Light Water Reactor Sustainability (LWRS) Program Spring Meeting

EPRI News & Updates

Colton Smith
Sr. Technical Leader

4/29/2025

Topics to Cover

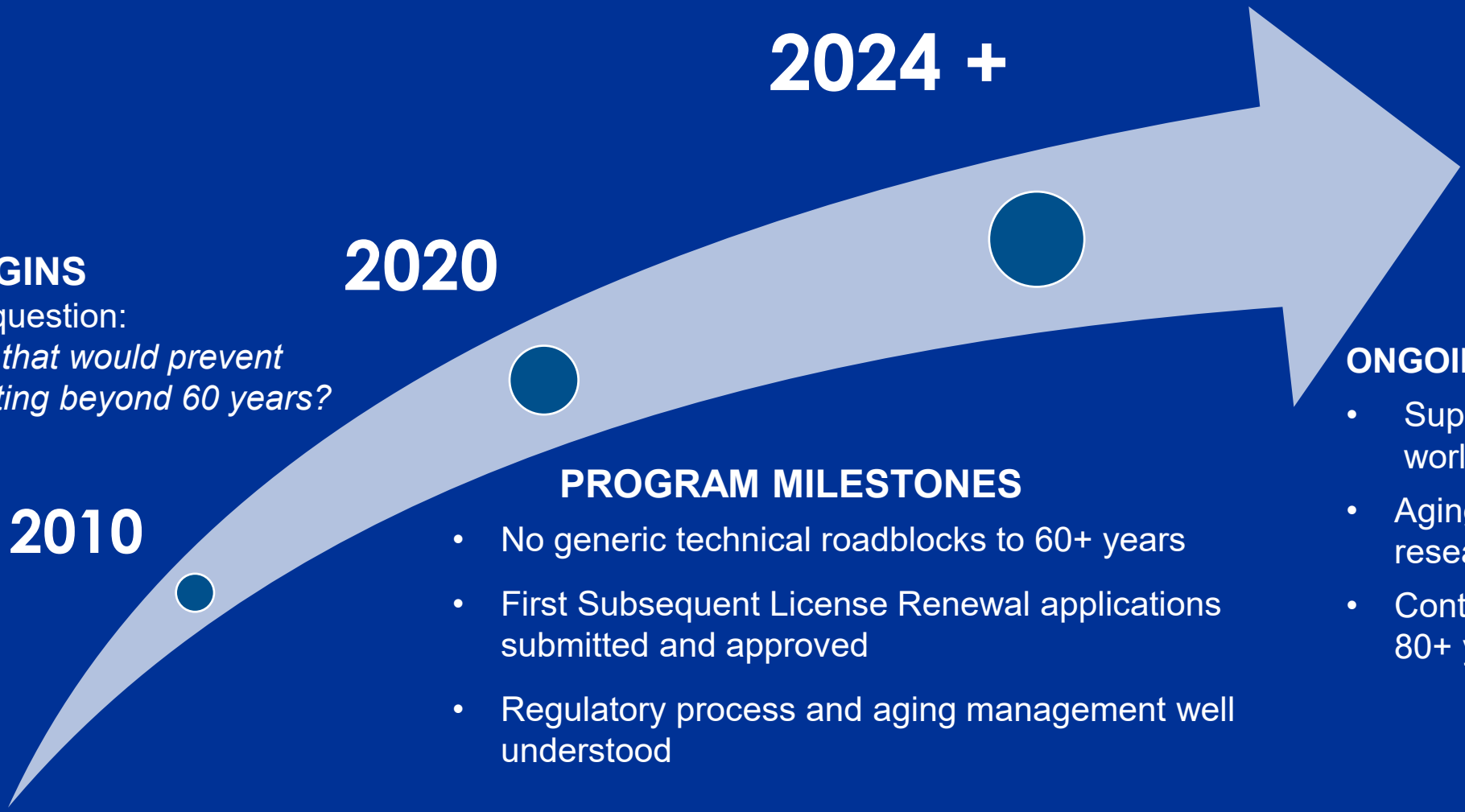
Long Term Operations

Plant Modernization

Data-Driven Decision Making

Visit the Operating Plant Initiatives Program Page for more information!

Nuclear Long Term Operation Research at EPRI



PROGRAM BEGINS

Prompted by the question:

"Is there anything that would prevent plants from operating beyond 60 years? 80? More?"

PROGRAM MILESTONES

- No generic technical roadblocks to 60+ years
- First Subsequent License Renewal applications submitted and approved
- Regulatory process and aging management well understood

ONGOING NEEDS

- Support for members worldwide
- Aging management research
- Continued research: 80+ years?

The LTO Wiki is now live!

PLANT MODERNIZATION

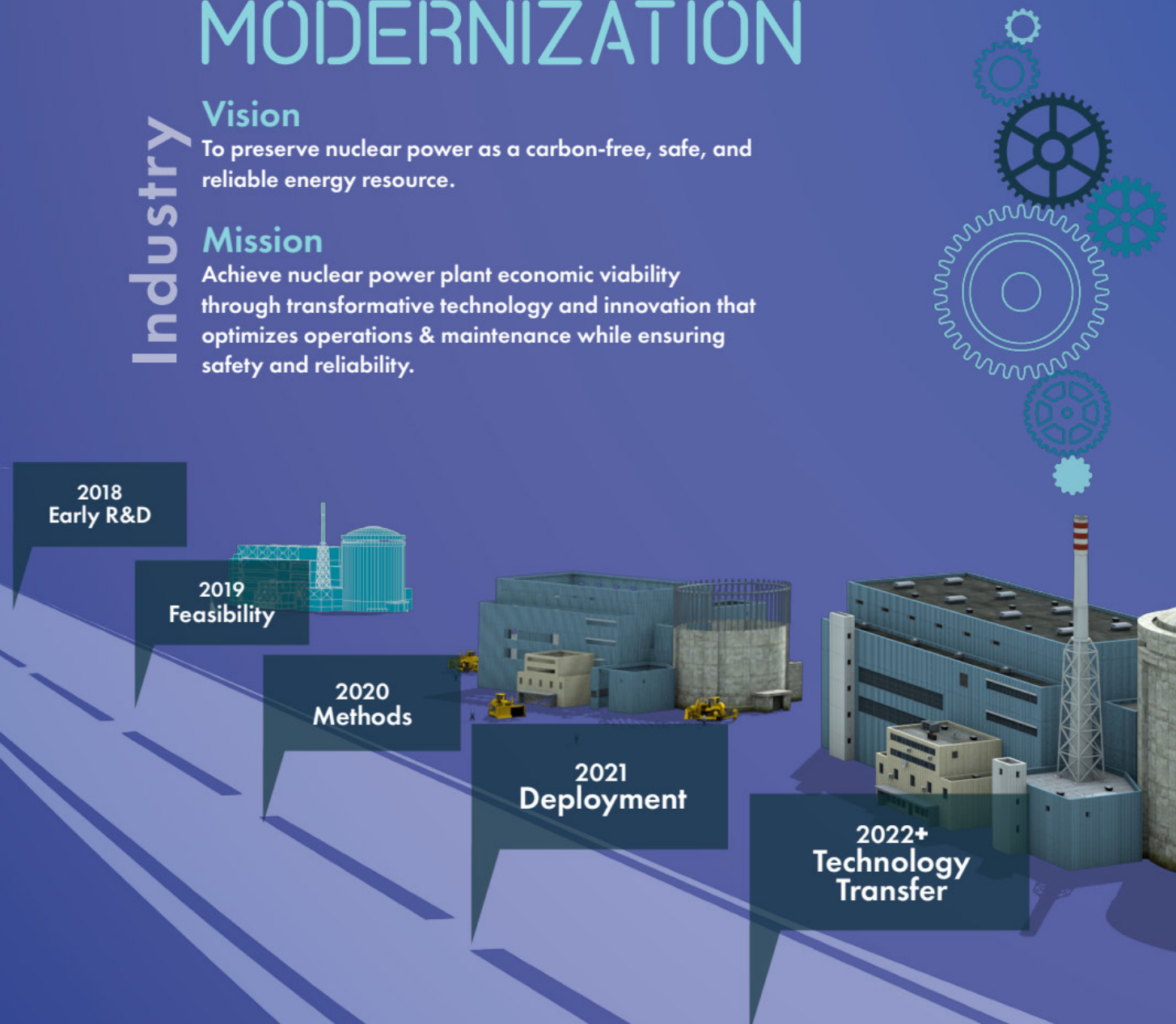
Industry

Vision

To preserve nuclear power as a carbon-free, safe, and reliable energy resource.

Mission

Achieve nuclear power plant economic viability through transformative technology and innovation that optimizes operations & maintenance while ensuring safety and reliability.



Collaborators

- Utilities
- Institute of Nuclear Power Operations (INPO)
- Nuclear Energy Institute (NEI)
- Owners, groups, other R&D organizations, vendors
- U.S. Department of Energy (DOE) and National Labs
- International Atomic Energy Agency (IAEA)

Strategic Goals

Feasibility

Show that modernization effort can be successful

Methods

Provide the tools to implement modernization ideas

Deployment

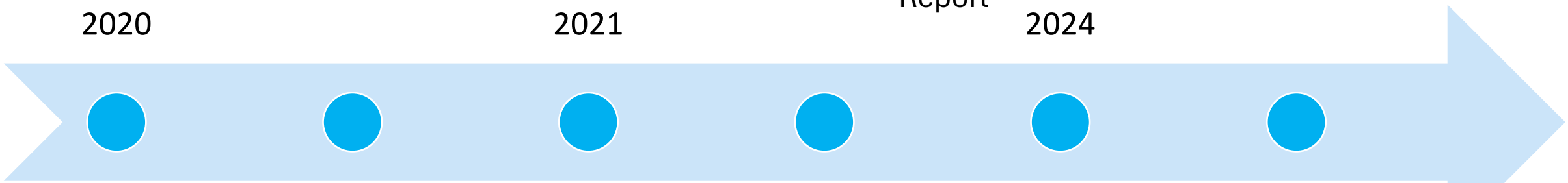
Demonstrate modernization can be implemented

Technology Transfer

Transfer modernization tools for members implementation

EPRI

Modernization Strategy Guide Timeline



2020
- Initial Modernization Guide release

2021
- 2 US-based pilots
- Member implementations

2021
- Modernization Guide Update

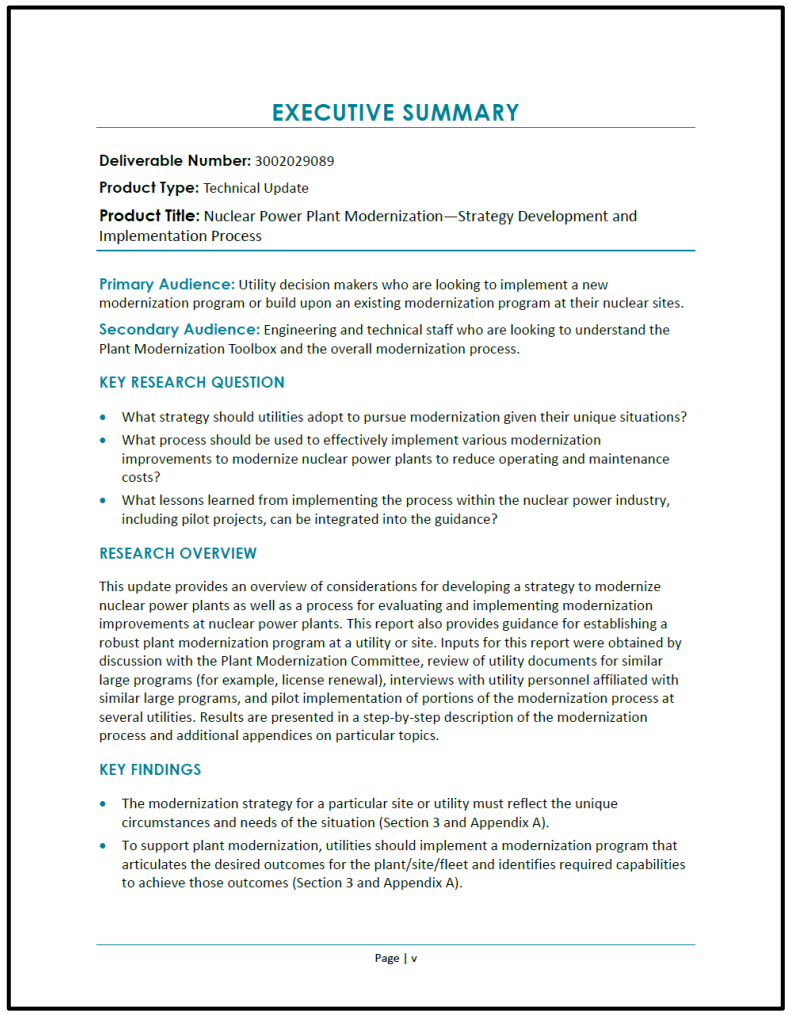
2022-2024
- Member implementations
- International pilot

2024
- Modernization Guide Update
- Modernization Strategy Development Member Report
- Benchmarking and Assessment Example Report

2025+
- Member implementations
- Continued Technology Transfer

Focusing on Technology Transfer to Members for Implementation

Modernization Strategy Reports



EXECUTIVE SUMMARY

Deliverable Number: 3002029089

Product Type: Technical Update

Product Title: Nuclear Power Plant Modernization—Strategy Development and Implementation Process

Primary Audience: Utility decision makers who are looking to implement a new modernization program or build upon an existing modernization program at their nuclear sites.

Secondary Audience: Engineering and technical staff who are looking to understand the Plant Modernization Toolbox and the overall modernization process.

KEY RESEARCH QUESTION

- What strategy should utilities adopt to pursue modernization given their unique situations?
- What process should be used to effectively implement various modernization improvements to modernize nuclear power plants to reduce operating and maintenance costs?
- What lessons learned from implementing the process within the nuclear power industry, including pilot projects, can be integrated into the guidance?

RESEARCH OVERVIEW

This update provides an overview of considerations for developing a strategy to modernize nuclear power plants as well as a process for evaluating and implementing modernization improvements at nuclear power plants. This report also provides guidance for establishing a robust plant modernization program at a utility or site. Inputs for this report were obtained by discussion with the Plant Modernization Committee, review of utility documents for similar large programs (for example, license renewal), interviews with utility personnel affiliated with similar large programs, and pilot implementation of portions of the modernization process at several utilities. Results are presented in a step-by-step description of the modernization process and additional appendices on particular topics.

KEY FINDINGS

- The modernization strategy for a particular site or utility must reflect the unique circumstances and needs of the situation (Section 3 and Appendix A).
- To support plant modernization, utilities should implement a modernization program that articulates the desired outcomes for the plant/site/fleet and identifies required capabilities to achieve those outcomes (Section 3 and Appendix A).

[Plant Moderation – Strategy Development and Implementation Process]

EPRI

TECHNICAL BRIEF

Application of EPRI Plant Modernization Strategy Development at Chubu

Showcasing the Value of Establishing a Plant Modernization Program

This technical brief summarizes the work completed to support setup of a Plant Modernization Program for Chubu Electric Power's Hamaoka Nuclear Power Station as part of an EPRI international pilot project. The project focused on implementing the first six steps of the Plant Modernization Process as outlined in the EPRI Report 3002020908, *Nuclear Power Plant Modernization-Strategy Development and Implementation Process* [1]. The full version of the Chubu Plant Modernization Strategy Report is attached as an appendix.

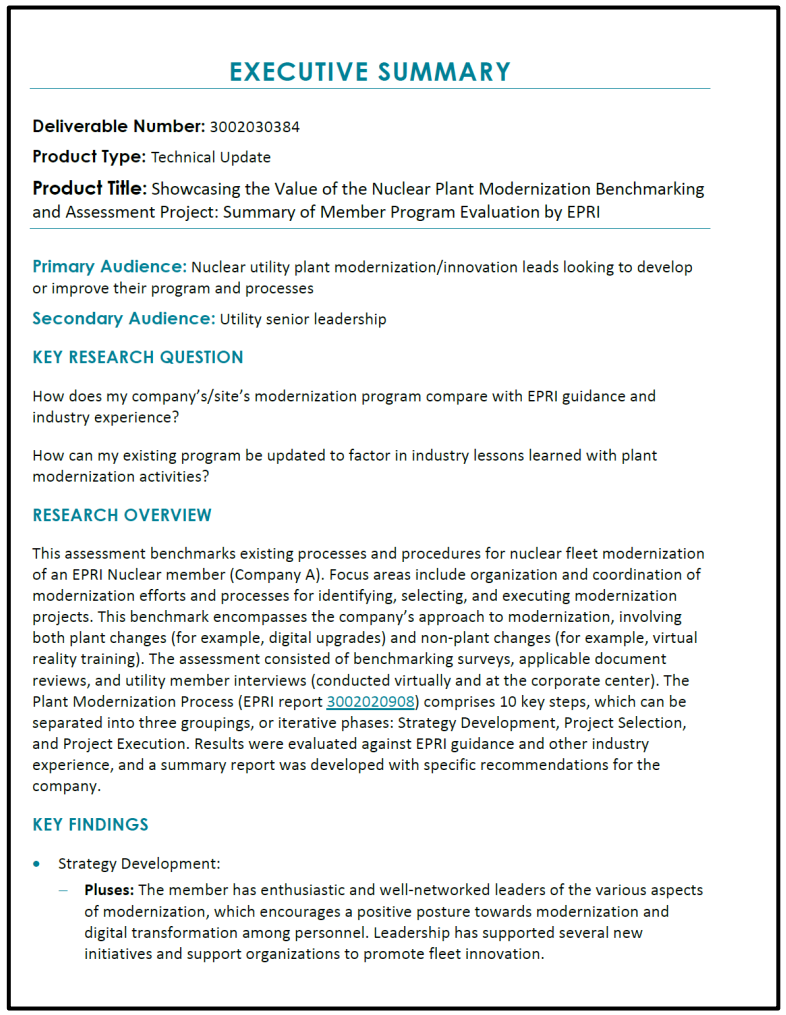
EPRI's Plant Modernization Initiative has been working to establish a technical and programmatic foundation for nuclear power plants to adopt new technologies and process improvements to reduce O&M costs. The plant modernization process is meant to build upon typical existing utility processes for large-scale initiatives and be compatible with existing plant procedures. This technical brief summarizes piloting the first six steps of the Plant Modernization Process to establish the Plant Modernization Program at Hamaoka. The first six steps are as follows:

1. **Establish a charter:** The charter provides a framework for the direction of the program, including key goals and objectives. Additionally, the major process elements of the modernization program are identified along with how these elements fit into existing plant processes. This information is used for the development of the modernization process description which is a foundational document for the program.
2. **Define strategic inputs and business risks:** This step involves identifying various strategic inputs and business risks that may affect decision making for plant modernization improvements.
3. **Investigate feasibility of improvements:** This step involves development of a list of candidate modernization improvements that address areas of greatest value for the plant.
4. **Perform scoping evaluations to select improvements:** This step is an evaluation of the list of candidate modernization improvements to select an optimized set of potential improvements to proceed with detailed business case.
5. **Gather inputs for business case analysis:** This step involves gathering the necessary inputs for the business case analysis in Step 6.
6. **Develop the business case analysis:** This step involves preparing a business case analysis and making a recommendation to utility and plant leadership on whether to proceed with a plant modernization improvement.

The Chubu business plan acknowledges that to advance the nuclear power generation business safely and steadily it is essential to have focused efforts for "voluntary and continuous improvement of safety" and "efforts to reduce costs and increase profits with an awareness of the unit price of power generation after restarting to improve economic efficiency."

With these goals in mind, this pilot project leverages Reference 1 to provide foundational documents for a Chubu modernization program (i.e., charter, process description), an initial list of recommended improvements for business case analysis, and a business case analysis on a select plant modernization improvement.

[Chubu Modernization Strategy Document]



EXECUTIVE SUMMARY

Deliverable Number: 3002030384

Product Type: Technical Update

Product Title: Showcasing the Value of the Nuclear Plant Modernization Benchmarking and Assessment Project: Summary of Member Program Evaluation by EPRI

Primary Audience: Nuclear utility plant modernization/innovation leads looking to develop or improve their program and processes

Secondary Audience: Utility senior leadership

KEY RESEARCH QUESTION

How does my company's/site's modernization program compare with EPRI guidance and industry experience?

How can my existing program be updated to factor in industry lessons learned with plant modernization activities?

RESEARCH OVERVIEW

This assessment benchmarks existing processes and procedures for nuclear fleet modernization of an EPRI Nuclear member (Company A). Focus areas include organization and coordination of modernization efforts and processes for identifying, selecting, and executing modernization projects. This benchmark encompasses the company's approach to modernization, involving both plant changes (for example, digital upgrades) and non-plant changes (for example, virtual reality training). The assessment consisted of benchmarking surveys, applicable document reviews, and utility member interviews (conducted virtually and at the corporate center). The Plant Modernization Process (EPRI report 3002020908) comprises 10 key steps, which can be separated into three groupings, or iterative phases: Strategy Development, Project Selection, and Project Execution. Results were evaluated against EPRI guidance and other industry experience, and a summary report was developed with specific recommendations for the company.

KEY FINDINGS

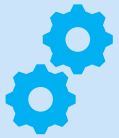
- Strategy Development:
  - **Pluses:** The member has enthusiastic and well-networked leaders of the various aspects of modernization, which encourages a positive posture towards modernization and digital transformation among personnel. Leadership has supported several new initiatives and support organizations to promote fleet innovation.

[Summary of a Member Program Evaluation]

Data-Driven Decision Making (3DM)

Leverage data science for the Nuclear Power industry

Launch & support activities across the Nuclear Sector



General application areas

Insights: learning from the past

Prognostics: anticipating the future

Automation: increasing reliability

Optimization: increasing efficiency

More details on the OPI/3DM program page

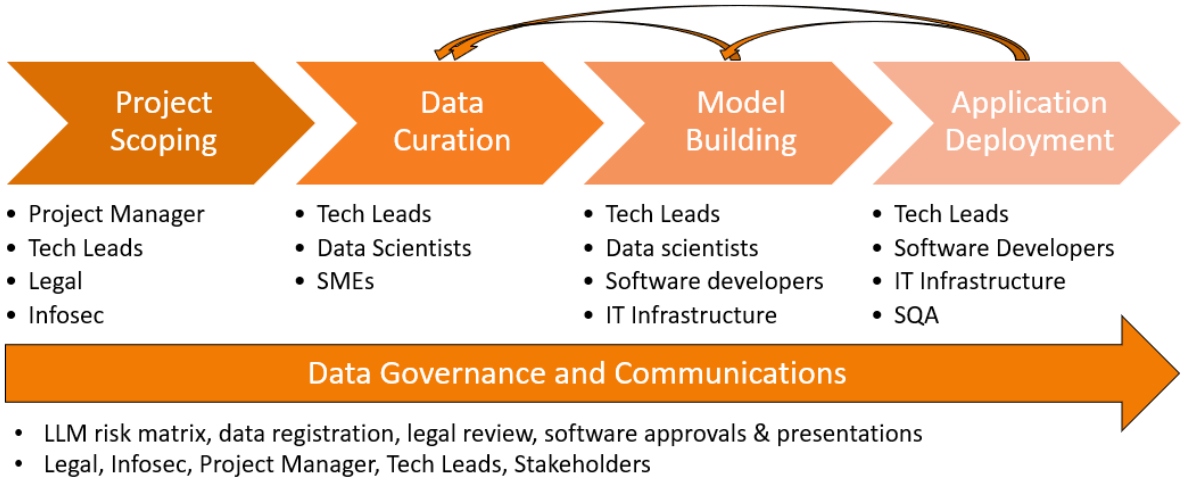
Projects and Results

Contacts: Rob Austin (raustin@epri.com) and Christine Lee (clee@epri.com)

Applying Data Science in the Nuclear Power Industry

Good Practice Guide for Setting Up Large Language Models (LLMs)

- Guidance on workflow steps:
  - Project scoping
  - Data curation
  - Model building
  - Application deployment
- Guidance on key activities for each step
- Use-Case examples



Development Team

- Technical Leads
  - Lead development team
  - Define technical scope, testing plan & timeline
  - Create deliverables
  - Technical communications
- Data Scientists
  - Clean & organize data
  - Research models & metrics
  - Develop proof of concept local application
- Software Developers
  - Convert proof of concept local application into online production version
  - Build backend for model & monitoring diagnostics
- Subject Matter Experts (SMEs)
  - Test application & provide feedback

Business Team

- Project Manager
  - Ensure project scope, timeline, & budget
- Legal
  - Leads business team
  - Evaluate & approve legal risks of models/applications
  - Compliance and export control
- Infosec
  - Evaluate & approve information security risks of models/applications
- IT Infrastructure
  - Build & maintain virtual/physical compute assets
- Software Quality Assurance (SQA)
  - Guide application through software development cycle via Secure Software Development Framework (SSDF)
- Stakeholders
  - Communicate value to members

Good Practice Guide for Setting Up Large Language Model-Powered Projects

Upcoming Plant Modernization & 3DM Related Meetings

Plant Modernization/3DM Committee Update Webcast, July 23 2025

- Virtual
- Registration will be available soon

Plant Modernization Process Workshop, Q3 2025

- Registration will be available soon

PMC/3DM Meeting as part of Nuclear Power Council, Aug. 26, 2025

- In-Person
- Toronto, Canada
- Register here

More Information

- Operating Plant Initiatives Links:
  - Operating Plant Initiatives Program Page
  - Plant Modernization Toolbox
- Digital Transformation Links:
  - DXRI Microsite
  - EPRI-Wide Digital Transformation Research Roadmap
  - EPRI-Wide Digital Transformation Wiki
- Supplemental Project Notices:
  - Digital Transformation Research Initiative (DXRI)
  - Plant Modernization Benchmarking & Assessment
  - Facilitating Nuclear Power Uprates
- EPRI Articles:
  - Modernization of the existing fleet: Gaining speed!
  - ANAV Uses EPRI Tools to Improve Its Maintenance Strategies
- Questions? Contact:
  - nuclearplantmod@epri.com
  - Rob Austin, EPRI (raustin@epri.com)
  - Colton Smith, EPRI (cosmith@epri.com)
  - Christine Lee, EPRI (clee@epri.com)
  - Monica Hurley, EPRI (mhurley@epri.com)

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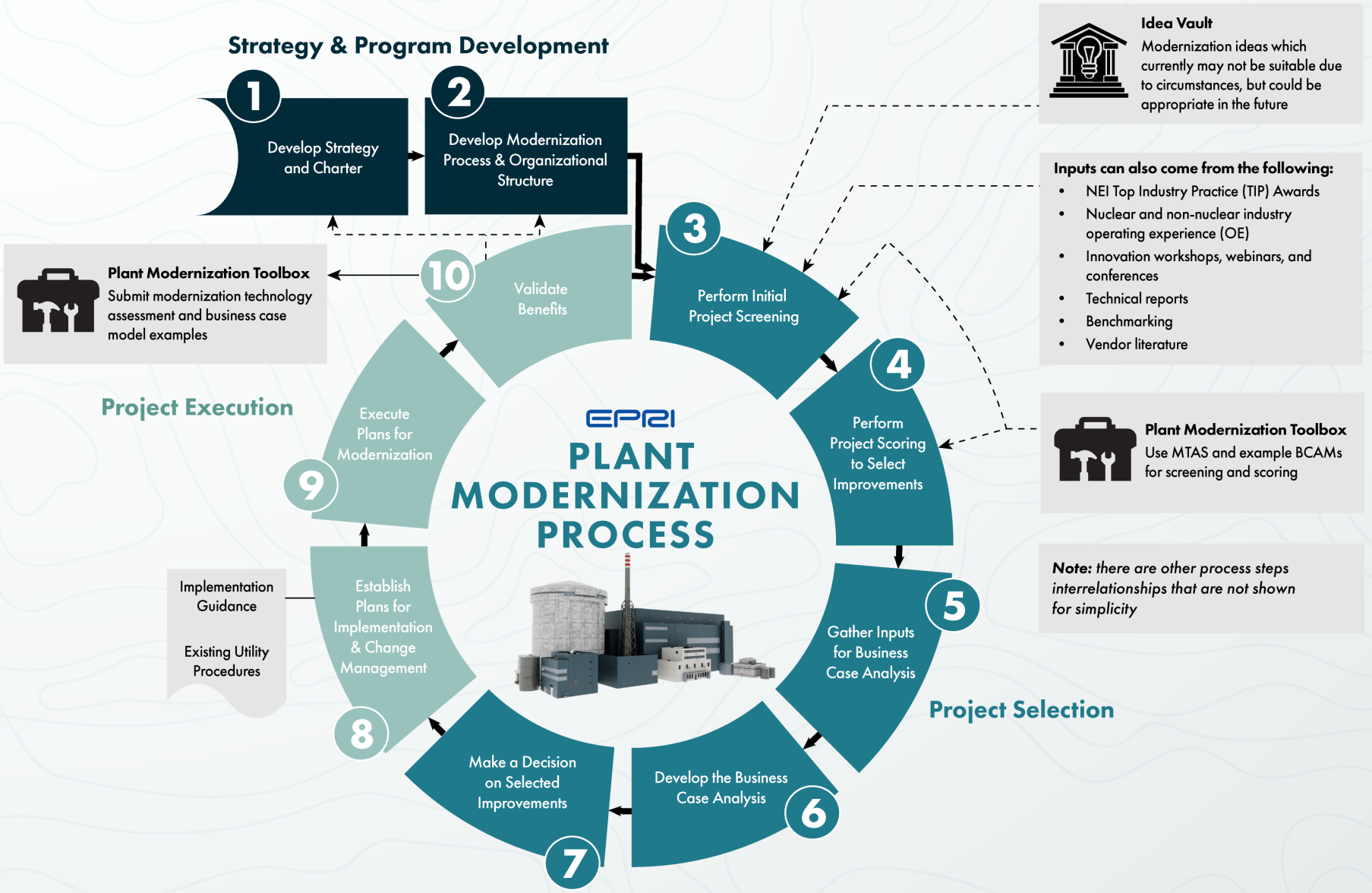
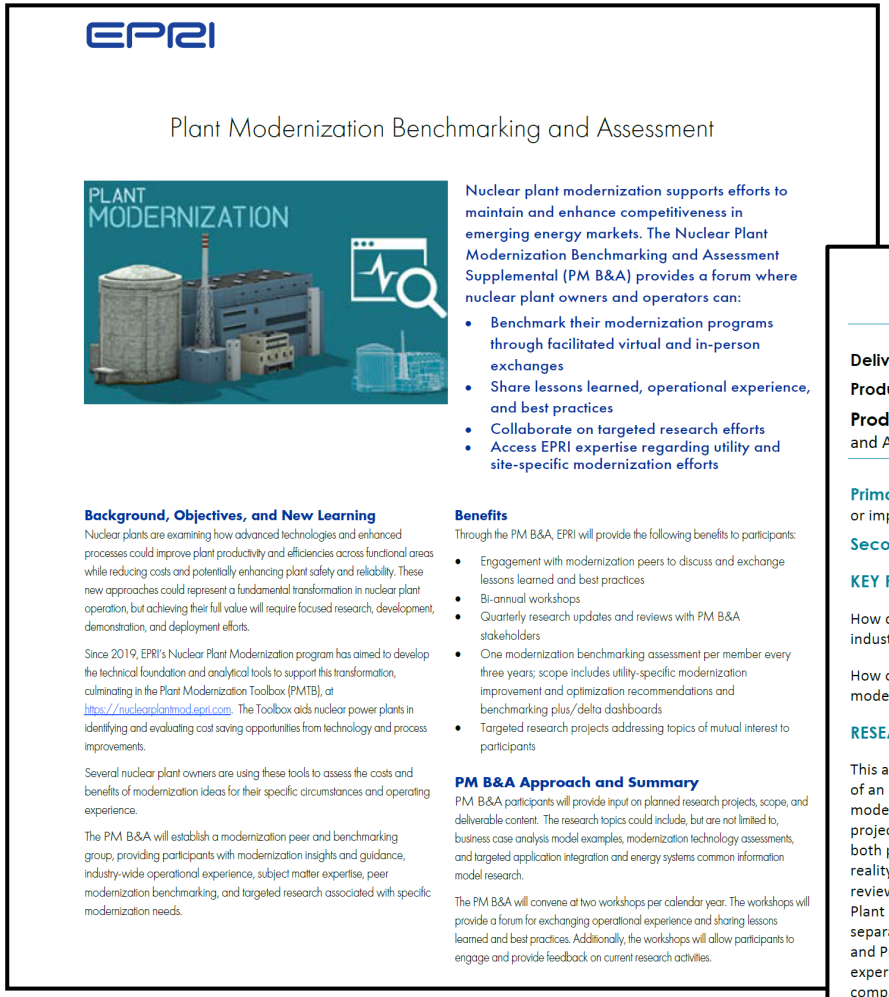


Scan the QR Code to download the updated report!

Supplemental

Plant Modernization Benchmarking and Assessment

- Collaboration among peers on lessons learned and best practices for sustaining modernization program
- One modernization benchmarking assessment every 3 years providing optimization recommendations and benchmarking plus and delta dashboards against EPRI's Guide



EPRI

Plant Modernization Benchmarking and Assessment

Nuclear plant modernization supports efforts to maintain and enhance competitiveness in emerging energy markets. The Nuclear Plant Modernization Benchmarking and Assessment Supplemental (PM B&A) provides a forum where nuclear plant owners and operators can:

- Benchmark their modernization programs through facilitated virtual and in-person exchanges
- Share lessons learned, operational experience, and best practices
- Collaborate on targeted research efforts
- Access EPRI expertise regarding utility and site-specific modernization efforts

Background, Objectives, and New Learning

Nuclear plants are examining how advanced technologies and enhanced processes could improve plant productivity and efficiencies across functional areas while reducing costs and potentially enhancing plant safety and reliability. These new approaches could represent a fundamental transformation in nuclear plant operation, but achieving their full value will require focused research, development, demonstration, and deployment efforts.

Since 2019, EPRI's Nuclear Plant Modernization program has aimed to develop the technical foundation and analytical tools to support this transformation, culminating in the Plant Modernization Toolbox (PMTB), at https://nuclearplantmod.epri.com. The Toolbox aids nuclear power plants in identifying and evaluating cost saving opportunities from technology and process improvements.

Several nuclear plant owners are using these tools to assess the costs and benefits of modernization ideas for their specific circumstances and operating experience.

The PM B&A will establish a modernization peer and benchmarking group, providing participants with modernization insights and guidance, industry-wide operational experience, subject matter expertise, peer modernization benchmarking, and targeted research associated with specific modernization needs.

Benefits

Through the PM B&A, EPRI will provide the following benefits to participants:

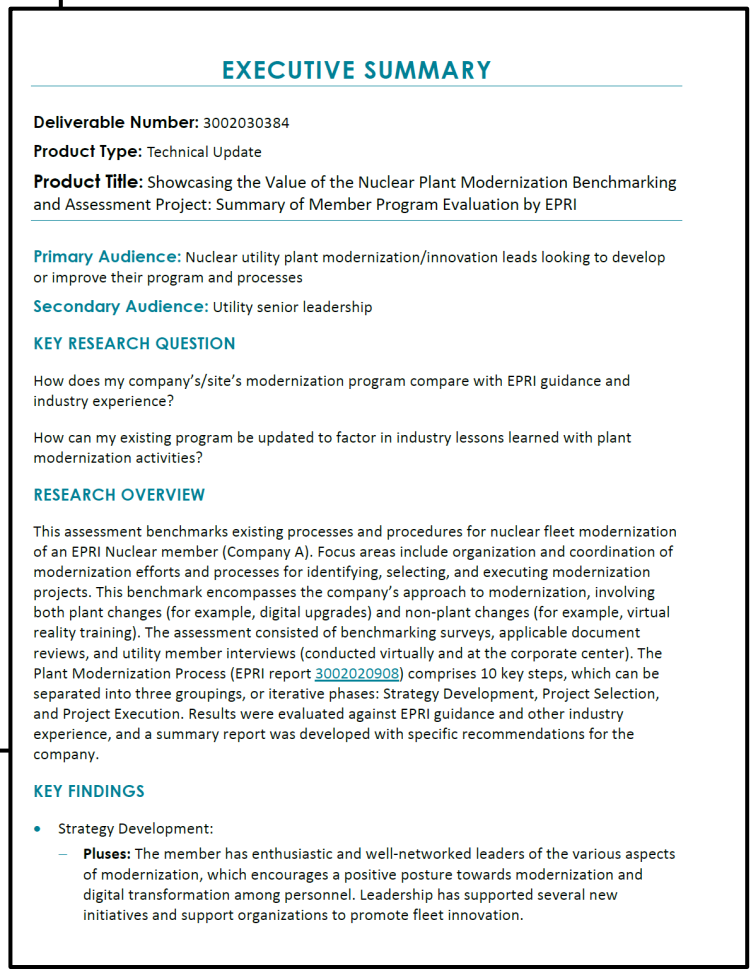
- Engagement with modernization peers to discuss and exchange lessons learned and best practices
- Bi-annual workshops
- Quarterly research updates and reviews with PM B&A stakeholders
- One modernization benchmarking assessment per member every three years; scope includes utility-specific modernization improvement and optimization recommendations and benchmarking plus/delta dashboards
- Targeted research projects addressing topics of mutual interest to participants

PM B&A Approach and Summary

PM B&A participants will provide input on planned research projects, scope, and deliverable content. The research topics could include, but are not limited to, business case analysis model examples, modernization technology assessments, and targeted application integration and energy systems common information model research.

The PM B&A will convene at two workshops per calendar year. The workshops will provide a forum for exchanging operational experience and sharing lessons learned and best practices. Additionally, the workshops will allow participants to engage and provide feedback on current research activities.

Benchmarking and Assessment Supplemental



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Summary of a Member Program Evaluation

EPRI Technical Application

Moderation Strategy Development

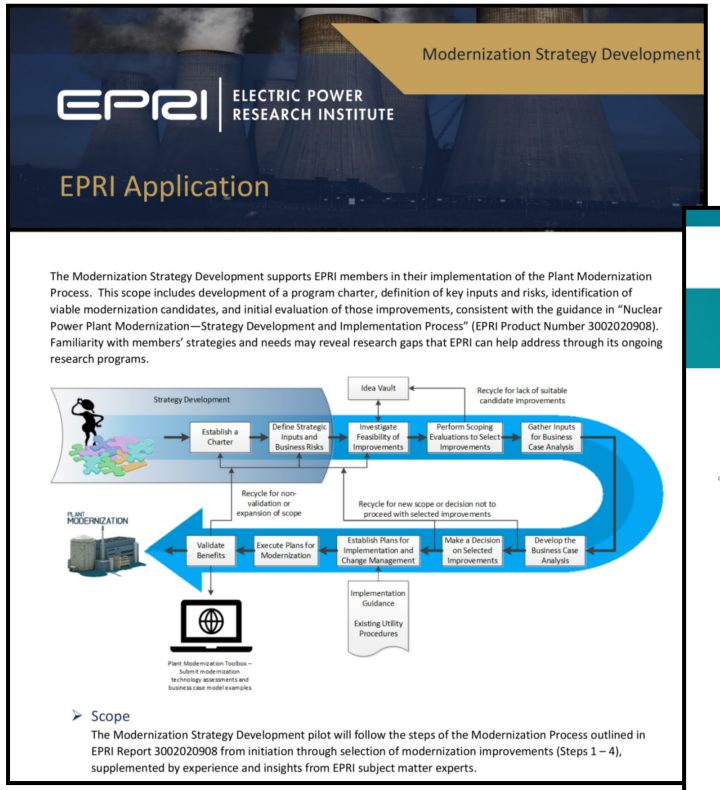
EPRI will walk the Utility/Site through Steps 1-6 of the Plant Modernization Strategy and Development Guideline

Products produced:

1. Modernization Strategy Document that includes:
    1. Program Charter
    2. Process Document
    3. Strategic Risks and Insights

"As a senior leader, I found it incredibly helpful from an oversight and decision making perspective to see all of the company's strategic inputs and business risks captured together in one document. With inspiration from this modernization assessment, we have now created a single page 5-year roadmap to align transformation / modernization initiatives with our vision and overall company priorities & risks."

Greg Wolfe
Senior Director, Innovation & Strategy
Operational Services
Bruce Power



[Technical Application Link]

4. Candidate and Recommended Modernization options
5. Completed Business Case on one of the recommended options.

[Chubu Modernization Strategy Document]