



Artificial Intelligence R&D at EPRI



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What is the Value of AI?



Automates complex or repetitive tasks to provide operational efficiency



Performs dirty, dull, and dangerous tasks for humans



Processes vast quantities of data; capable of finding hidden patterns



Improves reliability and repeatability



Capable of generating text, images, and other data



AI.EPRI.com

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Building an AI-Electric Power Community

Collecting, Curating and Sharing Data,
and Developing Solutions

Deepening AI Expertise in the Electric
Power Industry

EPRI

ARTIFICIAL • INTELLIGENCE

Our AI GRAND CHALLENGES



Grid-Interactive Smart Communities



Environmental Impacts



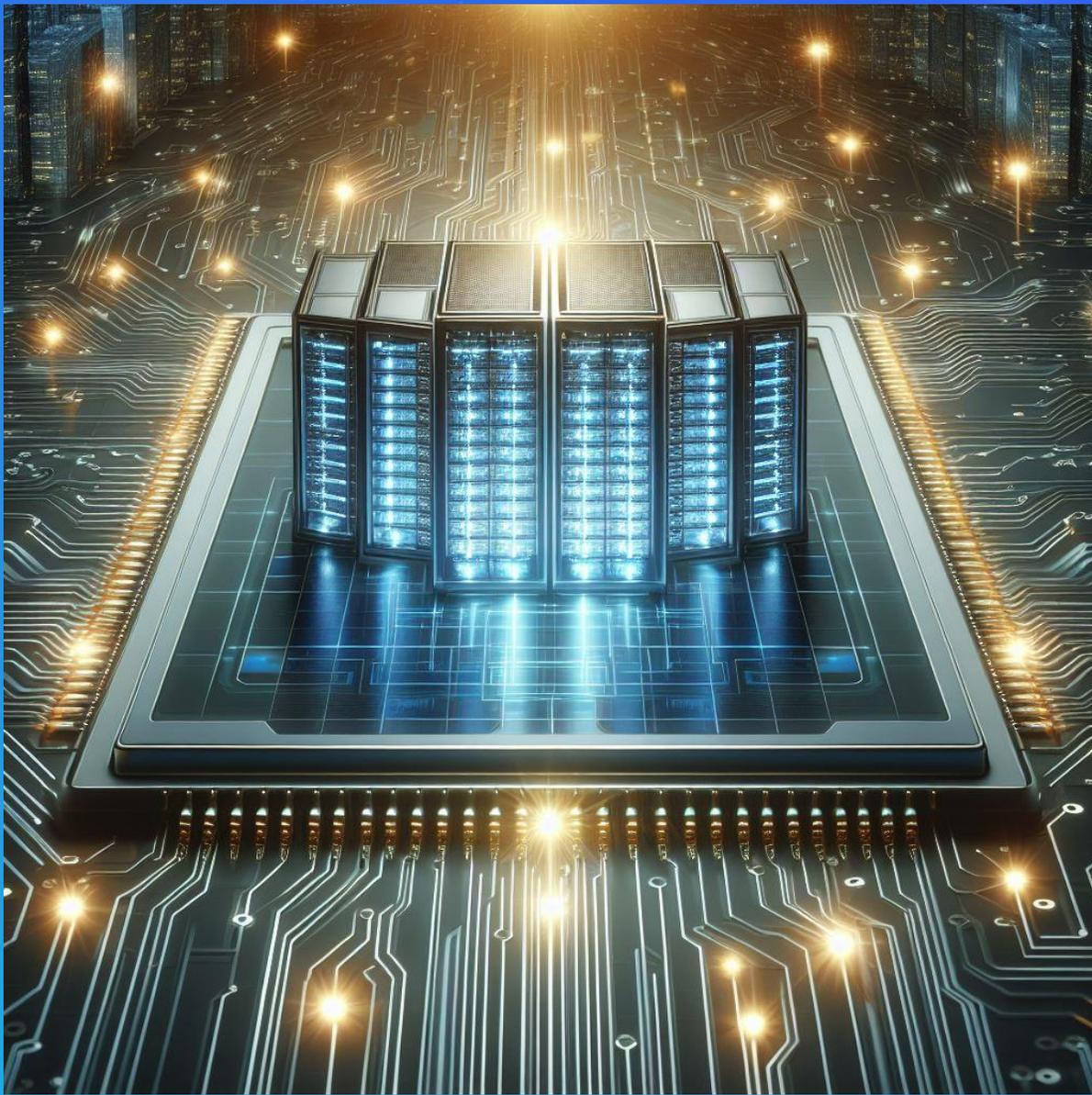
Energy System Resiliency



Intelligent and Autonomous Plants



AI-Enhanced Cybersecurity



AI's Impact on Load Growth

Data Center Load Growth

The International Energy Agency (IEA) predicted that datacenter energy usage will double from 2022-26¹

- Load growth expected from both AI and cryptocurrency mining

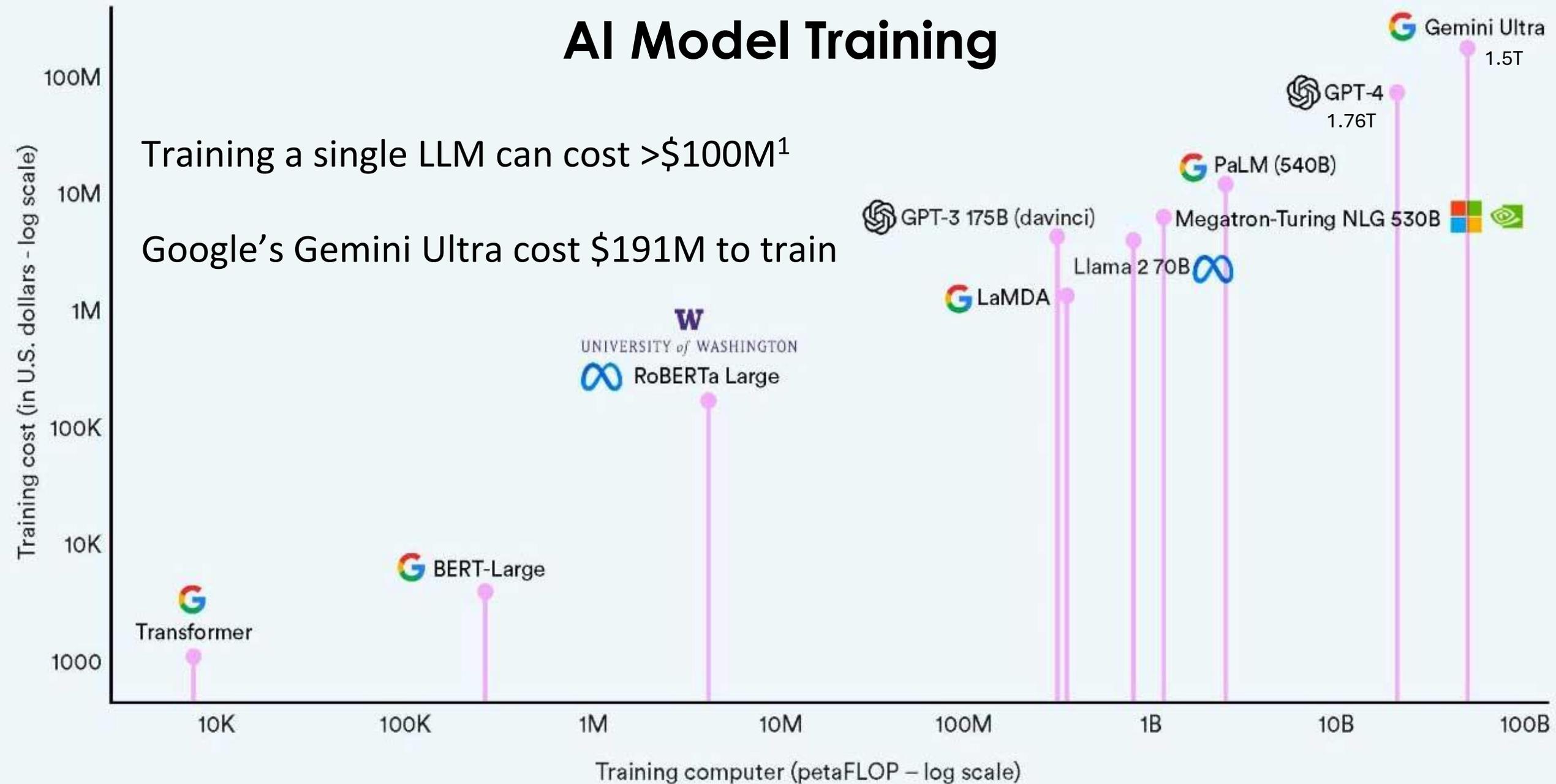


¹ <https://iea.blob.core.windows.net/assets/6b2fd954-2017-408e-bf08-952fdd62118a/Electricity2024-Analysisandforecastto2026.pdf>

AI Model Training

Training a single LLM can cost >\$100M¹

Google's Gemini Ultra cost \$191M to train



¹ <https://pureai.com/Articles/2024/04/23/Open-Source-Models-Cost.aspx>

Image from: <https://pureai.com/Articles/2024/04/23/Open-Source-Models-Cost.aspx>

AI is Accelerating Data Center Load Growth

▪ Challenge

- Data centers are growing at a pace faster than utilities can site and build generation
- AI data centers utilize more energy than traditional data centers
 - Some estimate as much as 5X the energy consumption

▪ Proposed Solution

- Utilize data centers as a grid asset in a shared energy economy
- Flex data center usage to adapt to local conditions
- Utilize data center backup generators using clean fuels (HVO, RNG, etc.)



▪ EPRI's Role

- Gather input
- Perform R&D to understand the benefits & limitations of a shared energy economy model
- Continue R&D on clean fuels
- Engage global stakeholders to share data and results

For more details, see EPRI Report: [Powering Intelligence: Analyzing Artificial Intelligence and Data Center Energy Consumption](#)





AI Use Cases for Energy

Core Drivers Toward Clean Energy Transition Goals

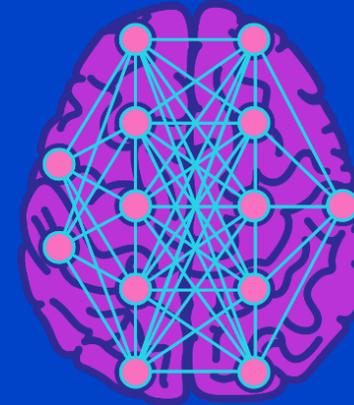
Maximize the utilization of existing assets with cost-competitive operations

- Life extension
- Power uprates and enhanced efficiency
- Streamlined maintenance for higher capacity factors
 - Improved inspection, mitigation, and repair

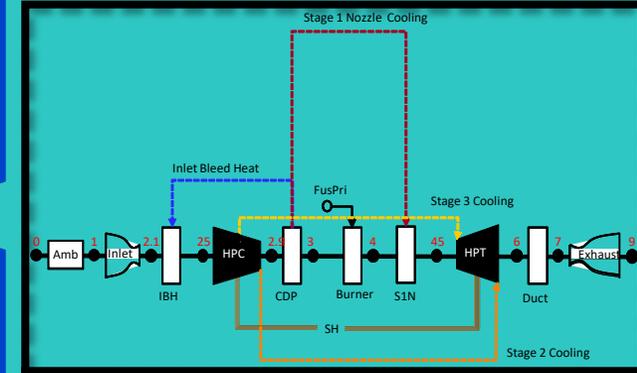


Performance & Dispatch Optimization with OPTORA Software

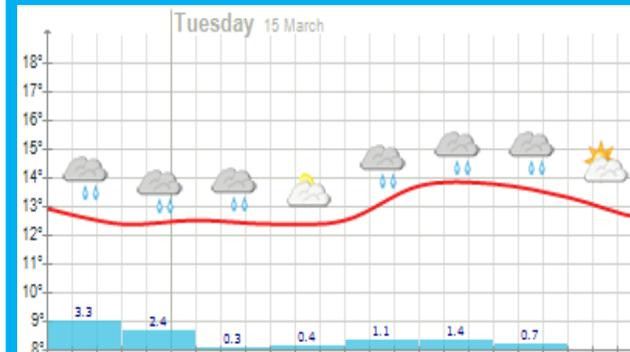
- Predicting GT capabilities can be difficult
 - Weather, Availability, Operating Conditions, & Noisy Data affect results
- OPTORA uses AI to eliminate guesswork
- Performance Predictions
 - ML model trained on Historian data
 - Model predicts weather conditions
- Dispatch Optimization
 - Algorithm selects dispatch order based on:
 - Augmentation, Fuel Costs, Startup/Shutdowns, Weather Impacts
 - Balances plant efficiency and reliability



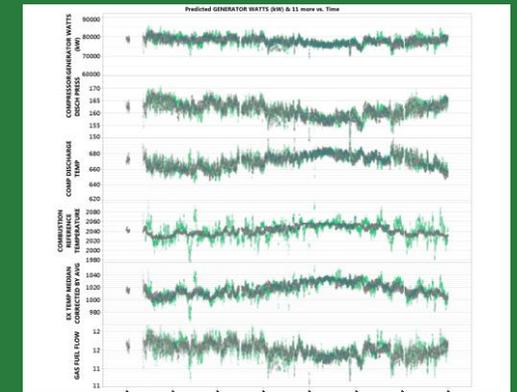
Machine Learning



Digital Twin



Weather Forecasts



Predicted Asset-Specific Capability

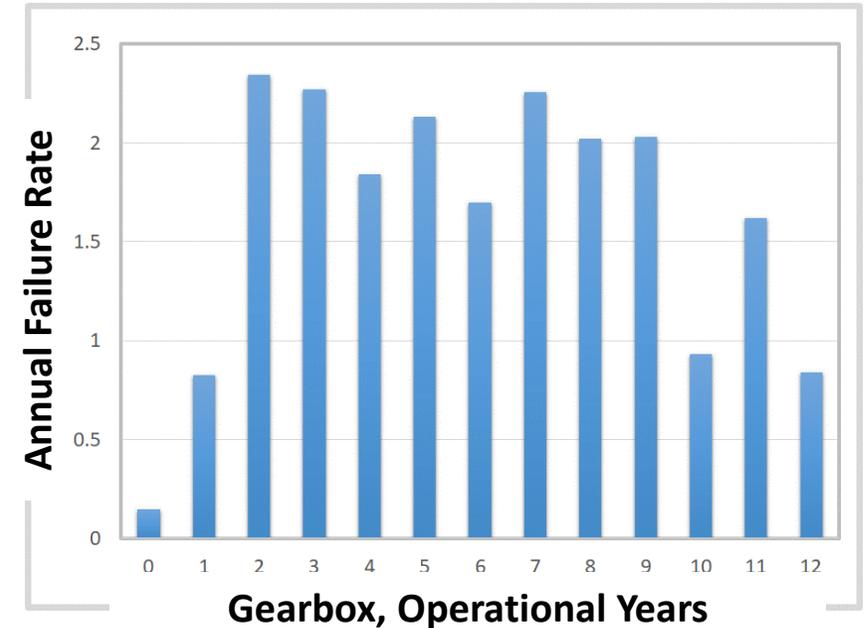
Physics-Based Machine Learning Model for Wind Turbine Drivetrain Health Monitoring

Objectives and Scope

- Identify key factors impacting wind turbine gearbox & generator life
- Develop AI models to identify early-stage degradation
- Validate monitoring methods using historic failure data

Value

- Effective health monitoring at M&D centers
- O&M cost reduction via preventive maintenance
- Turbine life extension and inventory management



Financial Impact: Each gearbox failure event may lead to more than \$350,000 of unplanned repair costs

Efficient health monitoring techniques can save >\$1M/year at a typical wind farm

AI-Enabled Fuel Failure Identification

■ Scope and objectives

- Develop an AI-based system for fuel failure identification in nuclear reactors.
- Extract additional characteristic information (such as power and Burnup) about failed fuel for optimization.

■ Value

- Enhance failed fuel detection efficiency and resolution.
- Improve fuel management decision-making processes.

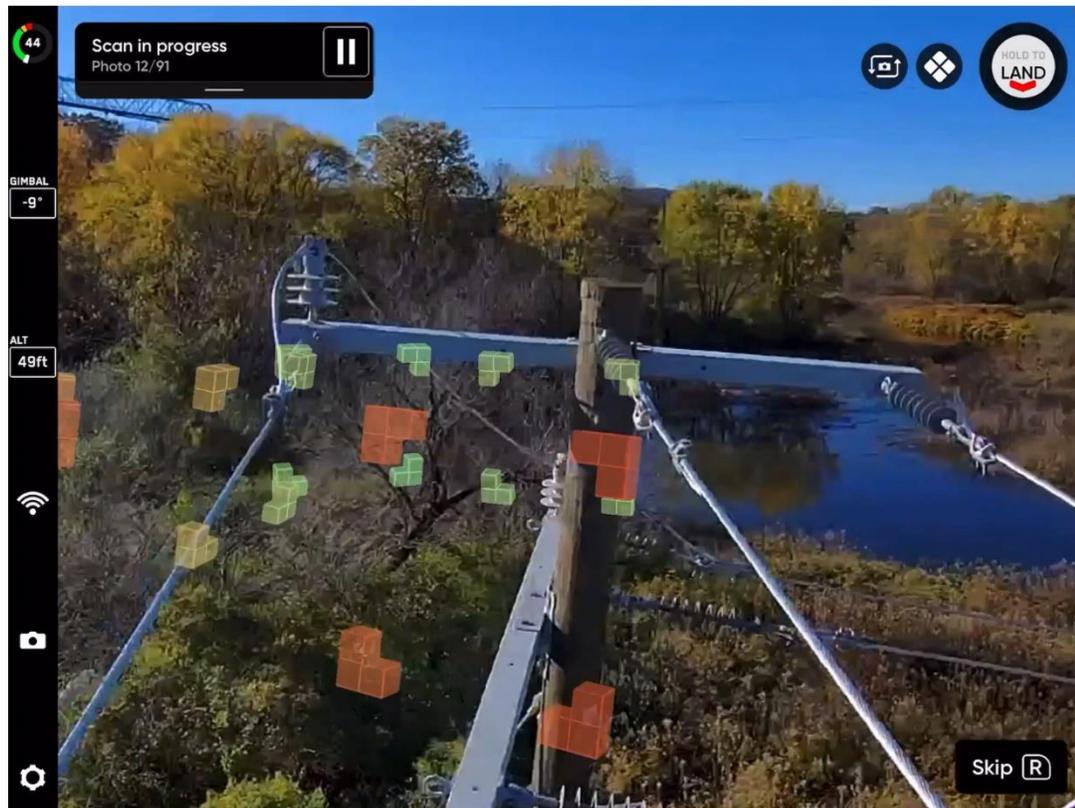


- Opportunities for member engagement
 - Nuclear Fuel Reliability Program TAC meetings.

Efficiently detect fuel failures and provide insights for optimized decision-making

Drones and AI Converge for T&D Asset Inspections

- Notable failures of transmission and distribution (T&D) equipment has highlighted the need for inspections of these aging infrastructure components
- The use of drones has multiplied the ability of utilities to collect vast quantities of images
- However, the ability to collect images has outpaced the utilities' ability to analyze the images



AI can augment a utility's ability to evaluate T&D inspection imagery

AI-Assisted Manual UT

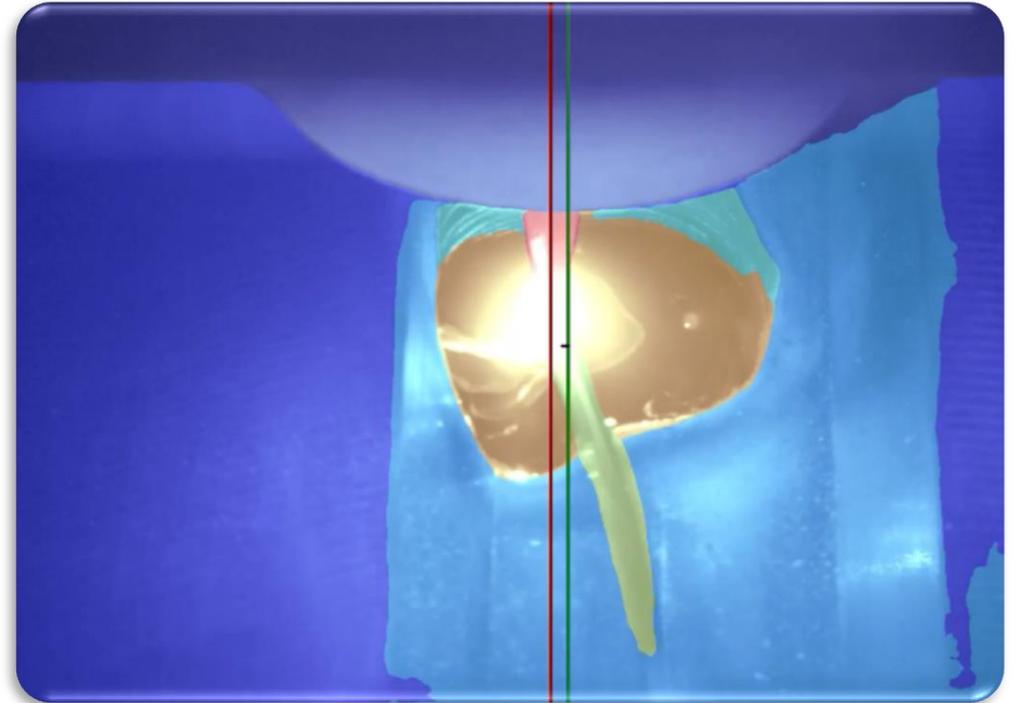
- **Scope and objectives**
 - Develop live AI-assistance for manual phased array ultrasonic inspections
 - Initial target: *dissimilar metal welds*
- **Value**
 - Assist inspector during live examinations, flagging anomalous regions
 - Enabling data records for subsequent review
- **Opportunities for member engagement**
 - NDE Program Research Integration Committee



Enabling live AI-assistance for manual phased-array UT inspections

Adaptive Feedback Welding

- **Scope and objectives**
 - Develop fully-automated welding system that functions as a welding operator using real-time sensor data with machine learning/AI
- **Value**
 - Fully automated welding reduces post-weld repairs and offsets welder workforce supply issues
 - Increases safety by removing welding operators from hazardous (i.e., radiation) working environments
- **Project status and key updates**
 - Real-time closed loop control successfully demonstrated
 - Progress made on adaptive groove filling
- **Opportunities for member engagement**
 - Liburdi Dimetrics purchased a license for the technology and is incorporating into their welding systems



Commercialization of technology has been achieved!



Generative AI R&D

Parallel Paths for Generative AI

EPRI.com Search

- Working with generative AI to provide EPRI members with the best answer they have access to.
 - Provides additional value to EPRI members; faster access to answers
 - Protects EPRI IP

Program-Specific Expert Systems

- Developing pilot projects for expert systems.
 - Capable of providing more in-depth answers for program-specific questions
 - Ability to fine-tune models to be more accurate and answer common questions
 - Primarily using retrieval augmented generation (RAG)

How often should in-service Grade 91 welds be re-inspected?

Source ^

- Product Summary (501)

Filetype ^

- pdf (501)

Generated answer for you



Based on the provided context from Section 17, in-service Grade 91 welds should be regularly re-inspected to monitor the stability of the repairs. A recommended base re-inspection interval is every other planned major outage or six years, whichever is less. The Owner/User may adjust the re-inspection interval based on trend results from previous inspections. Additionally, if a weld repair is performed where the material condition is degrading over time or incomplete removal of the defect was performed, periodic monitoring should be conducted based on a risk-based inspection program. In such cases, a post-repair inspection should be performed at the nearest opportunity, whether that be a planned outage or a purposeful inspection interval.

References: 1

Citations

- 1 Best Practice Guideline for Well-Engineered Weld Repair ...
- 2 Inspection and Damage Assessment of Turbine Casing C...
- 3 Gidelines for the Evaluation of High-Energy Seam-Welde...
- 4 Alternative Well-Engineered Weld Repair Options for Gra...
- 5 Alternative Well-Engineered Weld Repair Options for Gra...

Rephrase



Generative AI Beta Test on EPRI.com

How often should in-service Grade 91 welds be re-inspected?

Generated answer for you **Generative AI Answer:**

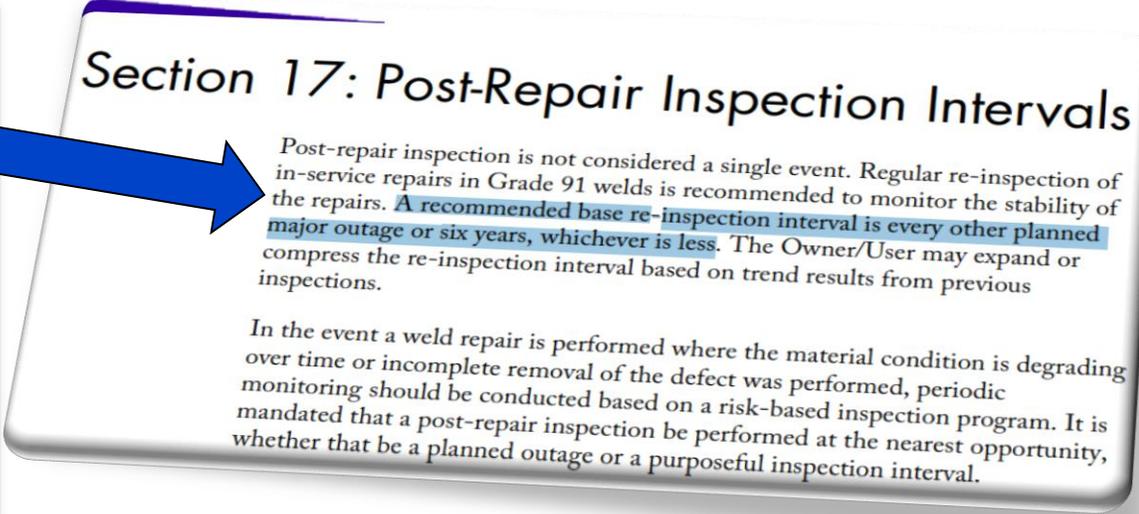
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Citations Rephrase



Results 1-10 of 501 for **How often should in-service Grade 91 welds be re-inspected?**

Sort by: Relevance

Product Summary **Regular Search Results**

Alternative **Weld**-Engineered **Weld** Repair Options for **Grade 91** Steel: A Review of Service Experience for Repairs Performed to **Welding** Methods 6 and 7

Alternative **Weld**-Engineered **Weld** Repair Options for **Grade 91** Steel A Review of Service ... In this example, the utility was self-insured and accepted the risk of the repair approach for a main ...

Text from EPRI Report 3002003833

Early beta testing shows potential to provide correct responses and references with low hallucinations

Using Gen AI for Asset Maintenance

Asset # CBL-003-AL3

Asset Name*

Lower Gas Generator Circulating Water Pump Tu ▾

Location

XYZ Gas Generator

System Status

Utility XYZ

Last Serviced

Sun Aug 20 2023

Maintenance Requests (3)

Maintenance Orders (7)

Example Data

Here are some things you can ask about
Lower Gas Generator Circulating Water Pump TurboFlex:



Cybersecurity Concerns for AI

Key Emerging Opportunities and Threats

AI

Opportunities

- Energy generation and grid optimization
- Generative AI, ChatGPT for utilities
- Automate data analysis
- Perform predictive maintenance
- AI-enhanced cybersecurity

Threats

- Text, audio, and video phishing/smishing & AI-assisted hacking, including deepfakes.
- Loss of confidential data or liability due to sharing/using information via Generative AI tools.

Quantum

Opportunities

- Quantum Computing / Quantum machine learning
- Quantum Sensors
- Quantum Communications/Cybersecurity

Threats

- Quantum cybersecurity – protect from “harvest data now, decrypt later” attacks.

AI-Enhanced Cybersecurity

Objectives and Scope

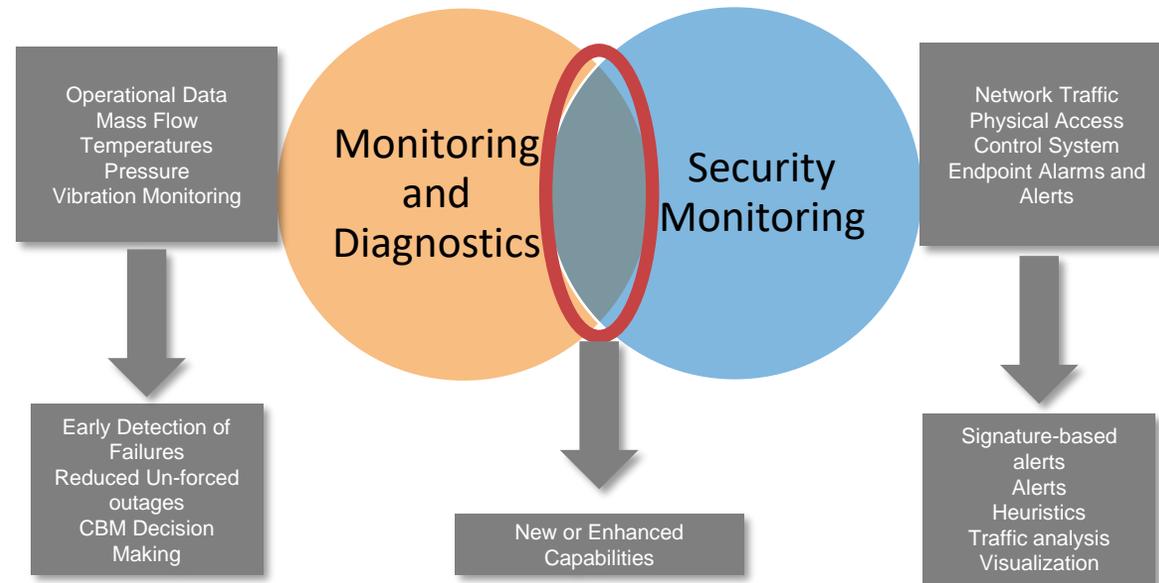
- Enhancing capabilities by bringing together the digital cyber and M&D data feeds
- Advanced cyber detection by integrating operational alerts
- Determine the best ways to utilize data sets to enhance cyber detection capabilities

Potential Impact

- Providing greater insight into operations and related cyber security concerns real-time
- Better alerts for configuration changes
- Visibility for non-networked assets

Value

- Increase operation security
- Improve alarm management for M&D centers



Data Sets	<ul style="list-style-type: none"> • Lab generated cyber attack data combined with sensor data • M&D center data (e.g., I4Gen data) • Images of lab cabinets
AI Approaches	<ul style="list-style-type: none"> • NNs or other supervised learning algorithms to mimic standard M&D center software • Potentially computer vision tools

Discussion

- How can EPRI work with you to maximize value from AI?
- What are you doing at your organization with AI?
- How are your AI activities organized and led?



Conclusions

- AI is a valuable tool for a wide range of power industry use cases.
 - AI can help automate tasks, improve worker efficiency, and enhance productivity.
 - AI can be used both offensively and defensively for cybersecurity.
- However, AI requires significant energy to train models.
 - Future enhancements may reduce energy needs.
- While significant advancements have been made, additional work and progress are needed.





TOGETHER...SHAPING THE FUTURE OF ENERGY®



Multi Spectral Satellite Data for Environmental and Vegetation Related Use Cases

Objectives and Scope

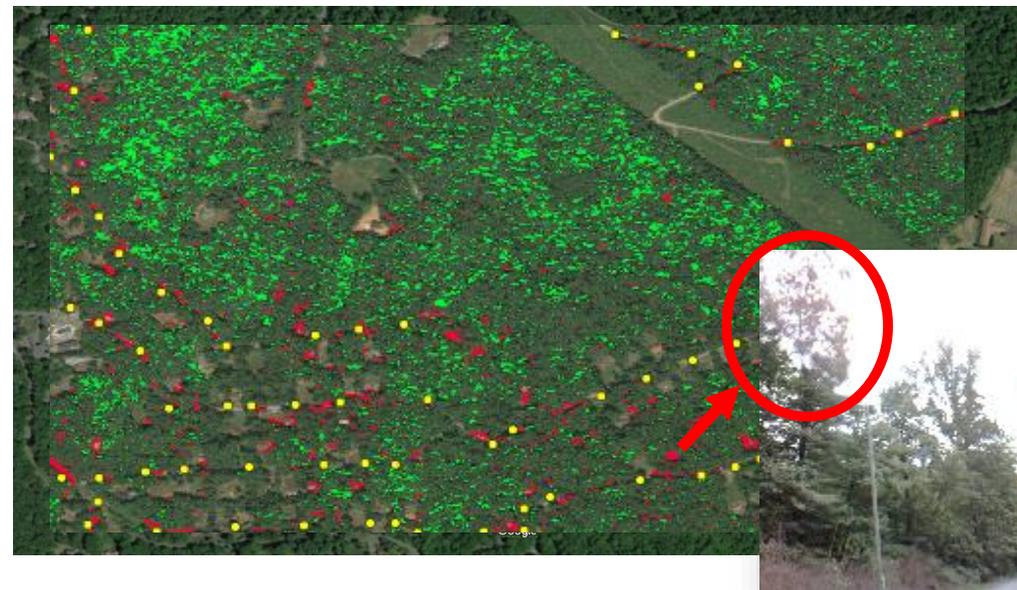
- Establish data framework for acquisition, curation, and sharing satellite imagery
- Evaluate and document most valuable use-cases for the electric power industry

Potential Impacts

- Industry repository to collaborate on valuable use cases

Value

- Reduce costs for vegetation management
- Identify and remediate outage risks in advance



Data Set	Vegetation Imagery
AI Approach	Change Detection and Supervised Learning



Multi-Spectral Satellite Data Can Support Dozens of Industry Use Cases

AI for Materials Qualification for Advanced Reactors

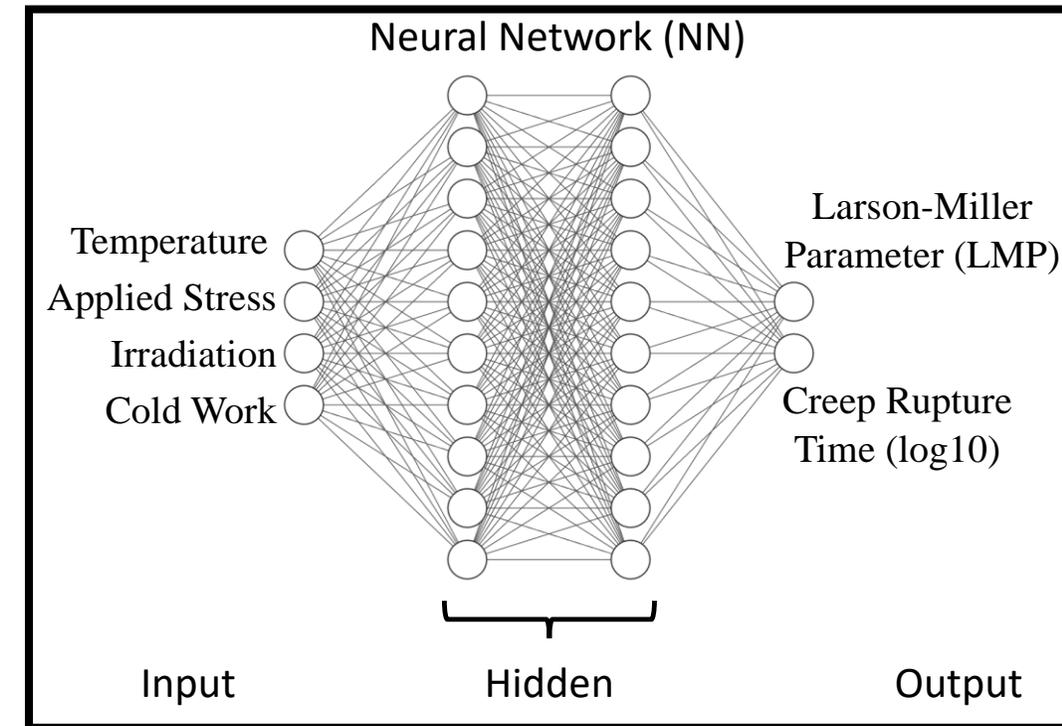
■ Scope and objectives

- Utilize AI to streamline materials testing to minimize prediction errors.
- Understanding creep behavior will be critical for Gen. IV reactors.

■ Value

- AI/ML modeling could be an effective tool in predicting creep behavior.
- Code qualification timelines for Gen. IV materials could be expedited.

Neural network (NN) structure



AI-enabled mechanical property prediction may allow for more time- and cost-effective approaches to understand materials degradation for advanced reactors.

AI-Assisted Relief Request (RR) Development and Knowledge Transfer

Scope and objectives

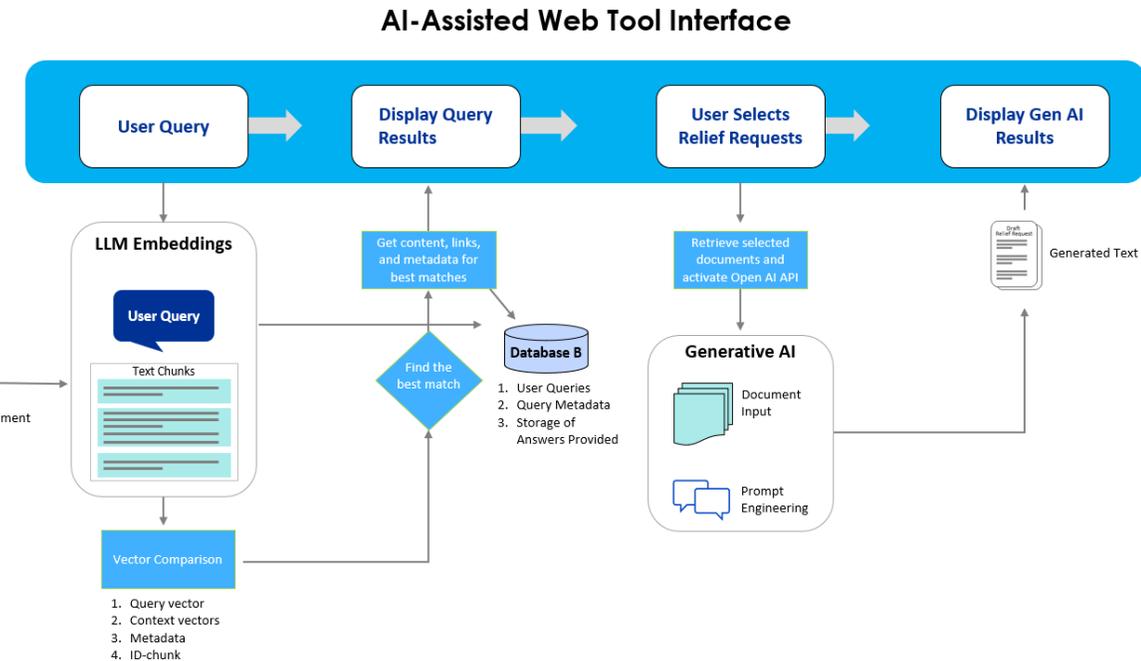
- Use LLM and AI to develop webtool to mine/curate RR datasets based on component, historical precedent, relief basis, and other complex metadata from NRC ADAMs
- Use LLM and AI to identify broad emerging trends, new precedents, and patterns in RR submittals to determine areas where additional research is needed
- Use generative AI to develop critical sections of a new RRs based on past RRs and historical precedent

Value

- Provide licensees/EPRI members a tool to significantly improve the efficiency of the relief request development process
- Address knowledge gaps in the regulatory submittal process for new-to-the-industry utility staff

Project status and key updates

- Webtool to mine/curate RR datasets has been developed and undergone initial internal (EPRI) testing – Currently making updates and expanding capabilities based on initial feedback
- Webinar on 4/24/24 introduced generative AI concept and initial testing to members to gain potential user group/alpha test participants: [RR Index Overview Webinar](#)
- Generative AI webtool development use case testing in progress



Opportunities for member engagement

- User Group/Alpha Testers for Webtool functionality and features

AI and Machine Learning for RR Development

AI to Inform Reorder Parameters

Scope and objectives

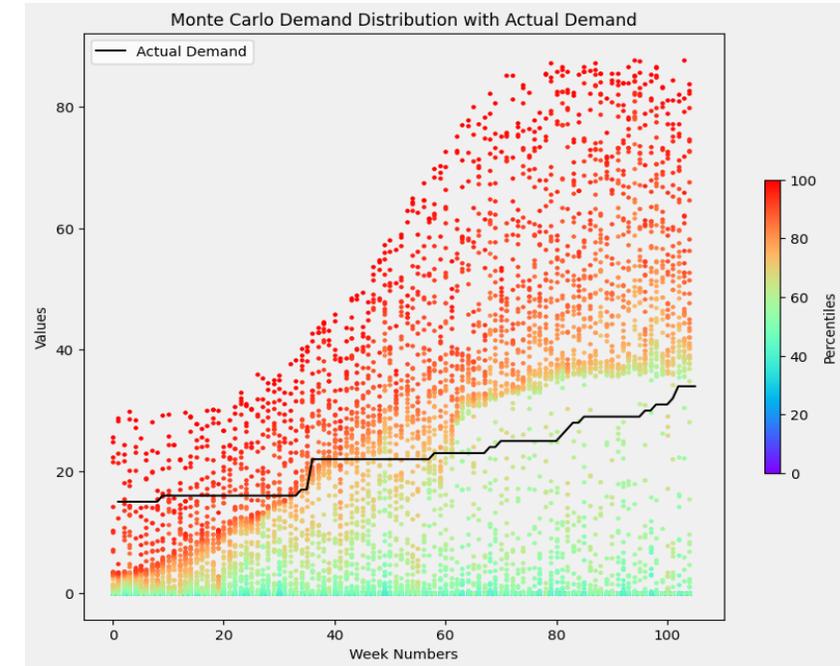
- Develop a proof-of-concept AI model to accurately predict spare part usage, where it has historically been difficult to predict, and conservatively over-predicted to avoid the consequences of not having parts available when needed.
- Evaluate the model predictions against actual utility usage and purchase data to determine if it would have resulted in a cost savings without impacting availability.
- Publish a technical update report to document the results, evaluation, and recommendations for next steps.

Value

- If successful, the model could be used to reduce the quantity of items purchased and stocked in inventory (reducing associated procurement costs, storage and handling costs, and ad-valorem taxes) without sacrificing spare part availability.

Project status and key updates

- Exploratory data analysis and model development completed
- Model simulations are being run, and model evaluation in progress
- Model will be tweaked based on results of evaluation
- Initial draft of technical update report started



Opportunities for member engagement

- Procurement Engineering and Related Topics (PEART) User Group
- Possible pilot site model implementation as proposed future project, based on results of proof-of-concept

Data analysis shows ~40% of items planned for work are never used, representing an opportunity for improved “data driven” purchase decisions that could lead to cost savings and reduced effort