CMS5 BENCHMARKING AGAINST A VVER-440 PLANT DATA

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ABSTRACT

Studsvik Scandpower's Core Management System (CMS5) is a production-level reactor physics code system for the design, analysis, optimization, and operational support of light water reactors. The system consists of the CASMO5 advanced lattice physics code and the SIMULATE5 three-dimensional nodal simulator and supports the complete nuclear fuel cycle. Initially developed for light water reactors with square fuel lattice geometries, CMS5 has been extended to support hexagonal fuel lattice geometries used in VVER-1000, VVER-1200, and VVER-440 reactors.

Benchmarking against plant measurements is a key component of extending CMS5 to new reactor applications. This work presents the benchmarking of CMS5 against operational data from a VVER-440 nuclear power plant covering six consecutive fuel cycles. The analysis includes comparisons of low-power physics test parameters, such as critical boron concentration, isothermal temperature coefficient, and SCRAM worth, as well as full-power boron letdown throughout the operating cycles.

The results demonstrate good agreement between calculations and measurements across all analyzed cycles and operating conditions. These findings confirm the consistent performance of the CMS5 methodology across multiple operating cycles and provide further validation for its use in VVER-440 core design, fuel management, and operational analyses.

Primary pH Control Using KOH – Efforts Toward Expanded Use and Optimization

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ABSTRACT

Over the past decade, EPRI has led a comprehensive research program to establish the technical basis for transitioning Western-designed pressurized water reactor (PWR) technologies—including plants designed or derived from Westinghouse, Combustion Engineering, and Babcock & Wilcox designs—from lithium hydroxide (LiOH, enriched in Li-7) to potassium hydroxide (KOH) for primary coolant pH control. The effort was initiated to address long-term supply chain vulnerabilities associated with enriched lithium-7 while maintaining the chemistry objectives of PWR operation, including materials integrity, fuel reliability, corrosion product control, radiation field management, and economic performance. The program has included laboratory testing, chemistry modeling, fuel and materials evaluations, corrosion and deposition studies, radiological assessments, cost-benefit analyses, and reviews of international operating experience, including decades of successful KOH application in VVER reactors. Collectively, these activities have established a comprehensive technical foundation for optimization of KOH-based primary water chemistry across the global PWR fleet. The resulting body of knowledge supports both deployment in Western-designed reactors and continued refinement of potassium-based chemistry practices in reactors already operating with KOH, including VVER designs.

This presentation proposes to summarize the evolution of the program, key technical findings, and lessons learned from utility, vendor, regulator, and international stakeholder engagement. Particular emphasis will be placed on the planned first application of KOH chemistry in a U.S. PWR unit in the fall of 2026 through a collaboration between EPRI and the Tennessee Valley Authority (TVA). The presentation will also discuss how plant experience, fuel performance monitoring, chemistry optimization studies, and radiological evaluations will be used to develop future industry guidance supporting optimized KOH chemistry across the global fleet of pressurized water reactors.

From Operational Experience to Digital Assets: Transforming Nuclear Knowledge

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ABSTRACT

The European Nuclear landscape is characterized by a few distinctive elements. First and foremost, Europe is still the most nuclearized continent, in number of reactors connected to the grid. Secondly, its reactors are ageing, in average between 35 to 40 years old, reaching the end of their initial lifetime, with more than 80% being older than 30. Last, even though they have been built by different manufacturers, they are still overall quite united in terms of technologies, most of them being Pressurized Water Reactors, either from Western (Westinghouse) or Eastern (VVER) designs.

Subsequently, in order to ensure long term operation of such a fleet, almost 200 reactors representing around 25% of Europe's electricity, maintaining knowledge and understanding of the design and changes is highly critical. Especially given that the workforce which built those reactors or started their commercial operations have been retiring for years now. This return of experience of design, build, commissioning and decades of exploitation and maintenance constitutes a key asset in the journey of Europe's energy landscape. With still a large diversity, in terms of systems and components, disciplines, languages, etc…

Assystem have been implementing within its teams and for its clients an approach called DLFE (Digital Learning From Experience), based on the CSV paradigm (Collect, Structure, Validate). The overall idea is to leverage new digital technologies, such as LLM and Generative AI to secure collection and valorization of existing operation knowledge. This hs been made possible thanks to extended work around 3 different dimension. First how to make this knowledge available to our engineers, using use cases such as Q/A, but also more advanced ones using agent-based process modeling. Secondly, knowledge and return of experience formalization and modeling, to

ensure proper adequation between existing knowledge and usable lessons learnt. This work have been performed on the basis of extended ontology exploration. Last, collection of the elements. This aspect have been extensively investigated process-wise and tooling-wise, leveraging elements in a step-by-step journey :

1. Open source and available documentation (such as IAEA, NEA, …)

2. Our existing and legacy methodologies, sometimes decades old

3. An extended campaign of interviews targeting at experts

4. An auto-interview enabling us to capitalize ‘on-the-flow’ on the lesson leveraged daily

5. A AI-Powered conversation-based self-interview, able to use also knowledge from the repository to ensure quality interaction with experts to address scientific issues

In that journey, 3 challenges are key to ensure efficient knowledge transfer from one generation to another, and subsequently enable safe long-term operation of NPP. Efficiency of collection, to ensure that the implicit is collected, not just the explicit which is by many means the tip of the iceberg. Structuration of the repositories, to reach the best compromise between valorization and standardization. And technical validity and relevance, ensure by the ‘human-in-the-loop’ as quality of knowledge is the key to efficiency.

From Data Overload to Early Warning: Applying Advanced Predictive Analytics to Nuclear Plant Equipment Health

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ABSTRACT

Nuclear plants operate with strong instrumentation, established equipment reliability programs, and rigorous engineering processes. Despite these strengths, early identification of developing equipment issues remains challenging due to the volume of available data and the complexity of plant systems. In this presentation, GE Vernova experts will share how asset performance management (APM) and AI/ML-based predictive analytics are being applied to help nuclear organizations detect abnormal equipment behavior earlier using real-time and historical data, engineered asset models, and failure mode expertise. The session will discuss how these capabilities can complement equipment reliability programs aligned with objectives to extended operations plants including NRC regulatory guideline (e.g. 10 CFR 50.59), while integrating with existing plant historians, maintenance systems, and other digital infrastructure. The presentation will feature real-world customer use cases.

Enhancing Nuclear Modernisation Through Smarter Equipment Qualification Using the KELPO Methodology

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ABSTRACT

Ensuring the availability of reliable and cost-effective equipment especially for safety classified systems and components, has become an increasing European level challenge for modern nuclear power plants. This challenge has been foreseen both with the operating power plants seeking for long-term operations as well as in nuclear new build projects. The KELPO™ methodology was developed by Finnish nuclear utilities as a response to these challenges, providing a practical and safety-focused approach for modernizing licensing and qualification

practices. KELPO™ enables the use of serially produced, high-quality industrial standard equipment in nuclear applications by harmonizing and streamlining qualification requirements. Instead of relying solely on nuclear-specific, tailor-made solutions, the methodology allows license holders to leverage established industrial standards and existing supplier quality systems, while maintaining compliance with nuclear safety requirements.

The development project was initiated in 2018 as a joint effort between Finnish nuclear utilities, with close collaboration with Finnish nuclear regulator STUK. Development progressed through joint piloting and gradual implementation, covering mechanical, electrical, and I&C components. Since 2020, KELPO™ has been applied in multiple equipment purchases for both Fortum and TVO's power plants, resulting in an expanded supplier base, reduced costs, and shorter delivery times. KELPO™ supports efficient nuclear modernization, strengthens supply chains, and has gained international interest, demonstrating its potential as a scalable solution in the nuclear industry. Fortum and TVO have also offered the methodology to other utilities internationally, and recently the piloting of the methodology has been initiated also in other countries.

The Anatomy of a Cyberattack Against Industrial Control Systems: Lessons Learned and Prevention Strategies for Cyber Resilience in Nuclear

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ABSTRACT

Industrial Control Systems (ICS) are the backbone of industrial operations and play a vital role in the nuclear sector, where they support both operational and, in some cases, safety-critical functions. As these systems become increasingly connected, they have emerged as prime targets for sophisticated cyber adversaries. Modern attacks no longer focus solely on IT environments; they increasingly target ICS directly through networks, engineering workstations, applications, firmware, and even hardware components.

The cyber threat landscape has evolved significantly over the past decade. While early attacks demonstrated the technical feasibility of compromising industrial processes, today's adversaries prioritize operational effectiveness, targeting the weakest points to achieve strategic disruption with greater efficiency.
This paper examines two major cyberattacks against critical infrastructure, the 2022 Industroyer2 attack on Ukraine's power grid and the 2025 attack on the Polish electricity network. Through these case studies, we reconstruct the attackers' methodology, from long-term reconnaissance and operational intelligence gathering to the exploitation of vulnerabilities and system misconfigurations in preparation for disruptive actions. We also analyze the defensive measures that limit the impact of these attacks and identify both successful practices and areas for improvement.
Drawing on these real-world incidents, our experts will highlight key lessons for the nuclear industry and present practical strategies to strengthen cyber resilience. The objective is to help nuclear operators move beyond a prevention-only mindset and develop the capabilities to detect, withstand, respond to, and rapidly recover from cyberattacks targeting industrial control systems.

From Obsolescence Intelligence to Action: Industry Insights and Proactive Management with POMS

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Westinghouse Electric Spain

ABSTRACT

Obsolescence is a persistent challenge across the nuclear industry, affecting both operating plants and new-build projects. Effective programmes must move beyond reacting to unavailable parts and establish a proactive, risk-informed approach that identifies, prioritises and resolves obsolescence before it affects maintenance, procurement or plant availability.

This presentation will cover key industry recommendations for proactive obsolescence management and examine trends and metrics derived from global nuclear industry data available through the Proactive Obsolescence Management System (POMS). POMS consolidates obsolescence information from more than 200 international nuclear facilities across multiple

reactor technologies, providing a vendor- and technology-neutral view of industry issues and potential solutions.

The presentation will explain how POMS supports different areas of a utility's obsolescence programme, including the identification of obsolete equipment, access to solution information, programme monitoring, comparison with industry data and forecasting of demand impacts. A particular focus will be placed on the Obsolescence Value Ranking, a configurable methodology that helps utilities identify their most significant vulnerabilities and develop site-specific priority lists.

The presentation will also show how POMS Action Plans document solution strategies, centralise technical knowledge and track obsolescence issues through completion, reducing duplicated effort and supporting collaboration across sites.

Finally, we will introduce POMS-V and the Industry Challenges process, which expands collaboration beyond the traditional POMS user community by connecting utilities and suppliers to identify potential solutions to obsolescence challenges.

Technologies for Surface Treatments and Repairs at Nuclear Power Plants

Jan Schubert
Centrum výzkumu Řež Innovations

ABSTRACT

[Abstract pending / to be provided]