience gained to date.

This project leverages expertise of an interdisciplinary team to perform a preliminary feasibility assessment of integrating modern borehole emplacement technology with the siting of advanced nuclear energy systems to provide compelling new deployment options for the next generation of nuclear owner-operator. The generic and AR technology agnostic nature of this study precludes categorical conclusions or recommendations on the feasibility of onsite borehole storage/disposal for a specific location, AR design, or business case. However, the issues and gaps that emerge from this review can inform actionable recommendations and next steps with respect to planning, design, siting, licensing, deployment, and operation.

Keywords

Deep borehole disposal
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PRIMARY AUDIENCE: Electric power utilities and other potential advanced reactor (AR) owner-operators

SECONDARY AUDIENCE: AR technology developers and other stakeholders with an interest in understanding deep borehole disposal as an alternative technology pathway enabling onsite management of spent nuclear fuel from ARs, including regulators, policymakers, investors, and the general public

KEY RESEARCH QUESTION

This study investigates the feasibility of co-locating onsite deep borehole storage and disposal with advanced nuclear plants to provide an alternative to offsite geologic disposal. The technology that makes this option possible is one that has benefited from substantial developments and applications in the oil and gas extraction industry and deep geologic characterization research—directionally drilled deep boreholes.

RESEARCH OVERVIEW

This preliminary assessment identifies key elements for planning, siting, licensing, and implementing deep borehole storage and disposal facilities co-located with ARs. These include regulatory considerations, physical site characteristics, spent fuel and waste package specifications, operations, safety analysis, public acceptance, strategic partnerships, risk management, and schedule and budget.

KEY FINDINGS

- No technical showstoppers are identified for further consideration of deep borehole disposal co-located with future deployments of ARs, based on a generic site and AR technology agnostic evaluation.
- Greater flexibility and optionality emerge from scenarios in which onsite disposal options for AR SNF are available, including mitigation of business risk by decoupling reactor operations from external backend fuel cycle issues that traditionally fall under national government responsibility—outside of owner-operator control.
- The horizontal variant of borehole technology evaluated in this study offers unique benefits for applications where waste package retrievability is a priority, such as for interim, fully-reversible storage prior to closure for permanent disposal.
- The applicable U.S. regulation for geological disposal of SNF, 10 CFR 60, is obsolete and represents a barrier for near-term implementation of deep borehole disposal in the United States. However, a potential path exists through the application of regulations at 10 CFR 72 governing independent storage installations. Under this approach, licensing of retrievable storage of AR SNF in borehole systems would be pursued initially with the option for permanent disposal under a revised or new regulation, with the benefit of information gained from monitoring and inspection over the period of retrievable interim storage.

- Establishing and maintaining support from the public, regulators, and other stakeholders is essential for any long-term SNF management strategy but is foundational for the implementation of a decentralized, onsite borehole disposal solution tailored for future ARs. Prudent regulatory/licensing approaches will integrate and enable sustained community participation in a voluntary facility siting process.
- Given the lack of viable alternatives to centralized mined repositories, which have proven costly and challenging to deploy in many countries, further evaluation and demonstration of deep borehole technologies could yield a valuable enabling option for the commercialization of advanced nuclear power plants in the United States and globally.

WHY THIS MATTERS

The identification and elaboration of a technically credible and socially acceptable alternative to the traditional and, to date, largely unsuccessful approach to geologic disposal via centralized, mined repositories supports the future adoption and deployment of ARs by providing a much needed narrative on the management of commercial SNF. This evaluation also serves to inform key industry, government, and regulatory stakeholders on the application of deep borehole disposal technology for SNF and HLW management. Meanwhile, this effort also serves to introduce the developers and sponsors of deep borehole technology to the commercial nuclear power industry and the constraints within which it operates.

HOW TO APPLY RESULTS

As a generic and preliminary evaluation, this study provides an informational foundation for more in-depth and application-specific assessment of deep borehole disposal as a potential onsite, integrated solution for the interim storage and permanent disposal of SNF from the next generation of advanced nuclear power plants. The key elements identified and defined in this report provide a framework within which more granular, site-specific, and/or AR technology-specific feasibility studies can be launched.

LEARNING AND ENGAGEMENT OPPORTUNITIES

EPRI brings to this project over two decades of pioneering research and development (R&D) on the integrated performance assessment of deep geologic disposal systems. This work was funded by EPRI utility members to provide independent oversight of and to inform the technical evaluation of the Yucca Mountain repository system in the United States. EPRI has also performed numerous studies on advanced nuclear fuel cycles and is currently focusing on R&D to support commercial demonstration and deployment of AR designs. Accordingly, this activity bridges and leverages multiple areas of prior and ongoing R&D. EPRI also continues to track developments in borehole technology and application as part of its technology scouting role.

Engagement and collaborative opportunities with EPRI in this area exist through:

- Membership in EPRI's Advanced Nuclear Technology program and a new Advanced Reactor Supplemental project established in 2019 for the purpose of expanding participation of AR developers and stakeholders in the EPRI collaborative model.
- Ongoing public outreach activities on AR technology topics through in-person and virtual workshops and technical conference presentations.

EPRI CONTACT: Andrew Sowder, Senior Technical Executive, asowder@epri.com

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com