EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Quick Insight Brief: Leveraging Artificial Intelligence for the Nuclear Energy Sector

The nuclear power industry is experiencing a digital data-driven transformation. Rapid growth in the deployment of sensors, distributed assets, and "intelligent systems" means that data are easier to access than ever before. With recent data science techniques, the industry can leverage data accumulated over years of operational experience, informing decisions that can guide future operations. To reap the benefits, the nuclear energy sector will need to master new analytics competencies—including managing and combining multiple sources and types of data, building analytic models, and interpreting findings to make better decisions.

EPRI is leading initiatives to collect and curate data in the nuclear industry and to develop artificial intelligence (AI) tools specific to the sector. In addition, EPRI is working to bridge the gap between the AI community and the nuclear sector so that AI can be used to help solve industry challenges. EPRI's goal: to enable data-driven decision making through the collaborative application of data science technologies.

This Quick Insight brief discusses areas where AI can impact the nuclear industry and provides information about current EPRI research activities on AI that pertain to the sector.

RESEARCH QUESTIONS

The following are the research questions addressed in this brief to help the nuclear industry understand the potential use cases of AI:

- How can AI technologies be used in the nuclear energy sector?
- What is needed in order for AI solutions for nuclear power plants to be developed?

KEY POINTS

- AI technologies can provide powerful tools to aid the nuclear industry, increasing reliability and efficiency and informing decisions by learning from the past and anticipating the future.
- By bringing together the nuclear industry domain experts and the AI community, impactful solutions to challenging issues facing the industry can be developed.
- Collaboration among all stakeholders is essential for the nuclear industry to realize the potential benefits of AI.

AI FOR THE NUCLEAR ENERGY SECTOR

AI presents the electricity sector with new opportunities. To help the industry harness AI effectively, EPRI research and projects are accelerating the development, application, and adoption of AI tools. In the nuclear energy sector, EPRI continues to launch and execute projects under four broad application areas: Insights, Prognostics, Automation, and Optimization. A sampling of these research projects is highlighted here.

Insights: *Learning from the Past*

Together, the nuclear industry has accumulated thousands of years of operating experience. Data science technologies allow EPRI to leverage this rich experience to unlock new best practices and to better inform future decisions. These new trends and observations will lead to improved operating and maintenance efficiencies that EPRI members can implement today.

- An exploration of the Work Order Database is assessing how different preventive maintenance strategies affect costs (3002020120).
- A project looking at Corrective Action Program (CAP) records aims to process entries automatically and obtain insights from the CAP database.
- Natural language processing (NLP) fueled by an industry-specific dictionary provides the backbone for the above activities. A recently published Quick Insight brief on the Power Industry Dictionary for Text-Mining (3002019609) showcases the value of this dictionary for one case study. EPRI continues to develop this dictionary to better support these and other efforts.

Prognostics: *Anticipating the Future*

Data science approaches can be leveraged to predict events, including failures, and assess current asset conditions, such as remaining useful life. If utilities are prepared, they can plan their maintenance and outage strategies, reducing unexpected downtime and minimizing periodic inspections.

- EPRI is leveraging machine learning techniques to inform flow-accelerated corrosion (FAC) inspection programs based on industry FAC databases (see 3002019731). A well-informed FAC inspection program could help assess needs and timing, eliminating costly and unnecessary inspections.
- Sensors installed at nuclear plants generate a wealth of data that are largely underutilized. EPRI has begun to mine these data for insights into plant operation and to investigate the potential trends and prognostics that can be exploited.

Automation: *Increasing Reliability*

Various common activities in nuclear plants place staff into high-pressure or demanding situations, increasing the chance of human factor errors and personal safety risk. Many of these issues can be reduced by leveraging data science technologies for automation. Even activity time can be diminished, reducing factors such as radiation exposure or critical downtime.

- EPRI is involved in a number of projects that seek to develop automated analysis capabilities for several nondestructive evaluation (NDE) tasks. These include automatic defect detection for remote visual inspection of fuel assemblies (3002013226), reactor internals, and containment buildings (3002018419). EPRI is also studying automated analysis of ultrasonic inspection of reactor upper head penetration welds and dissimilar metal welds, automatic defect sizing for eddy current inspections in balance-of-plant applications, and automated detection of equipment faults from vibration data. For a closer look at EPRI's research on AI for NDE, see 3002021074.
- With the incorporation of AI and real-time data from an array of sensors, a fully automated arc welding process is being developed.
- By integrating dry cask storage (DSC) vent detection from visual images with temperature extraction from a coupled thermal camera, EPRI is developing an automatic remote solution for monitoring DSC vent temperature to replace daily walkdowns.

Optimization: *Increasing Efficiency*

Utilities can leverage data science techniques to optimize processes, plans, and strategies such as inventory management, outage scheduling, and fuel cycle parameters. The result: improved operations, plans, strategies, and decision drivers.

- EPRI is developing AI solutions that can increase supply chain efficiency and reduce total supply chain costs by providing utilities with an effective means of determining reorder parameters and by flagging purchase requests that would result in unused inventory.
- By leveraging four industry databases (CMA, FRED, SGDD, and SRMC), EPRI is developing a holistic decision logic to enable nuclear power plants to assess the impacts of proposed system changes on their source term and radiation fields (3002017357). Additionally, plants will be able to optimize the application of technologies and methods to maximize achievable benefits. For more information on other ways such databases are bringing benefits to the nuclear industry, see 3002018104.
- EPRI is using AI to develop a method to evaluate different scenarios for the segmentation of reactor internals with various constraints and uncertainties. The goal: to find optimal solutions for waste packaging, scheduling, and costs for decommissioning activities.

COLLABORATION: KEY FOR AI SUCCESS

AI technologies can be a powerful tool to aid the nuclear sector with data-driven solutions. A significant challenge, however, is the substantial need for data. Here, ongoing industry collaboration and data sharing can continue to provide EPRI with thousands of cumulative years of data that can, in turn, be used to improve utility operations. In light of this, EPRI has included three datasets related to the nuclear industry in the EPRI10—the 10 most impactful datasets in the electric industry:

- *Nondestructive Evaluation Assessment Dataset*: Nuclear utilities perform a wide range of NDE inspections to assess the health of various components. These datasets are often multi-dimensional in nature and can be very complicated to analyze. Distinguishing flaw signals from noise, background, material inclusions, or internal component features and complicated geometries is also difficult. With a database of relevant NDE data, algorithms can assist inspectors in flaw detection and analysis, enabling better results.
- *Maintenance Dataset*: Information about maintenance practices in the industry is recorded in millions of work orders. By diving into these data, insights into the causes and consequences of equipment failure can be gained. Working with large volumes of asset data, EPRI will test the use of AI in an array of applications—from fleet surrogate models to repair guideline tools. As more information is gathered on the many facets of equipment failure, the sector will be better equipped to avoid such issues in the future.
- *Operational Dataset*: New levels of operational excellence can be reached by optimizing plant and fleet performance as EPRI mines decades of utility operational experience through continuous operational data, asset data, and static asset information. EPRI is exploring how AI can leverage these data for early detection and avoidance of issues, for proactive performance monitoring, and for service life assessment.

EPRI is continuously engaged in collaborative efforts with the industry to collect and curate these datasets. Indeed, most of the examples discussed in this Quick Insight brief are examples of such collaboration, as they have been derived from field data provided by EPRI-member utilities. By leveraging the experience of the industry as more data are collected, industry domain experts and the AI community can work together to develop reliable AI solutions to inform and drive decisions that improve operations.

EPRI RESOURCES

EPRI members and other industry stakeholders that are interested in AI projects and that have applicable data are encouraged to share their data with EPRI. By bringing together the industry and the AI community, relevant problems can be addressed. For information on EPRI's AI research for the nuclear sector and to learn more about opportunities for collaboration, please contact either of the following individuals:

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To learn more about EPRI's AI initiative, visit ai.epri.com.

EPRI Nuclear members can visit the 3DM website in the Member Center to learn more about the Nuclear sector Data-Driven Decision Making initiative.

Data Driven-Decision Making

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