

# EPRI Research and Development Projects for NPP Decommissioning

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**IFE Workshop on Current and  
Emerging Methods for  
Optimising Safety and Efficiency  
in Nuclear Decommissioning**

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# EPRI Decommissioning

## Technology Program Overview (1/2)

- **Program Objective**
  - To provide technical guidance for the planning and conduct of facility decommissioning
- **Program Strengths**
  - Documentation of more than 20 years experience in the successful decommissioning of commercial power plants (more than 100 EPRI reports published)
  - More than 20 years of R&D results covering all critical technical areas in plant decommissioning
  - Offers a forum for utilities to share current experiences and state-of-the-art technologies for plant decommissioning



**US Decommissioning Workshop: Charlotte, North Carolina June 19-20, 2017**  
**International Decommissioning Workshop: Lyon, France October 24-25, 2017**

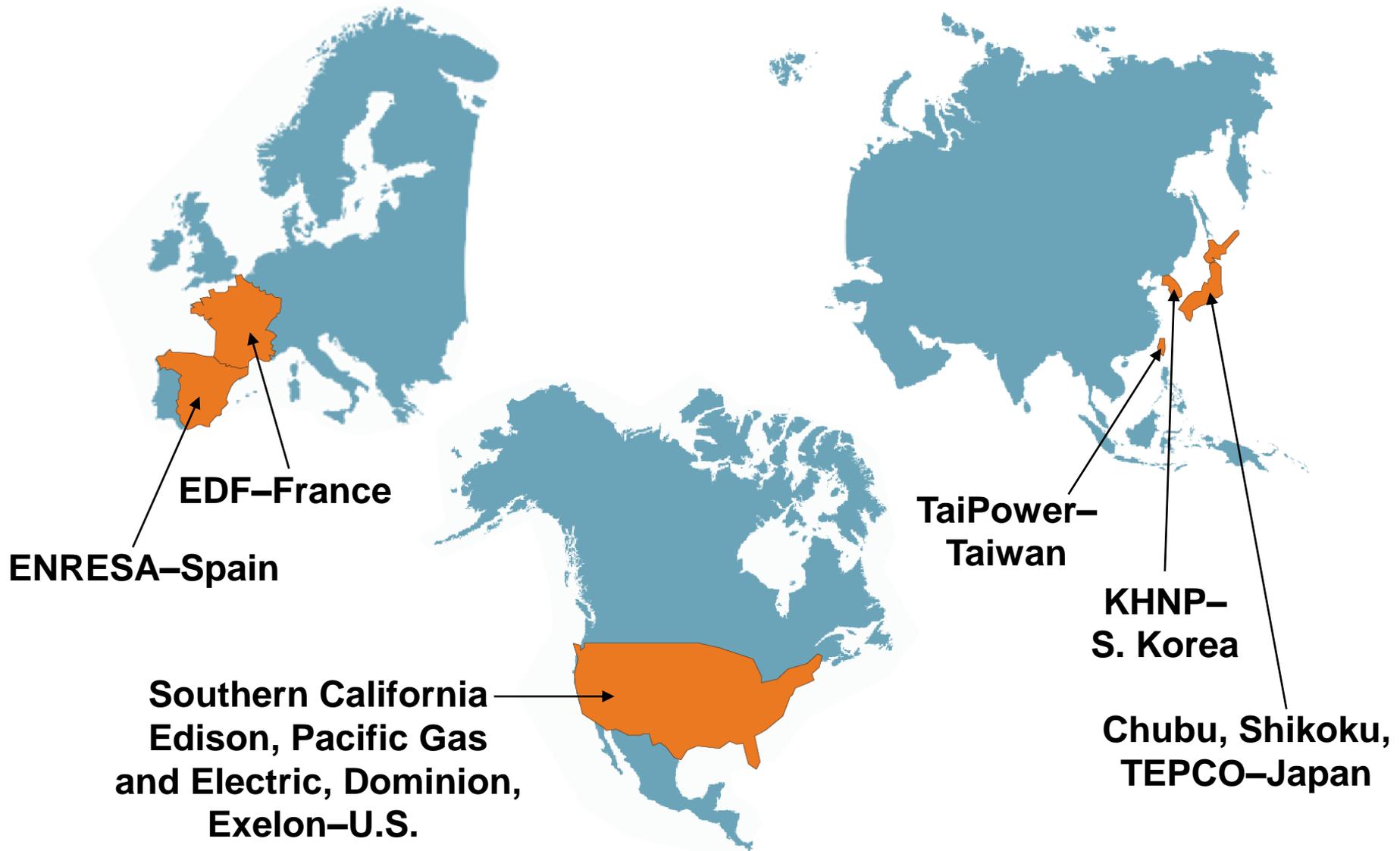
# EPRI Decommissioning Technology Program Overview (2/2)

- Guidance for key decommissioning activities
- Enhanced technologies in critical areas influencing safety, cost, schedule, risk and staff requirements
- Documentation of experience and synthesis of lessons learned to develop best practice guidance
- Examples:
  - Decommissioning planning guidance
  - Decontamination for decommissioning process development
  - Guidance for site characterization and release
  - Guidance for waste management
  - Experience with reactor vessel and internals segmentation



**Program results applicable to all  
plant designs and all countries**

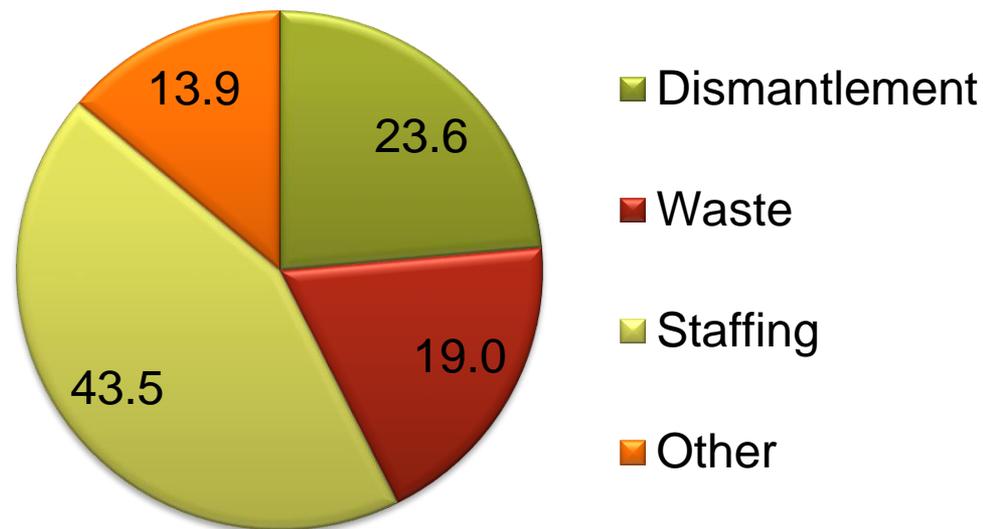
# Decommissioning Technology Program Membership



# Decommissioning Research and Development Drivers (1/2)

- Technologies exist for successful decommissioning
- Overall cost driven by utility staffing cost (“hotel load”)
- Technology improvements needed to shorten duration
  - Cost of staffing during decommissioning: 25M Euro/year or more

## U.S. Cost Categories as Percentage of Total Costs



***EPRI Report: Decommissioning Experiences and Lessons Learned: Decommissioning Costs (#1023025, 2011)***

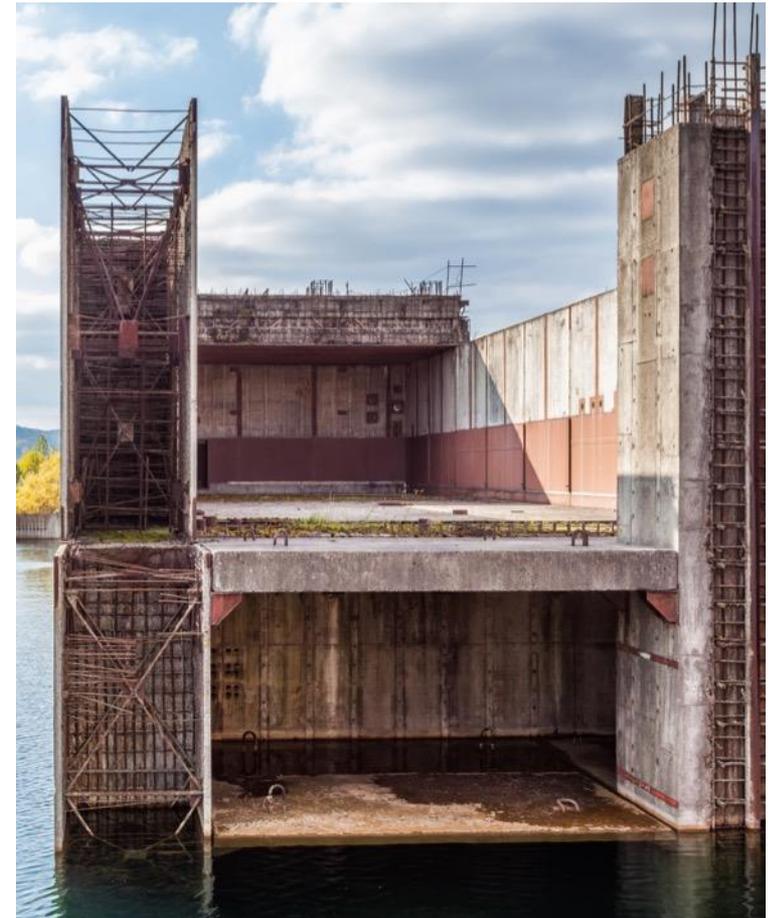
# Decommissioning Research and Development Drivers (2/2)

- A large volume of waste material is generated during decommissioning
  - Radioactive, hazardous and non-radioactive/below clearance limit
  - Accurate estimation, tracking and characterization are critical
  - Optimized treatment and packaging options for efficient waste handling can have a substantial effect on costs
- Decommissioning is a complex process: effective planning and project monitoring is critical
  - Regulatory requirements apply throughout the process
  - Substantial involvement of external stakeholders
  - Management of multiple contractors/subcontractors
  - Little in-house expertise exists for most utilities

# Recent and Ongoing EPRI Research

# Decommission Planning

- Lessons learned from completed projects are key inputs to planning
- Most regulators require some level of planning throughout plant operations
  - Necessary to establish set-asides for decommission fund
  - Inaccuracies in planning may result in budget shortfalls during decommissioning
- Detailed planning should optimally be started no later than five years before permanent plant shutdown
  - Address early and long-lead decommissioning activities
- Relevant EPRI report published in 2016



**Estimated costs in excess of 50M Euro attributed to lack of time for good planning at several early-shutdown plants in the 1990s**

# Groundwater Monitoring During Decommissioning Planning

- Recent regulation and guidance in the U.S. has increased the focus on subsurface contamination at NPPs
- International guidance concerning drinking water standards also provides levels for consideration outside the U.S.
- Requirements and Scope of Groundwater Monitoring Programs differ for operations and decommissioning at NPPs
- Guidance provided in the following documents can be used to help address these regulations and guidance during operations and decommissioning of nuclear facilities:
  - *Nuclear Energy Institute (US) 07-07, Groundwater Protection Initiative*
  - *EPRI Groundwater Protection Guidelines*
  - *EPRI Soil and Groundwater Remediation Guidelines*
- Guidance specific to decommissioning planning provided in *EPRI Groundwater Monitoring Guidance for Decommissioning Planning* (published in 2016)



# Review and Assessment of Robotic Systems and Process Automation for Commercial NPP Decommissioning

## Issue

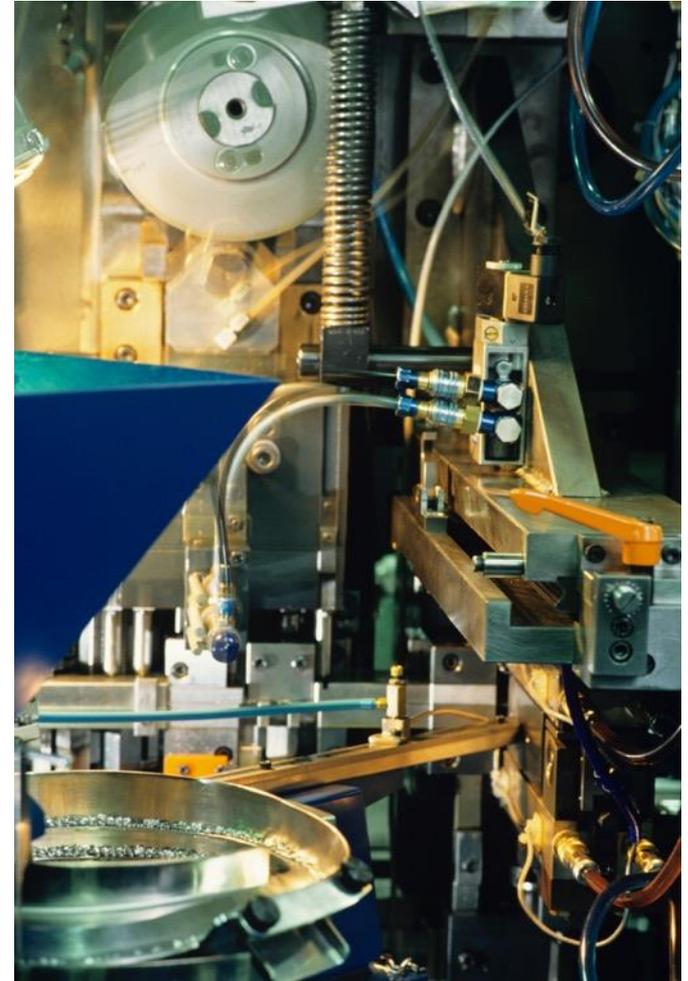
- Use of robotics/automated systems offer a substantial benefit with respect to worker safety, exposure reduction, project cost and overall schedule

## Project Goal

- Systematic evaluation of decommissioning tasks to determine those that would benefit from use of automated systems/robotics
- Evaluate available automated and robotic systems used in non-decommissioning/non-nuclear applications

## Project Benefit

- Informs Future R&D in development of new technologies for performance of critical decommissioning tasks



# Decommissioning Waste Management Tracking Software Technical Specification

- A large quantity of waste is generated during decommissioning.
- Waste is typically handled many times before it is transported for disposal.
- It is critical to track waste from the point of generation to final packaging for disposal
- EPRI project developed technical specification software to uniquely track decommissioning waste through the preparations for shipment to final waste disposal
- Benefits included an integrated, industry-standard approach to waste tracking during decommissioning
  - Benefits work-flow management
  - Cost reductions, particularly with respect to waste characterization and classification



# Decommissioning Wiki Database

- A wealth of experience is available from completed and ongoing decommissioning projects
- Experience largely captured in more than 30 EPRI reports
- There is a need for a searchable data base for decommissioning experience covering all areas (planning, execution, site characterization and release)
- Project Status
  - Began development of Wiki-format database in 2016
  - Database roll out to EPRI program members in early 2017
  - Additional functionality, content and access to be added through 2018



# Development/Demonstration of US Department of Energy D&D Technologies for Commercial Power Plant Decommissioning

- More than 20 years of R&D experience available in the US DOE Environmental Management program
  - Field-proven technologies in all areas related to facility decontamination and dismantlement
- Project objectives
  - Review technologies
  - Collaborative demonstration of promising field-proven technologies
  - Collaborative R&D to develop new technologies



Integrated Remote Platform for Application of Fixatives on Vertical Surfaces at Oak Ridge

***EPRI Report: Assessment of US Department of Energy D&D Technologies for Commercial Power Plant Decommissioning, 3002005411, 2015***

# DOE Collaboration Project Approach

- Work Completed:
  - Status of past and current DOE R&D projects evaluated
  - Technologies identified for further development or demonstration identified
- Proposed 2017 - 2018 scope is to complete at least two of the following based on 2016 work:
  - Develop a DOE technology(s) to a field-ready state
  - Conduct a field demonstration of a field-ready DOE technology not previously demonstrated
- Research Value:
  - Schedule reduction can have very large cost benefit as the expenditure rate during plant decommissioning can be in the range of 300,000 Euro per day.
  - It is expected that this project will help to reduce the overall cost of decommissioning

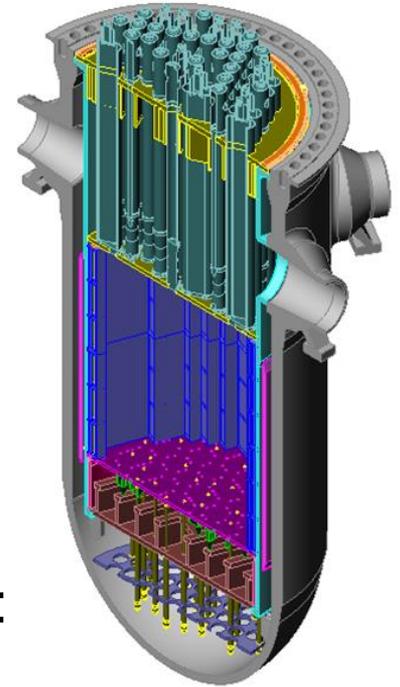
# Decommissioning Sourcebook Project

- Develop a sourcebook for planning and execution of nuclear plant decommissioning based on:
  - The investigation and analysis of previous NPPs decommissioning experiences
  - Consideration of new developments and lessons learned
  - The regulatory requirements and guidance in various countries
  - Other considerations such as cost and the availability of waste disposal
- Key decommissioning activities to be covered:
  - Decommissioning strategies
  - Decommissioning milestones and schedules
  - Site characterization
  - Decontamination methods for primary loop, equipment and concrete
  - Segmentation methods (including Reactor Pressure Vessel, Reactor Internals, Steam Generator, Pressurizer, etc.)
  - Dismantlement and demolition methods for SSCs
  - Recycling of decommissioning wastes (including metals, concrete, etc.)
  - Site remediation and release
  - Decommissioning radioactive waste management strategies (including treatment)

# Application of Robotics and System Automation to the Segmentation of the Reactor and Reactor Internals

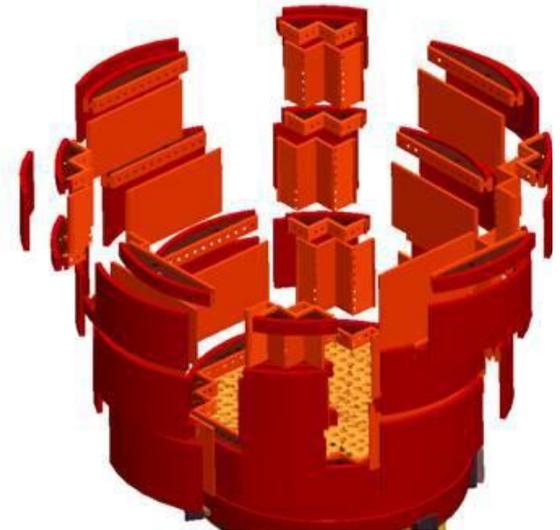
# Why Focus on Reactor Internals Segmentation?

- Typically one of the most challenging nuclear power plant decommissioning tasks
- Cutting of the various assemblies typically must be performed underwater to minimize exposures.
- Experience is that the technologies used have shortcomings.
- Has led to high personal exposures, long project durations, and high total costs.
- Previous EPRI work on automation has focused on:
  - Phase 1 (2014-2015): evaluation of all decommissioning tasks to identify candidate tasks for automation
  - **Results:** highest priority tasks are reactor internals segmentation, site characterization and concrete decontamination



# EPRI Project: System Automation for Reactor Internals Segmentation (2016 – 2019)

- Objective: Develop a system automation approach to manipulator and/or cutting technologies that can safely reduce the duration of reactor internals segmentation projects.
- 2016 – Identified candidate technologies for further development and/or testing including:
  - Underwater laser cutting
  - Improved saw technologies
  - Automated visual guidance control of cutting and segment handling
  - EPRI Report to be published in early 2017
- 2017/2018 - Development of technologies identified in 2016 work via small scale testing.
- 2018/2019 - Based on the results of the small scale testing, full scale non-rad testing
- 2019/2020 – Based on non-rad testing, a full scale field demonstration would be conducted.



Segmentation Plan for Reactor Internals

