

EPRI

# EPRI Research on LTO to Support Climate Change Goals & Energy Security Needs

NIC 2024



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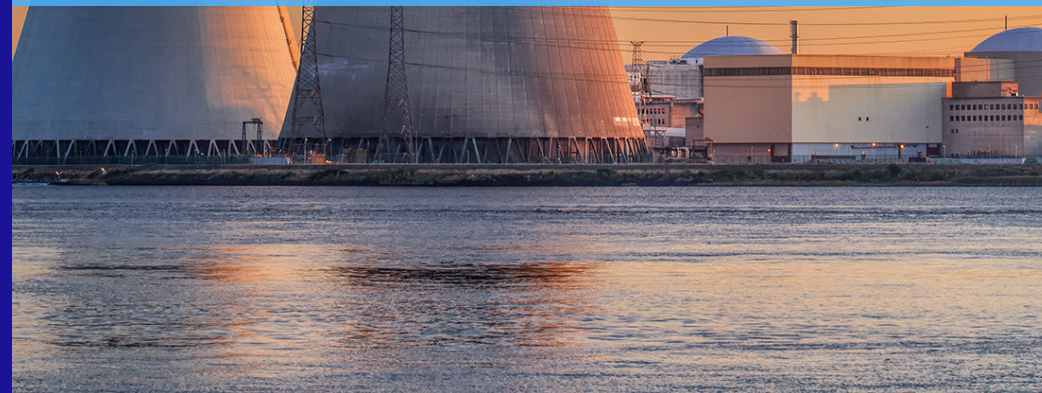
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# Overview of Topics

## Goal of this Presentation:

To establish a common understanding of Long-Term Operation (LTO) and EPRI's research activities supporting LTO needed to achieve climate change goals for carbon reduction and to meet energy security needs.

- 1 LTO – What is it and Why do we need it?
- 2 EPRI – Who is EPRI?
- 3 EPRI Research Activities to Support LTO
- 4 Conclusion



A blue-tinted image showing a pair of hands holding a globe of the Earth. The background is a dark blue space with stars and a faint constellation. The text "LTO – What is it and Why do we need it?" is overlaid in white.

**LTO – What is it and Why do we need it?**

# What is Long Term Operation (LTO)?



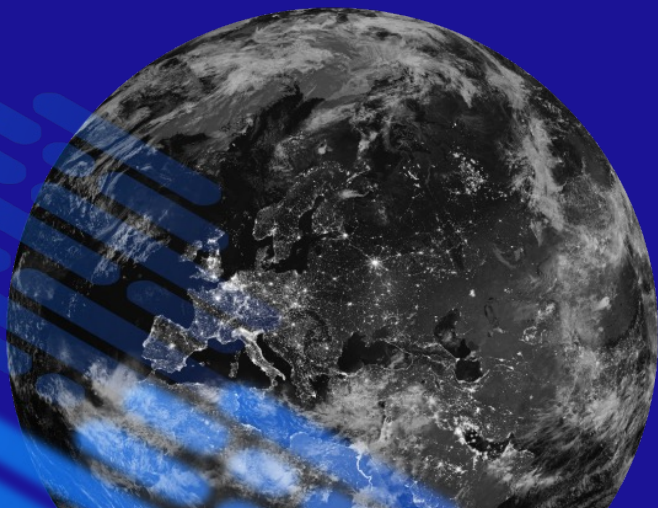
Long Term Operation (LTO) is generally defined as operating existing nuclear power plants for longer than the original operating license term (e.g., beyond 30 to 40 years in most countries).

The original license term was not based on design or operating limitations, so license extensions or renewals are part of most countries' existing regulatory processes.

In the U.S., almost 60% of the operating plants have operated more than 40 years. Worldwide, more than 65% have operated for more than 30 years. **Therefore, LTO is now well established, and a proven practice based on successful, reliable and safe operation of existing nuclear energy facilities around the world.**

**LTO - extending the operating term successfully, reliably, and safely**

# Why is LTO needed?



## Energy Security

- Reduces dependence on fossil fuels & energy imports



## Energy Diversity

- Supports generation portfolio risk management



## Reliability

- Consistent supply with high-capacity factors

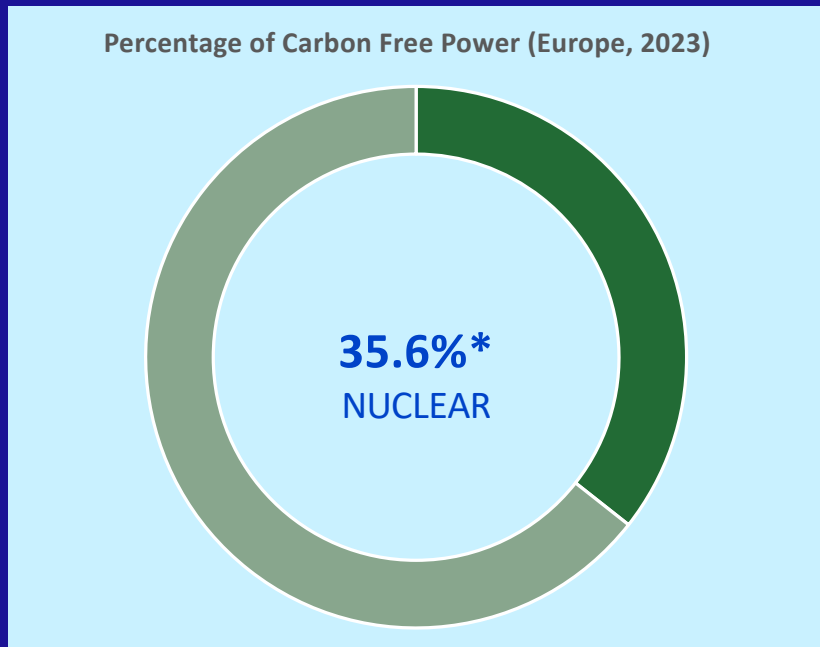


## Carbon Free

- Existing nuclear is essential to meeting carbon reduction goals

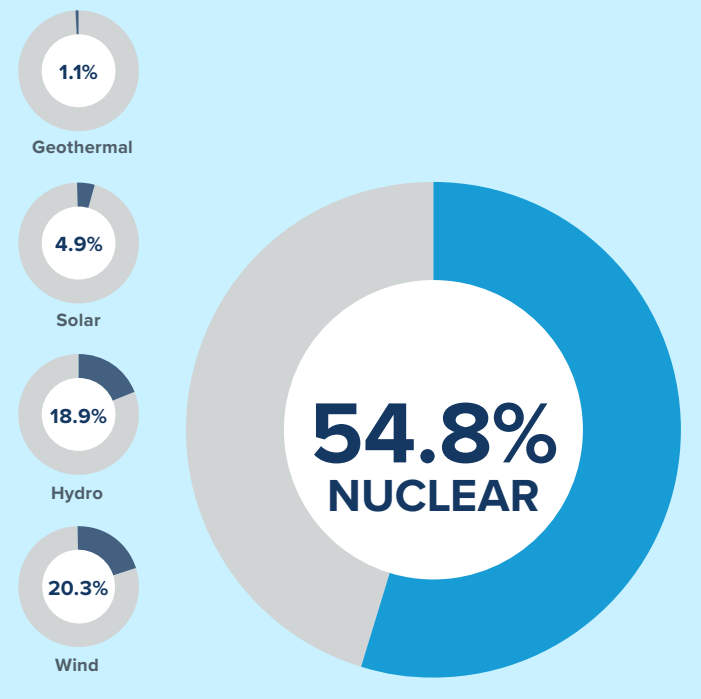
**LTO is key to accomplishing carbon reduction goals around the world**

# Why is LTO needed?



Source: <https://ourworldindata.org/electricity-mix> [Online Resource]

## Sources of Carbon-Free Electricity in the U.S.

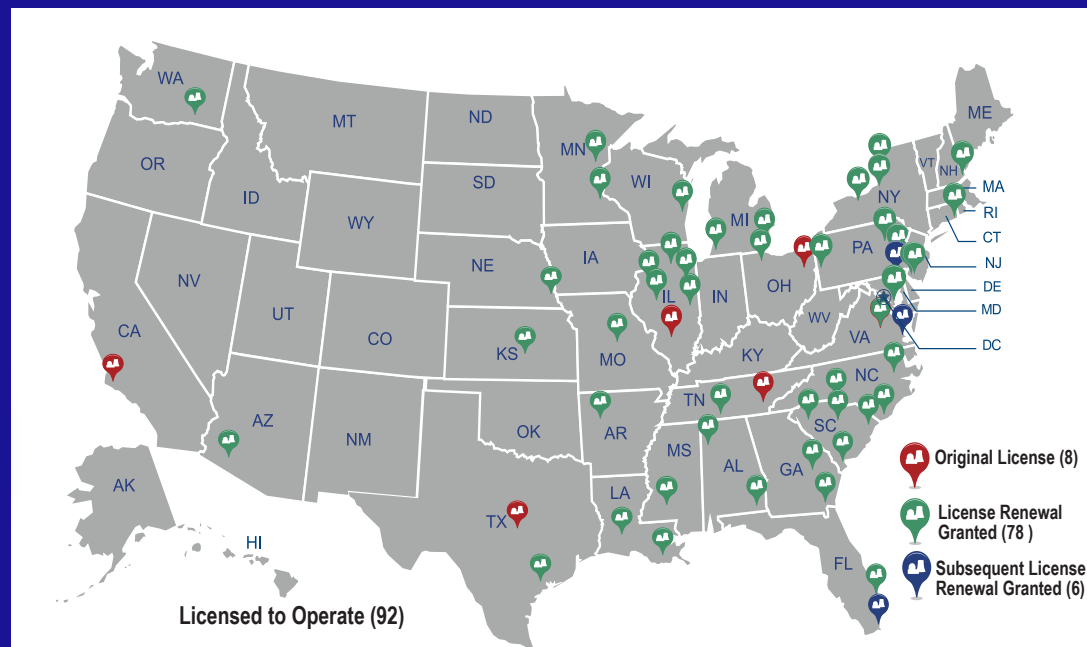


Source: 2020 Nuclear Energy Institute Inc

Extending the operating license is the cheapest and most reliable source of safe and secure low carbon electricity

# Status of LTO in the US – 94\* operating nuclear plants

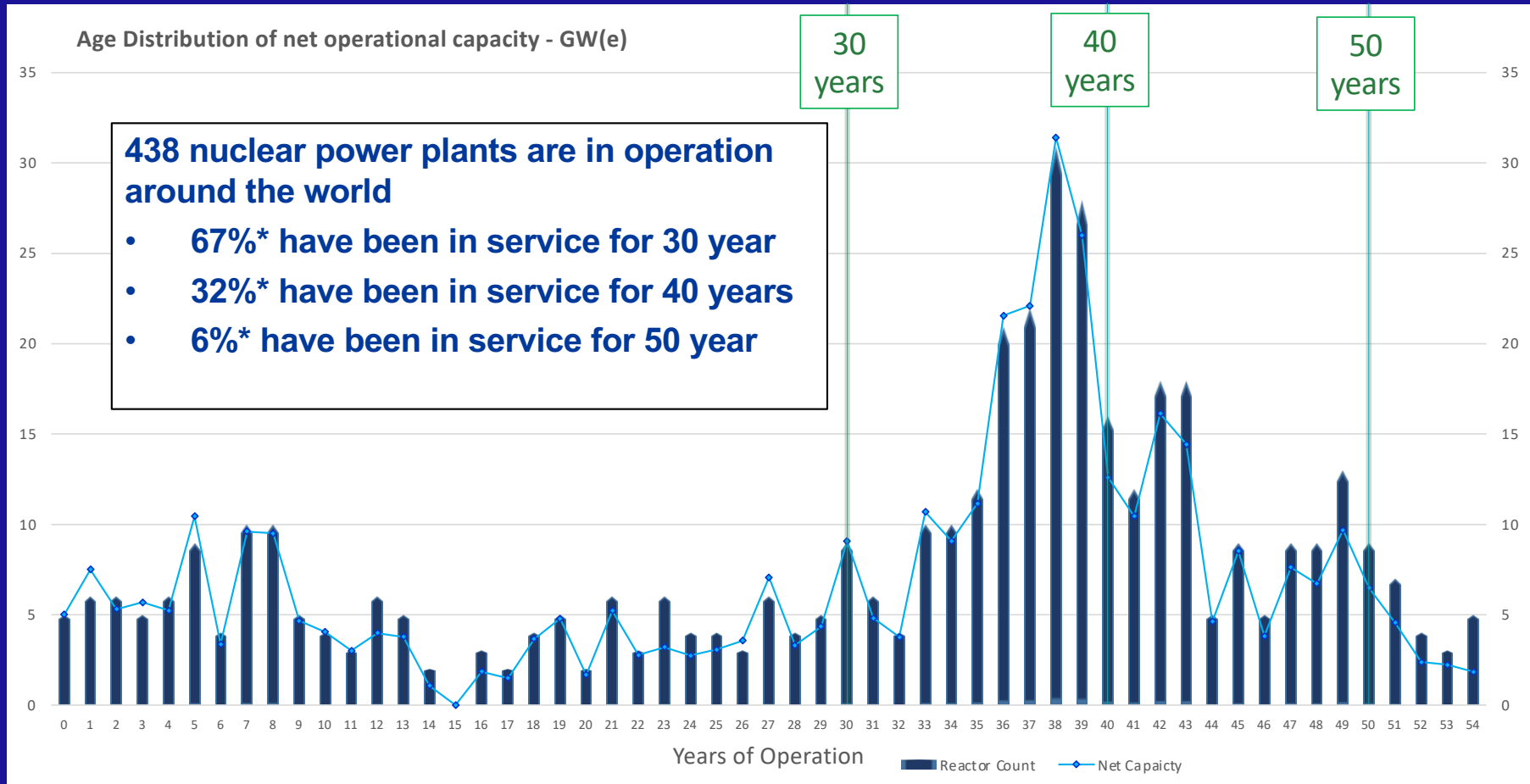
- ~ 58% - have now operated beyond initial 40-year license (55 units as of end of 2023)
- ~ 90% - Approved for license extension:
  - ~ 83% - Approved for 60 years of operation
    - 78 operating units (as of end of 2023)
  - ~ 6% - Approved\*\* for 80 years of operation
    - 6 operating units (as of end of 2023)
- 100% of plants are engaged in Long Term Operation (LTO) planning
  - Recent government policies provide strong incentive to continue NPP operation
    - Most plants working towards SLR
    - Plants beginning to look beyond 80 years



Note: The NRC has issued a total of 95 initial license renewals; 10 of these units have permanently shut down. Data are as of October 2022. For the most recent information, go to the NRC Web page at <https://www.nrc.gov/info-finder.html>.

\* Vogtle-3 & 4 started up since the publication of the NRC image of Oct 2022  
\*\* Pending successful resolution of on-going environmental review litigation

# Status of LTO Worldwide

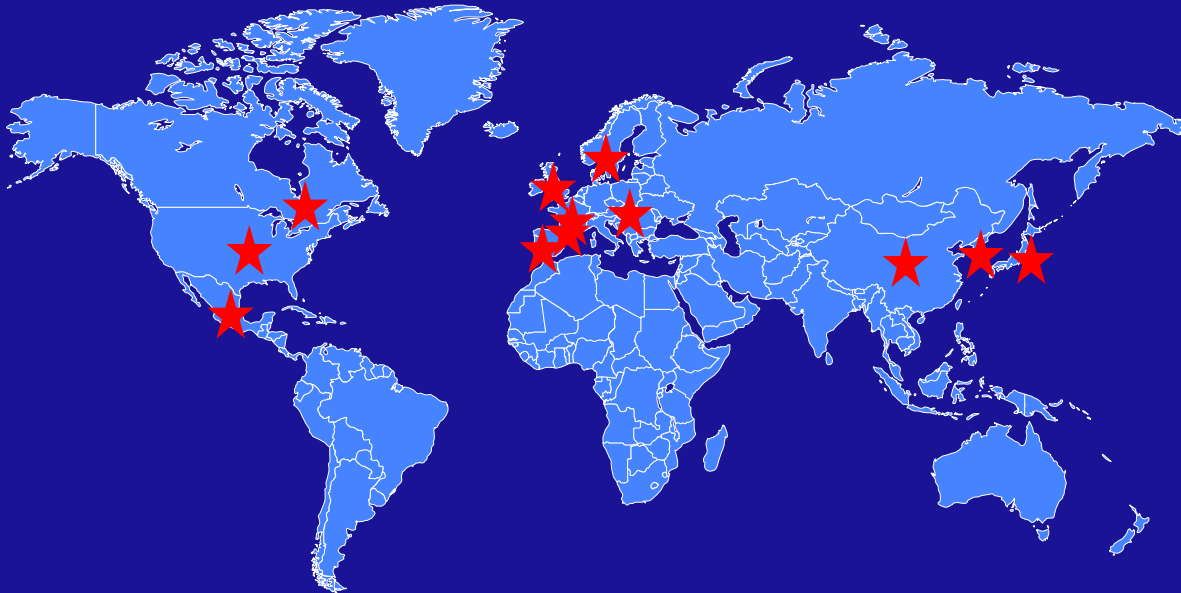


\*IAEA PRIS database, end of 2023, % of global operational nuclear capacity

<sup>3</sup>Source: <https://ourworldindata.org/electricity-mix> [Online Resource]



# Global Momentum for LTO



**Hungary looks to extend lifespan of Paks nuclear plant**  
Reuters, June 2022

**Switzerland Extends Lifespan of Nuclear Power Plants Amid Electricity Shortage Concerns**

BNN Breaking, November 2023

**The Finnish government grants Loviisa extension for continued operation until the end of 2050**

World Nuclear New, February 2023

- Nuclear Energy Is Essential to Energy Security
- Nuclear Plays a Critical Role in Climate Commitments
- Public Policy Signals Point to Nuclear

**Announcements of LTO intentions ARE global**

A blue-tinted image featuring a pair of hands holding a globe. The globe is overlaid with a circuit board pattern. The background is a dark blue space with stars and a faint constellation. The text "EPRI – Who is EPRI?" is centered over the globe.

**EPRI – Who is EPRI?**



# ABOUT US

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

# EPRI Research & Development

## TECHNOLOGY INNOVATION

Driving thought leadership, advanced R&D, and technology scouting and incubation to sustain a full pipeline of solutions



Nuclear Power



Energy Supply and Low-Carbon Resources



Electrification and Sustainable Energy Strategy



Transmission and Distribution Infrastructure



Integrated Grid and Energy Services

## STRATEGIC RESEARCH



Low-Carbon Resources



End-Use/  
Economy-Wide Carbon Reduction



Electric System Reliability/Resilience



Electric System Flexibility



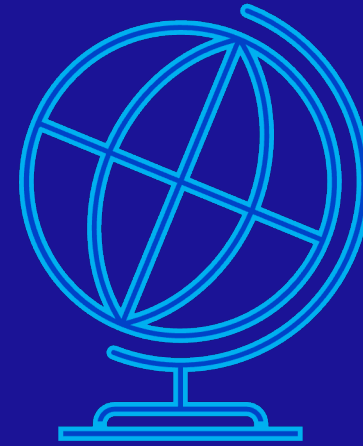
Market Transformation/  
Policy/Regulatory Education

# Nuclear Sector Membership

**51** full members:

**29** Non U.S.-based

**22** U.S.-based



**>350** reactors globally

**>80%** of the world's commercial reactors

**Global Operating Experience (OE) being shared every day**

# EPRI Global collaborators

Our world-renowned industry collaboration extends to these and many others





**EPRI Research Activities to Support LTO**

# Long Term Operation (LTO)

## MISSION

To provide the technical basis and research needed to support long term operation of nuclear power plants through proven practices and innovation that optimizes aging management programs while ensuring safety and reliability.

## EXECUTION

Mission achieved through:

- Determining key issues
- Developing methods
- Developing tech basis
- Transferring technology

*Together...Shaping the Future of Energy®*

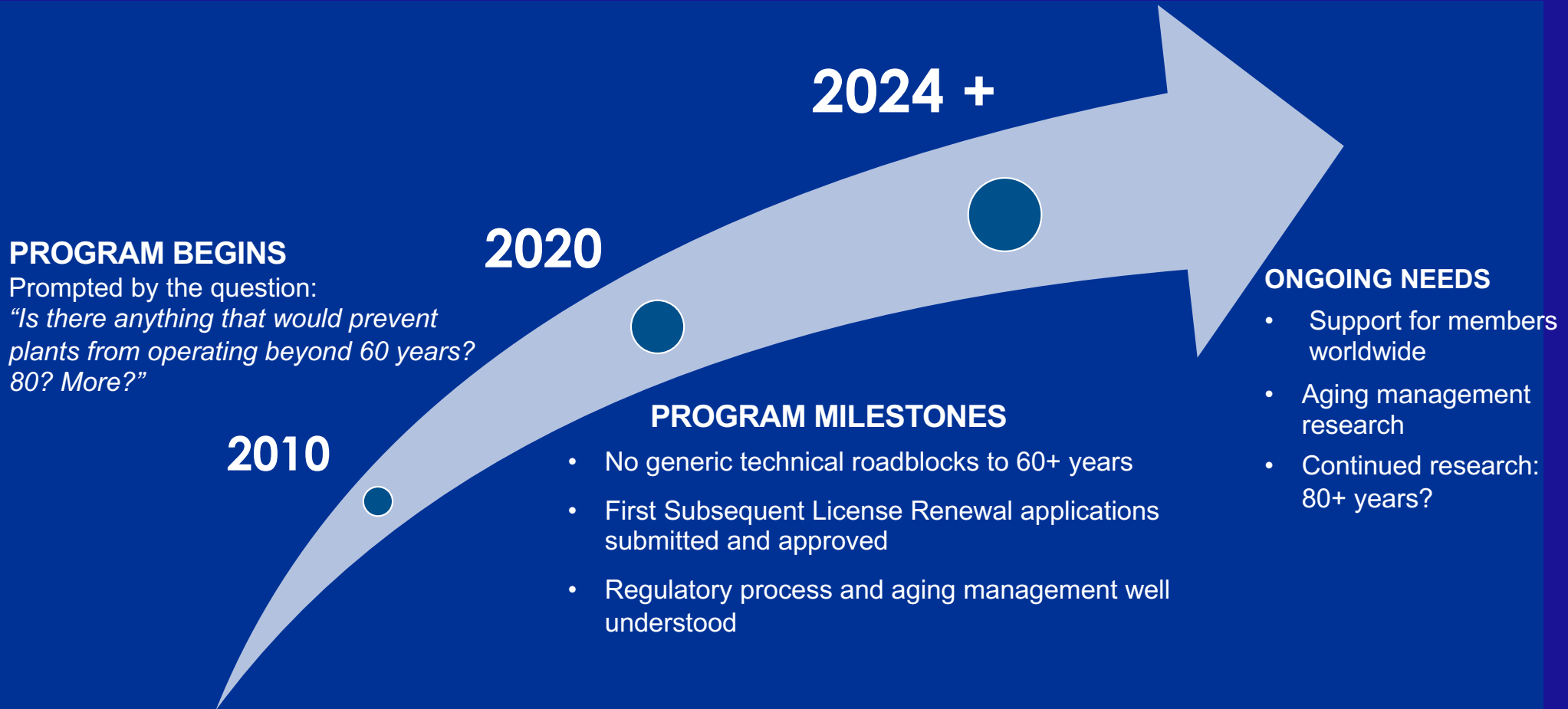


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# Nuclear Long Term Operation Research at EPRI



# Technical Issues of High Interest for 60+ Years of Operation

- **Reactor pressure vessel – neutron embrittlement**

- Trends for high fluence levels
- Sufficiency of material surveillance program capsules

- **Reactor vessel internals - high fluence effects**

- Irradiation-assisted stress corrosion cracking
- Loss of fracture toughness; void swelling

- **Concrete and containment performance**

- Radiation and high temperature exposure
- Alkali-silica reaction

- **Electrical cables**

- Environmental qualification
- In-service testing
- Long-term submersion



Each issue was addressed in SLR guidance

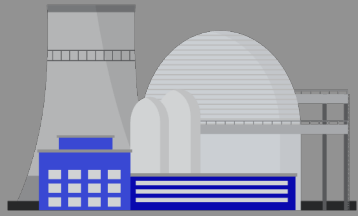
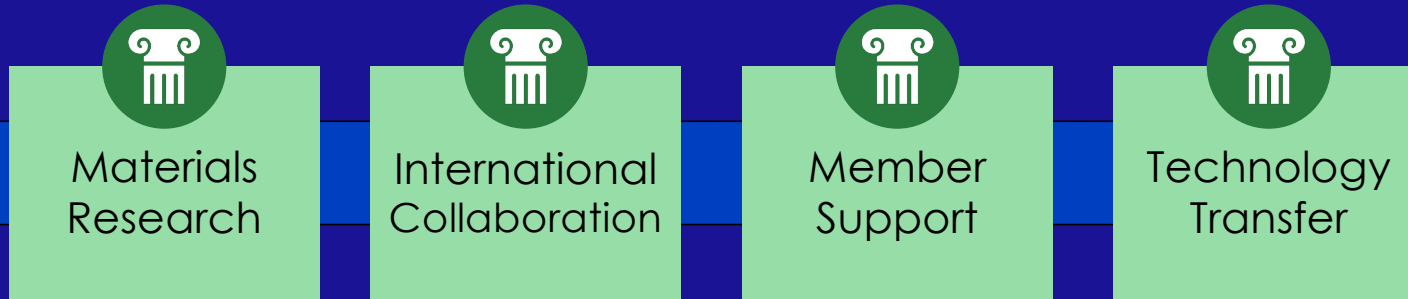


Research continues to validate and update guidance, as necessary

**NRC and Industry List of Issues for Subsequent License Renewal (SLR)  
Addressed in EPRI, industry, and NRC guidance**

# Long Term Operation (LTO)

Strategic  
Pillars



## Research Focus Areas



# LTO: Primary Materials and Components

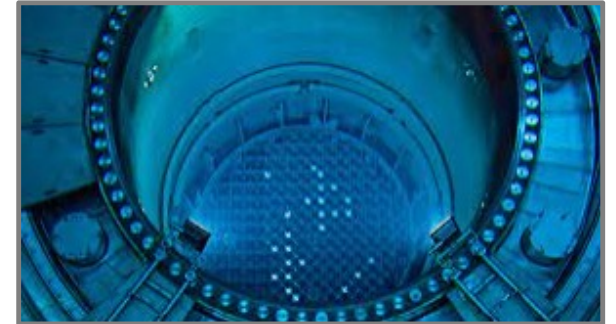


## Historical Body of Work:

- Material Reliability Program (MRP)
- Boiling Water Reactor Vessel Integrity Project (BWRVIP)
- Steam Generator Materials Program (SGMP)
- Material Degradation Matrix (MDM)
- Issue Management Tables (IMT)

## Current Research Topics:

- Continuing primary materials aging research & harvesting
- Advanced NDE
- Advanced welding
- Chemistry



# LTO: Electrical Cables & Components



## Historical Body of Work:

- Electrical cable aging management
- Electrical component aging management
- Condition monitoring

## Current Research Topics:

- Continuing cable and component aging management
- Environmental qualification
- Advanced cable condition monitoring
- Training and inspection guidelines



# LTO: Concrete and Structures



## Historical Body of Work:

- Concrete aging management
- Structures monitoring
- NDE techniques
- Inspection qualification

## Current Research Topics:

- Continuing concrete & structures aging management
- Advanced NDE
- Operating experience capture
- Training and inspection guidelines

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**Field Guide for Structures  
Monitoring Program Visual  
Inspections**

3002023714

# LTO: Mechanical Components



## Historical Body of Work:

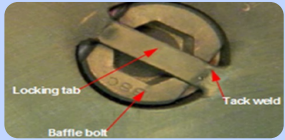
- Maintenance program guidance
- Buried and underground piping
- Selective Leaching
- NDE techniques
- Best Practices and OE on Components (pumps, valves, diesels, etc.)

## Current Research Topics:

- Continuing mechanical component aging management
- Advanced NDE
- Operating experience capture
- Component user's groups



# LTO and Aging Management Major Focus Areas



## Reactor Vessel, Core Internals, Primary Components

- Technical bases to support the aging of RPV, internals materials, steam generator, etc. (MRP, BWRVIP, SGMP)
- Advances in repair options such as welding for highly irradiated materials
- Water chemistry to protect and mitigate potential aging effects



## Concrete and Civil Structures

- Developed guidance on Alkali Silica Reaction
- Developed guidance on irradiation effects on the concrete biological shield and on structures
- Developed guidance on best practices for structural aging management programs



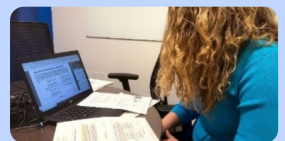
## Electrical Cables

- Research that supports cable reliability through end of plant operation
- Advances in condition monitoring technology and cable testing methods for aging management programs
- Cable Users Group (CUG) to share OE and best practices



## Other Projects

- Risk Insights for Aging Management Program implementation + LAMBDA software for asset management
- Spent Fuel Pool Coupon International Database to support an industrywide AMP, i-LAMP
- Advancing the state of practice relative to Selective Leaching and advanced NDE



## Ongoing Knowledge Transfer

- **EPRI Training** – Distance learning, computer based, classroom, and on-site technical training on aging management processes and practices



# Example Aging Management Courses



Low and Medium Voltage Cable Aging Management



Cable Aging Management: Identification of Adverse Environment, & Introduction to Visual/Tactile Assessment of Cable



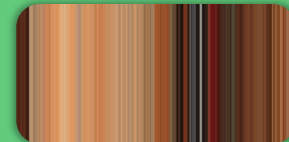
NDE for Engineers



Alkali Silica Reaction (ASR)



Aging Management Activities for Corrosion of Concrete Reinforcement



Related Courses:  
FAC, MIC, cathodic protection, buried pipe, coatings, NDE, etc.

See: <https://www.epri.com/training/courses?sectorLTN=Nuclear>

A blue-tinted image showing a pair of hands holding a globe. The globe has a grid of latitude and longitude lines. The word "Conclusion" is written in white, bold, sans-serif font across the center of the globe. The background is a dark blue gradient with faint, glowing lines and dots, suggesting a digital or networked environment.

**Conclusion**

## LTO Question:

Is there a generic technical issue that needs to be addressed that would PREVENT plants from extending their operating life/license beyond 60 years to 80 or even longer?

## Answer:

There are no generic technical roadblocks, first applications for 60+ years of operation have been submitted and approved. Regulatory process and aging management programs (AMPs) and continuing research needs are well understood.

**Extending the life of existing reactors is one of the most cost-effective ways to produce carbon-free electricity and meet future power demand needs.**

The background of the slide is a blue gradient with a faint image of a person's hands holding a globe. The sky is filled with stars and constellations, creating a celestial theme.

## EPRI Contact Information

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**LTO and Aging Management Strategy**

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The EPRI logo is displayed in white, bold, sans-serif capital letters on a dark blue background. The background of the entire slide is a dense grid of small, semi-transparent portrait photos of diverse people, creating a sense of community and global reach.

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