

Artificial Intelligence in the Nuclear Field: A Survey of Activities by Regulatory Bodies and International Organizations

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1. Introduction

Artificial intelligence (AI) has recently attracted increasing attention as a key technology that can help reduce operation and maintenance (O&M) costs, address workforce shortages, automate inspections, and improve workflow efficiency in nuclear facilities. Field applications of AI at nuclear power plants have also been reported, particularly in the United States and Europe [1, 2].

However, the nuclear industry is a high-hazard sector subject to stringent requirements for safety, reliability, security, and regulatory acceptance. Unlike conventional software, which operates deterministically according to predefined rules, AI systems generate outputs through data-driven learning and probabilistic decision-making. Accordingly, expanding the use of AI requires an examination of whether existing nuclear regulatory frameworks can adequately address AI-specific characteristics and whether additional measures are needed. Regulatory readiness to conduct such reviews must be established alongside technological development.

Against this background, major national regulatory bodies, including the U.S. Nuclear Regulatory Commission (NRC), the U.K. Office for Nuclear Regulation (ONR), and Japan's Nuclear Regulation Authority (NRA), are pursuing regulatory activities in preparation for the application of AI in the nuclear field. International cooperation and related discussions are also under way through CANUKUS, a trilateral cooperative framework among the nuclear regulators of Canada (the Canadian Nuclear Safety Commission, CNSC), the United Kingdom, and the United States, as well as through the OECD Nuclear Energy Agency (OECD/NEA) and the International Atomic Energy Agency (IAEA).

This paper surveys the AI-related activities of these entities in the nuclear field.

2. Responses of Major National Regulatory Bodies

2.1 NRC

Anticipating the industry's potential application of AI to NRC-regulated activities, the NRC developed the Artificial Intelligence Strategic Plan: Fiscal Years 2023–2027 to ensure its readiness to review such uses

[3]. The plan sets out five strategic goals: (1) Ensure NRC Readiness for Regulatory Decision-Making; (2) Establish an Organizational Framework to Review AI Applications; (3) Strengthen and Expand AI Partnerships; (4) Cultivate an AI-Proficient Workforce; and (5) Pursue Use Cases to Build an AI Foundation Across the NRC.

In Advancing Use of Artificial Intelligence at the U.S. Nuclear Regulatory Commission (SECY-24-0035), the NRC presented its agency-wide approach to AI [4]. The paper reports 61 proposed AI use cases from 23 organizational units, of which 36 were assessed as feasible with currently available AI tools, including generative AI for meeting minutes and document summarization and machine learning and natural language processing for predictive analytics, automated review of public comments, and interregional inspector scheduling. It also sets out a two-stage implementation plan: developing an agency-wide AI strategy, followed by introducing generative AI services and integrating AI with the Agencywide Documents Access and Management System (ADAMS).

In addition, the NRC commissioned Sphere of Influence, Inc. to study the use of machine learning to prioritize inspections [5]. The study applied unsupervised machine learning to NRC inspection reports for clustering and presented a case in which safety-related clusters were identified, indicating that the NRC is examining the use of AI not only for generative AI-based work support but also for the analysis of regulatory information such as inspection reports.

To assess whether the existing regulatory framework could adequately address the potential use of AI systems, the NRC commissioned the Southwest Research Institute (SwRI) to conduct a gap analysis of 517 Regulatory Guides (RGs) [6]. Potential gaps were identified in 100 or fewer RGs, and the report assesses the existing NRC regulations as adequate for regulating AI technologies in most cases. SwRI classified the potential gaps into eight categories: Implied Manual Actions; Special Computations; Preoperational and Initial Testing Programs May Omit AI; Habitability Conditions under Autonomous Operations; Periodic Testing, Monitoring, and Reporting; Software for Safety-Related Applications; Radiation Safety Support; and Miscellaneous: Training and Human Factors Engineering. The report states that the most common type of gap involves RGs that specify actions to be

performed by humans even though those actions could also be performed by AI systems. SwRI also provided six recommendations to the NRC staff: (1) develop guidance on data quality for ML; (2) develop guidance on systematic testing and documentation of AI system responses, particularly for rare and extreme inputs; (3) develop guidance on systematic fail-safe design, including detection of inputs differing from the ML database and of anomalous AI responses, and mitigation of AI errors; (4) develop guidance on testing and documentation of AI-based computations and predictions; (5) examine FDA and FAA work on AI regulation; and (6) deploy a pilot program to evaluate computations by an existing licensee using AI technologies.

The NRC commissioned Pacific Northwest National Laboratory (PNNL) and Oak Ridge National Laboratory (ORNL) to evaluate the applicability of AI-based assisted data analysis (ADA) to nondestructive examination, including ultrasonic testing (UT) [7, 8]. PNNL found that commercial rule-based ADA did not perform at the level of qualified inspectors, partly because of false detections, whereas ORNL applied machine learning, particularly deep learning, to UT data and demonstrated relatively high accuracy in determining the presence or absence of defects [8]. The ORNL assessment further indicated that the performance of machine-learning-based methods depends on the training dataset and that their applicability should be determined by considering trade-offs among the true positive rate, false positive rate, and false negative rate.

2.2 ONR

The ONR commissioned Adelard LLP to assess whether its existing regulatory approach and the underpinning legislation were appropriate for regulating AI/ML technologies, resulting in the report *The Impact of AI/ML on Nuclear Regulation* [9]. The report examined the suitability of the existing regulatory framework, including the Safety Assessment Principles (SAPs), and presented a phased roadmap to support AI/ML assurance, covering the development of an AI/ML regulatory framework based on the SAPs and relevant guidance, capability building within industry and the ONR, architectural approaches and data strategies, and participation in standardization activities.

In collaboration with the Environment Agency, the ONR conducted a regulatory sandbox pilot involving two AI use cases related to structural integrity and a robotic glovebox [10]. The pilot tested how the ONR's regulatory framework could be applied to AI use cases and sought to identify anticipated regulatory challenges and key issues at an early stage; the results indicated that the benefits of AI and its differences from existing technologies should be clearly articulated, while the associated risks should be fully understood and managed through a robust framework. Using Agile,

Shift-Left, sprint workshops, and deep-dive approaches, the sandbox confirmed the importance of rapidly identifying issues and benefits associated with the use cases and openly sharing views among participants [11].

In response to the UK government's principles-based framework for AI regulation [12], the ONR published ONR's Pro-Innovation Approach to AI Regulation [13] to explain how its regulatory approach aligns with the government's expectations. The document states that the UK's goal-setting and non-prescriptive nuclear regulatory regime is technology-neutral and that innovative technologies such as AI systems can be assessed under existing regulatory principles, provided that sufficient justification demonstrates that nuclear safety and security expectations are met. It also sets out five principles for AI regulation: safety, security and robustness; appropriate transparency and explainability; fairness; accountability and governance; and contestability and redress. It further states that explainability and transparency are prerequisites for supporting credible safety and security claims, with the required level depending on the safety and security significance of the function.

2.3 NRA

Amid an expected increase in the review workload arising from plant modification work and reactor replacements associated with Japan's New Regulatory Requirements, and in light of the enactment of Japan's AI Act [14], the Secretariat of the NRA (NRA Secretariat) plans to carry out studies and development work from FY2026 on the use of AI, including large language models (LLMs), to support its review activities [15]. The initiative will proceed in stages by first identifying areas of review work in which AI can be effectively utilized and examining its feasibility, and then developing and validating a pilot system based on review data. In addition, under a project to enhance emergency monitoring technologies, efforts are under way to advance related technologies, including through the use of AI. The project also includes the development of systems in which AI supports the assessment of environmental radiation conditions during emergencies.

To promote work efficiency, the NRA Secretariat has been piloting Microsoft Copilot since 2025, with some staff using it in their day-to-day work. An internal business reform promotion team collects staff feedback on Copilot use and conducts surveys to identify the types of work in which efficiency improvements can be expected [16]. The team plans to continue formulating measures for the active adoption of generative AI in routine work; to advance these efforts, the NRA Secretariat has requested the establishment of a director-level post for business reform promotion as part of its FY2026 organizational and staffing request [15].

The Regulatory Standards and Research Department,

Secretariat of the NRA, is conducting studies on AI as part of its response to new technologies [17]. It has also been reported to be examining AI-based analysis and prediction methods in safety research, including the automation of fire impact assessments using generative AI and the AI-based acceleration of numerical calculations [18].

3. Global Regulatory Cooperation and Activities of International Organizations

3.1 CANUKUS

CANUKUS issued the joint document *Considerations for Developing Artificial Intelligence Systems in Nuclear Applications*, which sets out “principles that all participants in the AI lifecycle should consider, including developers, licensees and regulators” [19]. The document addresses six topics: “Common areas of focus for regulators when approaching AI”; “Understanding how to manage systems based on the consequences of AI failure and the level of AI autonomy”; “The importance of human and organisational factors in the use of AI”; “Integrating AI into existing nuclear systems”; “Managing the AI lifecycle from design to deployment”; and “Considerations for safety cases for AI in nuclear applications.”

3.2 OECD/NEA

Through the International RegLab Project, the OECD/NEA is examining issues related to the deployment of disruptive innovations in the nuclear regulatory domain. Running from March 2025 to August 2027, the project aims to conduct four RegLabs on these issues. The project is being carried out in cooperation with the Electric Power Research Institute (EPRI) and the IAEA ISOP Network, with participation from the CNSC, France’s Autorité de sûreté nucléaire et de radioprotection (ASNR), the NRA, the Korea Atomic Energy Research Institute (KAERI), Spain’s Consejo de Seguridad Nuclear (CSN), the ONR, and the NRC [20]. Members of the International RegLab Project held their first meeting in April 2025, which the OECD/NEA described as marking the start of an initiative to enable the safe and efficient application of disruptive technologies in order to enhance regulatory readiness. Four RegLab sandboxing rounds will be organized before August 2027, and project members will share insights and recommendations with their national and international technical committees based on the outcomes [21].

The first deep-dive workshop (RegLab 1), held in October 2025, examined a use case involving AI to monitor real-time data collected from large samples of sensors and identify inconsistencies in system behavior that deviated from expected operating criteria [22]. The second workshop, held in May 2026, discussed the

safety implications of using AI under human supervision or in fully autonomous environments and examined AI agents tasked with optimizing equipment reliability and maintenance planning within the framework of the Institute of Nuclear Power Operations (INPO) AP-913 and AP-928 processes. The next phase, RegLab 3, will consider remote operations through virtual workshops later in 2026 [23].

3.3 IAEA

In connection with the AI for Good initiative, the IAEA is undertaking activities to promote AI use in the nuclear field. An IAEA expert meeting report [24] presents AI as having the potential to contribute to nuclear power by optimizing complex procedures and improving reactor design, performance, and safety; enhancing reliability and reducing errors through task automation; and strengthening plant process monitoring and anomaly detection. It also emphasizes the need to establish a new field of ethics of nuclear and AI technology (ENAI) to address the ethical challenges accompanying such applications.

The IAEA designated Purdue University as an IAEA Collaborating Centre on AI and is supporting, over five years, the establishment of a Benchmark Hub and an evaluation initiative to ensure the reliability and enhance the acceptance of AI technologies in the nuclear field [25]. In addition, the IAEA held a technical meeting on safety considerations in the use of AI in nuclear power plants, focusing on human factors engineering (HFE) and instrumentation and control (I&C) systems, to facilitate discussions among Member States and collect information for future revisions of IAEA Safety Guides SSG-51 and SSG-39, which concern HFE and I&C systems, respectively [26].

4. Discussion

Table I summarizes the major AI-related activities surveyed in this paper. Major national regulatory bodies differ in the scope and focus of their AI-related activities. The NRC is pursuing a broad range of activities, including AI strategic planning, internal use of AI, gap analysis of the existing regulatory framework, and technical evaluation of specific AI applications. The ONR has conducted regulatory sandboxing within its goal-setting and non-prescriptive regulatory framework to identify anticipated regulatory challenges and key issues associated with specific AI use cases. The NRA Secretariat has thus far focused primarily on examining AI use in internal operations, including review support, work efficiency, and safety research. Overall, the NRC takes an approach spanning strategy, the regulatory framework, and technical evaluation; the ONR places relatively greater emphasis on use-case-based regulatory review; and the NRA Secretariat focuses on examining the potential use of AI in regulatory work and research activities.

Table I: Major AI-Related Activities of Regulatory Bodies and International Organizations

Entity	Major Activities
NRC	Development of the AI Strategic Plan; internal use of AI and regulatory information analysis; regulatory framework gap analysis; technical evaluation of AI applications [3–8]
ONR	Assessment of the impact of AI/ML on nuclear regulation; regulatory sandbox pilot; pro-innovation approach to AI regulation [9–13]
NRA Secretariat	Planned studies and development work on AI for review support; use of generative AI to improve work efficiency; examination of AI use in safety research [15–18]
CANUKUS	Joint considerations for developing AI systems in nuclear applications [19]
OECD/NEA	Review of AI use cases through the International RegLab Project [20–23]
IAEA	Activities related to the AI for Good initiative: an expert meeting report on the potential of AI in nuclear power and the need for ENAI; designation of an AI Collaborating Centre and support for the establishment of a Benchmark Hub and an evaluation initiative; technical meeting on safety considerations related to HFE and I&C [24–26]

CANUKUS sets out considerations for the development and application of AI systems in the nuclear field. The OECD/NEA is reviewing specific use cases through the RegLab project, including anomaly detection and AI support for maintenance planning, with remote operations planned for a subsequent phase. The IAEA is pursuing activities to promote AI use, covering the potential contributions and ethical considerations of AI, benchmarking and evaluation, and safety considerations related to HFE and I&C systems.

The activities surveyed above suggest the need to establish regulatory readiness and develop regulatory infrastructure in Korea in preparation for the expanding use of AI in the nuclear field. This entails systematically examining whether existing regulatory requirements and guidance can adequately address AI characteristics such as data-driven learning and probabilistic decision-making, and whether additional guidance or technical bases are needed. It also involves strengthening internal capabilities by developing regulatory staff expertise, establishing a technical review framework, and accumulating experience in assessing the performance, limitations, and potential safety implications of AI through technical evaluation of use cases and regulatory research. Furthermore, there is a need to pursue international cooperation to exchange views on AI-related regulatory issues and evaluation approaches and to incorporate the resulting insights into domestic regulatory research.

5. Conclusion

In relation to the expanding use of AI in the nuclear field, this paper surveyed the activities of major national regulatory bodies, including the NRC, the ONR, and the NRA, as well as those of CANUKUS as an international cooperative framework, the OECD/NEA, and the IAEA. The findings show that the major national regulatory bodies are examining the potential use of AI within existing nuclear regulatory frameworks, while differing in scope and focus. The activities of the international cooperative framework and international organizations center on presenting

joint considerations, reviewing specific use cases, and advancing work on AI use, evaluation, and safety. These AI-related developments suggest the need to establish regulatory readiness in Korea.

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REFERENCES

- [1] K. Ito and T. Takagi, “Application of AI Technology in the Maintenance at Western Nuclear Power Plants,” Proc. 16th Academic Conf. Japan Society of Maintenology, pp. 307–309, Jul. 2019.
- [2] Y. Konno, “Pioneering the Future of the Nuclear Industry: Exploring the Potential of AI and Large Language Models—Trends in AI Applications in the U.S. Nuclear Industry,” Journal of the Atomic Energy Society of Japan, vol. 67, no. 9, pp. 539–542, Sep. 2025.
- [3] U.S. Nuclear Regulatory Commission, “Artificial Intelligence Strategic Plan: Fiscal Years 2023–2027,” NUREG-2261, Office of Nuclear Regulatory Research, Washington, DC, USA, May 2023.
- [4] U.S. Nuclear Regulatory Commission, “Advancing Use of Artificial Intelligence at the U.S. Nuclear Regulatory Commission,” SECY-24-0035, Apr. 2024.
- [5] Sphere of Influence, Inc., “Use Machine Learning to Prioritize Inspections: Phase III Final Report,” Jun. 2023.
- [6] Southwest Research Institute, “Regulatory Framework Gap Assessment for the Use of Artificial Intelligence in Nuclear Applications,” Oct. 2024.
- [7] Pacific Northwest National Laboratory, “Evaluation of Commercial Rule-Based Assisted Data Analysis,” PNNL-35758, Mar. 2024.
- [8] Oak Ridge National Laboratory, “An Assessment of Machine Learning Applied to Ultrasonic Nondestructive Evaluation,” ORNL/SPR-2023/3245, Dec. 2023.
- [9] Adelard LLP, “The Impact of AI/ML on Nuclear Regulation,” Jun. 2021.

- [10] Office for Nuclear Regulation, “Outcomes of Nuclear AI Regulatory Sandbox Pilot Published,” Nov. 2023.
- [11] Office for Nuclear Regulation and Environment Agency, “Regulators’ Pioneer Fund (Department for Science, Innovation and Technology): Pilot of a Regulatory Sandbox on Artificial Intelligence in the Nuclear Sector,” Nov. 2023.
- [12] U.K. Department for Science, Innovation and Technology, “A Pro-Innovation Approach to AI Regulation,” CP 815, Mar. 2023.
- [13] Office for Nuclear Regulation, “ONR’s Pro-Innovation Approach to AI Regulation,” Apr. 2024.
- [14] Japan, “Act on Promotion of Research and Development, and Utilization of Artificial Intelligence-related Technology,” Act No. 53 of 2025, Jun. 2025.
- [15] Nuclear Regulation Authority, “Overview of the FY2026 Budget Request of the Nuclear Regulation Authority,” 2025.
- [16] Nuclear Regulation Authority, “Status of Business Reform Initiatives at the NRA Secretariat,” Material 6, May 20, 2026.
- [17] F. Nagase, “Safety Research Conducted by the Nuclear Regulation Authority,” FY2025 JAEA–NRA Safety Research Results Meeting, Nov. 2025.
- [18] Denryoku Jiji Tsushin, “NRA Secretariat Accelerates Efforts to Utilize AI in the Nuclear Field,” 2025.
- [19] Canadian Nuclear Safety Commission, Office for Nuclear Regulation, and U.S. Nuclear Regulatory Commission, “Considerations for Developing Artificial Intelligence Systems in Nuclear Applications,” Sep. 2024.
- [20] OECD Nuclear Energy Agency, “International RegLab Project,” 2025.
- [21] OECD Nuclear Energy Agency, “International RegLab Project Begins Work on Innovation Sandboxing in the Nuclear Sector,” Apr. 2025.
- [22] OECD Nuclear Energy Agency, “AI in Nuclear Operations: RegLab Workshop Convenes Regulators, Operators and Vendors,” Nov. 2025.
- [23] OECD Nuclear Energy Agency, “AI and Nuclear Safety in Focus during RegLab Deep Dive Workshop in Korea,” May 2026.
- [24] International Atomic Energy Agency, “Artificial Intelligence for Accelerating Nuclear Applications, Science and Technology,” IAEA/ART/INT, Vienna, Austria, Aug. 2022.
- [25] International Atomic Energy Agency, “IAEA Designates First Collaborating Centre on Artificial Intelligence for Nuclear Power,” Feb. 2024.
- [26] International Atomic Energy Agency, “Technical Meeting on Safety Considerations in the Use of Artificial Intelligence in Nuclear Power Plants with a Focus on Human Factors Engineering and Instrumentation and Control Systems,” Nov. 2025.