**Scaling Up and Innovating Artificial Intelligence for Nuclear Power Today and Tomorrow**

Neil Wilmshurst

Electric Power Research Institute (EPRI)

Charlotte, North Carolina, U.S.

Email: [nwilmshu@epri.com](mailto:nwilmshu@epri.com)

AI adoption is scaling up in the electric power industry – including nuclear. Tactics for maximizing the existing nuclear fleet within the current decarbonizing power sector is critical, especially as the economics of advanced nuclear and more efficient renewables continue to improve. AI must be a tool in the “tactics” toolbox for nuclear plant operators.

EPRI’s Nuclear Sector and AI/machine learning experts have been researching a variety of projects to improve the nuclear plants of today and the future. The projects aim to provide insight to operators from historical reports, use prognostics to anticipate future actions, use automation to increase reliability, and optimize processes to increase efficiencies. Highlights include:

* A dictionary for natural language processing (NLP):
  + - * Taking a template-like approach, EPRI is working to build subject-specific NLP dictionaries that are linkable and transferable between tools and platforms.
      * Using the INPO operational database, EPRI has demonstrated the value of this AI solution for groundwater contamination. Not only will this dictionary reduce costs by optimizing staff time, but it will also be capable of recommending future courses of action based on maintenance reports from utilities.
      * In a pilot case, NLP models using the dictionary operated at around 88 percent accuracy and have shown the capability to proactively detect potential leaks and spills. In the future, this could help to track contamination history and make real-time predictions based on the available data.
* Automated diagnostics and processing of Corrective Action Program (CAP) data
  + - * Reviewing 50 reports a day, about 10,000 per year, for the last 20 years has taken about 6 people 2 hours a day, 5 days a week to screen and review all of them. What if AI/machine learning could be used to reduce that effort to 1 person, 1 hour a day, 5 days a week? That’s more than a 90% reduction in staff time to review CAP reports.
      * EPRI has been working to collect data from a volunteer member to evaluate auto-processing review options, identify prognostic capabilities, and ultimately create an AI solution that automatically processes CAP data.
      * The solution is expected to provide early detection of anomalies, improve the resolution time for identified plant issues, increase safety, all while reducing personnel burden.
* Machine Learning to Predict Flow-Accelerated Corrosion (FAC) Wear Rates
  + - * EPRI has leveraged and applied a machine learning model to improve wear rate predictions in its CHECWORKS™ database to improve FAC programs.
      * Results revealed that machine learning significantly improves wear rate prediction accuracy, especially for thinner components, and potentially decreases the number of earlier-than-needed inspections in the nearer term.
* Machine vision models to automatically detect damage in concrete structures
  + - * EPRI is in the process of training models to perform visual inspection of concrete structures. Initial data analysis of concrete imagery classification and defect localization models reveal good detection rates, low false call rates, good performance for spall and corrosion (given limited quantity); however, some issues remain to be addressed, such as low precision and crack detection to develop an optimized, field-deployable solution.
      * Overall, the initial results show this approach is feasible and can provide value to the industry.

AI solutions and technology are not the only component to effective scaling of AI deployment across existing and future nuclear power providers and operators. There is also a workforce development challenge. In fact, according to a Eurelectric 2020 AI Insights paper, “The Power Sector in a Post-Digital Age,” 80% of utilities executives believe they risk going out of business in five years if they don't scale AI. There is currently a talent shortage for data science and AI expertise. EPRI is working to help bridge this gap by providing training on data science and AI through various channels, including hosting training events, providing links to publicly available materials through its website, and via a co-funded effort with the U.S. Department of Energy through EPRI’s Grid-Ready Energy Analytics Training (GREAT with Data) program. All of these efforts, and possibly more, will be needed to help provide the necessary skills to match AI talent with electric power experts to scale up adoption of AI throughout the electric power sector.

One important area of research is for AI models to provide explainability, but only a small number of models today can provide insights as to why they make the decisions they do – others may be too complicated for humans to understand. Take, for example, the CHECWORKS™ software. Physics-based models were easily explainable and had been incrementally optimized over the last 30 years. AI models, on the other hand, were able to reduce error in wear rate predictions by about 50% over physics-based models, but didn’t provide the process or steps used to arrive at these improved wear rates. Incidentally, since humans are typically capable of thinking in up to about 4 dimensions, these models may be beyond our comprehension and involve tens, hundreds, or more dimensions to optimize the results in the models. Explainability of AI models is an area of active R&D and will be important to widespread adoption of these technologies in the future.

Lastly, nuclear and the entire electric power industry must also trust AI models and their results. The nuclear industry employs a “trust but verify” approach in all it does. Fortunately, AI models can be compared against ground truth data such that current implementations of AI models can produce highly accurate and valuable results that can also be benchmarked to verify accuracy and repeatability.

The time is now—not tomorrow—to accelerate AI applications across the nuclear sector. EPRI’s artificial intelligence initiative is working to build an AI and electric power community; collect, curate and share data securely; identify new use cases for key datasets; facilitate demonstrations of solutions; develop data science training for industry professionals and deepen AI expertise across the industry.