

Regulatory Trends in the Use of AI Technology in Nuclear Power

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1. Introduction

The use of AI technologies, including big data and machine learning, has been increasing rapidly across society in recent years, bringing convenience and efficiency to users. It is also contributing to improved integrity and safety in the nuclear power sector, including nuclear power plants. However, as the New York Times compared it to the power of nuclear weapons, it has also been highlighted as a potentially devastating force in the wrong hands. Therefore, national regulation of the peaceful use of AI is also becoming increasingly important. This paper will introduce the recent regulatory trends in the application of AI technology in the major nuclear power countries or organization.

2. Trends in Major Nuclear Organizations

2.1 NRC of USA^[1]

By the increasing interest and demand of AI technology in nuclear industry, NRC (Nuclear Regulatory Commission) in USA understands it is one of the fastest-growing technologies globally and has the potential to enhance decision-making processes for the nuclear industry by providing insights into vast amounts of data generated during the design and operation of nuclear facilities. As a result, the nuclear industry has expressed a growing interest in researching and using AI technologies to improve operational performance and mitigate operational risk. The NRC is committed to continue to keep pace with technological innovations to ensure the safe and secure use of AI in NRC-regulated activities. Therefore, they hosted workshops not only three times in the year of 2021 but almost every year since then to hear and discuss the regulatory insight of developed countries. It was intended for regulatory enhancements as part of its effort to become a modern, risk-informed regulator, and for preparedness to understand and evaluate the AI technology. As a result, NUREG-2261 was issued. The main content is that regulators should strive to ensure the safe use of AI in regulated activities in line with technological innovation, and should develop strategies and skilled persons to review and evaluate the use of AI in regulated activities. The AI strategy consists of five goals: ensuring readiness for regulatory decision-making, establishing

an AI use review organization, strengthening and expanding AI partnerships, cultivating AI experts, and pursuing AI use cases across the NRC. And in the white paper recently issued by CWG(Certification Working Group) which aims to foster the development of certification as recognized framework that AI tools and technologies as responsible, trustworthy, ethical, and fair, they proposed regulatory regimes for well-developed AI certification ecosystem. They recommended leading the way in establishing fundamental objectives for AI certification standards and certifications for government, and investing time and resources with collaboration to get the foundations in place and quick move to advance for all stakeholders.

2.2 IAEA^[2]

The IAEA held its first meeting on AI in the fall of 2021 to discuss the peaceful use of AI in nuclear technology and recognize its potential to improve nuclear power plant design, performance, and safety. The main areas and problems of nuclear power plants currently applying AI technologies were introduced, and the role of the IAEA and the expected outcomes were explained, along with the types and methods of follow-up research. However, transparency, reliability, and security/ethics issues of AI technology were raised. They published an initial document and a TECDOC describing perspectives from all disciplines, encouraging predictive research that leverages AI technology for automation to improve safety and reliability, and discussing compliance issues and cyberattack preparedness for AI solutions. In the document "Summary of AI in nuclear applications, science and technology", they explained the need for and expectations of AI ethics, the need for research efforts to accelerate the development of nuclear physics, the application of AI in the nuclear industry, the application of AI in nuclear security and radiation protection, and the expectations of protective measures.

Recently, IAEA has designated the center for Science of Information at Purdue university in the USA as the first IAEA collaborating centre to support the agency's activities on AI for nuclear power applications, including reactor design, plant operations, and training and education.

3. Trends in Major Nuclear Power Countries^[3]

2.1 France

In France, the use of AI, data analytics, and digital twins in the nuclear industry is on the rise. In addition, the contribution of AI technology to improving safety assessment by regulators was recognized and the need to establish nuclear activities that meet safety demonstration and assessment requirements was presented. Support areas for AI utilization include evaluation tools, internal and external data, and expert systems. To summarize the IRSN (Institute for Radiation Protection and Nuclear Safety)'s regulatory perspective, in the EU, AI enforcement is risk-based and requires vendors to conduct pre-market assessments. Risk is categorized into three main categories: unacceptable AI that poses a potential threat to individuals/society; high-risk AI systems, which fall into two categories, including third-party conformance assessments and autonomous AI extreme environment robots; and limited-risk AI, which is acceptable if it meets minimum transparency requirements.

2.2 Canada

The Canadian Nuclear Safety Commission (CNSC) recognizes AI technology as a Disruptive Innovative Emerging Technology (DIET) and has established a working group within the regulator. This group shares innovative ideas internally and externally (industry/academia/stakeholders/CNSC) to build and maintain an agile, innovative and technology-neutral regulatory methodology. The CNSC collaborated with regulators from the UK and the US to publish a trilateral white paper in 2024, and participated in the working group to establish the IAEA ISOP (IAEA Support and Innovation for Operating Nuclear Power Plants) to prepare the TECDOC "Explanatory Application of AI Technologies to Operating Nuclear Power Plants". In addition, a report titled "CNSC Proposals for Utilizing AI in the Nuclear Industry" was published to investigate the potential for AI utilization within regulatory agencies, the possibility of evaluating license applications, rapid data retrieval, and decision support, and to promote AI-assisted decision making rather than AI-autonomous decision making.

2.3 England

The UK also recognizes the potential for AI to provide unprecedented insights to reduce risk and improve facility management efficiency, resulting in cost savings. The Office for Nuclear Regulation (ONR)'s main concern is whether AI technology can be used safely and regulated. It has already worked with aviation, shipping, and financial regulators to encourage the development of standards and guidance, and has conducted non-regulatory reviews of AI-infused systems. The UK has used a regulatory sandbox approach to trial external programs, allowing them to be used for flaw detection using non-destructive testing techniques and

for a limited range of robot control. The ONR's regulatory view recognizes the potential for AI to improve safety and security in the nuclear industry, but emphasizes that the risks posed by AI must be identified, understood, and managed, and does not allow for demonstration of safety based on testing alone.

2.4 Korea^[4,5]

According to data from recent regulatory information meetings, KINS's regulatory perspective on the use of AI technology in nuclear power is that, first of all, it recognizes the increasing trend of AI use in areas such as automatic prediction, diagnosis, and failure prevention of nuclear power systems as a challenge, and AI use related to nuclear power plant safety is subject to regulation, and it is necessary to solve current issues such as visibility and interpretability to ensure its reliability. Recently, KEPCO has developed Prometheus, an automatic predictive diagnosis system for nuclear power plant facilities using analytical AI, and is applying it to turbines, generators, pumps, and transformers in nuclear power plants, and has installed about 12,000 units, including rotating facilities and power facilities. In addition, it is building the world's largest digital connected facility diagnosis signal big data and is developing a digital twin system. Currently, operators are utilizing AI technology in non-safety fields such as early detection of abnormal conditions before a safety event occurs, and there are no domestic regulatory requirements for AI utilization yet. Therefore, it is expected that new technical standards will need to be developed in order to respond to the expected audit requirements of operators in the future. In order to utilize AI technology in the future, explainability, reliability, and robustness must be confirmed, satisfaction of related technical standards must be demonstrated, and measures must be taken against vulnerabilities such as cybersecurity in data management.

3. Conclusions

As technology advances, the use of AI in the nuclear industry is an inevitable social and industrial imperative. While AI technology has positive aspects that contribute to efficiency and safety improvements, it is necessary to prevent its negative use to ensure safety and reliability.

Based on the recent efforts and trends in advanced nuclear power countries, it is suggested that a permanent organization be established to guide the utilization of AI technology in the right direction through continuous consultation between experts from the nuclear industry and nuclear academia under the leadership of the government before it is too late.

REFERENCES

- [1] NUREG-2261, Artificial Intelligence Strategic Plan (Fiscal year 2023-2027), NRC, 2023.
 - [2] Artificial Intelligence for Accelerating Nuclear Applications, Science and Technology, IAEA, 2022.
 - [3] NRC, Data Science and Artificial Intelligence Regulatory Applications Workshops #1&2&3, NRC homepage, 2021-2024.
 - [4] Gu-young Jung, Necessity of Effective Data-based Safety Regulation and Challenges, Symposium for Nuclear Safety Regulatory Information, 2023
 - [5] Seung Joon Lee, Intelligent system for NPP emergency operations using artificial intelligence, research report of MSIT, 2019.
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