

**EPRI** | ELECTRIC POWER RESEARCH INSTITUTE

# Electric Power Research Institute (EPRI) and the Advanced Nuclear Technology (ANT)




## Program Overview

February 15, 2017

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## Our History...Born in a Blackout



- EPRI was founded by and for the electricity industry in 1972 following **The Great Northeast Blackout** in New York City in 1965
- Formally established in 1973 as the Electric Power Research Institute, EPRI manages a broad public-private collaborative research program on behalf of the electric utility industry, the industry's customers, and society at large

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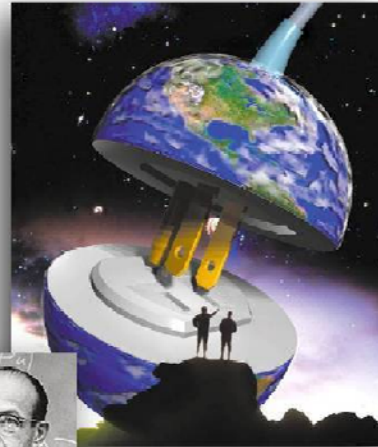
## Our History...Born in a Blackout



- EPRI is an independent, nonprofit center for public interest energy and environmental research
- Collaborative resource for the electricity sector
- Major offices in Palo Alto, CA; Charlotte, NC; and Knoxville, TN
  - Laboratories in Knoxville, Charlotte, and Lenox, MA



**Chauncey Starr**  
EPRI Founder



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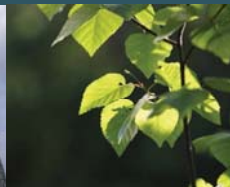
## EPRI's Mission

Advancing safe, reliable, affordable and environmentally responsible electricity for society through global collaboration, thought leadership, and science & technology innovation.

- Independent
- Non-Profit
- Collaborative



**Nuclear**



**Environment**



**Generation**



**Power Delivery and Utilization**

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## EPRI Portfolio Spans the Entire Electricity Sector



### Nuclear Power

- Advanced Nuclear Technology
- Chemistry, Low-Level Waste, and Radiation Management
- Equipment Reliability
- Fuel Reliability
- Instrumentation and Control
- Long-Term Operations
- Material Degradation/Aging
- Nondestructive Evaluation and Material Characterization
- Risk and Safety Management
- Used Fuel and High-Level Waste Management

### Environment

- Air Quality
- Environmental Aspects of Renewables
- Global Climate Change
- Land and Groundwater
- Occupational Health and Safety
- T&D Environmental Issues
- Water and Ecosystems

### Generation

- Advanced Coal Plants, Carbon Capture, and Storage
- Combustion Turbines
- Environmental Controls
- Generation Planning
- Major Component Reliability
- Operations and Maintenance
- Renewables

### Power Delivery & Utilization

- Transmission Lines and Substations
- Grid Operations and Planning
- Distribution
- Energy Utilization
- Cross Cutting Technologies

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## EPRI Nuclear Sector's Mission

### Nuclear Power

- Advanced Nuclear Technology
- Chemistry, Low-Level Waste and Radiation Management
- Equipment Reliability
- Fuel Reliability
- Long-Term Operations
- Materials Degradation/Aging
- Nondestructive Evaluation and Material Characterization
- Risk and Safety Management
- Used Fuel and High-Level Waste Management



To develop and provide the nuclear industry with safe, reliable, economic, and environmentally responsible technologies that:

1. Maximize the utilization of existing nuclear plants
2. Enable the deployment of advanced nuclear plants
3. Support long-term sustainability of nuclear energy


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## Nuclear Sector Membership



GLOBAL PARTICIPANTS



>320

reactors worldwide


GLOBAL BREADTH & DEPTH

>75%

of the world's commercial nuclear units

Participants Encompass Most Nuclear Reactor Designs

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## ANT Program Mission

The EPRI Advanced Nuclear Technology (ANT) Program leads Research and Development (R&D) through EPRI's collaborative model to proactively evaluate and address issues regarding the near-term deployment of advanced light water reactors.

MISSION

Basic Research and Development

National Laboratories, Universities

➔

Collaborative Technology Development, Integration and Application


EPRI

➔

Technology Commercialization

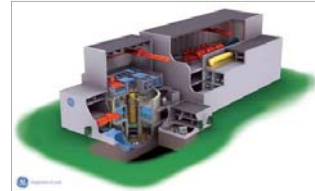
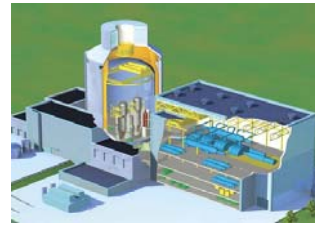
Suppliers, Vendors

The ANT Program is a scientific research program for those around the world and at various stages of new nuclear plant development and deployment, concentrating on the economic, technical, regulatory, and social issues that could affect the ability to license, construct, start-up, and operate advanced light water reactors.

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## ANT Program Overview

- **Accelerates and focuses work targeted at new plants**
  - Work not already being done in other areas of EPRI
- **Primary focus is on light water reactor designs**
  - Gen III, Gen III+, and light water Small Modular Reactor (SMR) designs
- **Increasing focus on longer term designs**
  - Gen IV and non-light water SMRs
- **Address Multiple Stakeholders**
  - Global issues and various stages of deployment
- **Target issues where EPRI can have an impact**
  - Clear value in our collaborative environment



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## ANT Program Goals

- **Reduce the Overall Deployment Risk and Uncertainty for New Nuclear Plants**
  - Reduce cost of new plant construction through increased speed and quality
  - Reduce the cost of systems and components and their installation
  - Reduce lifetime operations and maintenance (O&M) costs
- **Apply New and Existing Technology to Reduce Costs and Increase Safety and Reliability**
  - Leverage existing technologies inside and outside the nuclear industry
  - Work with codes and standards bodies to ensure technology is usable
  - R&D to solve challenges brought by new plant designs
- **Facilitate Common Approaches across the Fleet through Use of the EPRI Collaborative Model**
  - Generate industry standardization through cooperation in developing technologies, processes, and guidance



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## ANT Technical Focus Areas

- **Engineering, Procurement, and Construction**

- Siting, design, construction materials, and construction activities of the physical plant, including modular construction

- **Materials and Components**

- Class 1, 2 & 3 piping systems and related components such as valves, heat exchangers, and pumps
- Optimize methods for fabrication, installation, joining, inspection, and operations, including chemistry
- New applications of materials and component

- **Modern Technology Application**

- Maximize the use of enabling, new, and potentially non-nuclear specific, technology in new nuclear plants

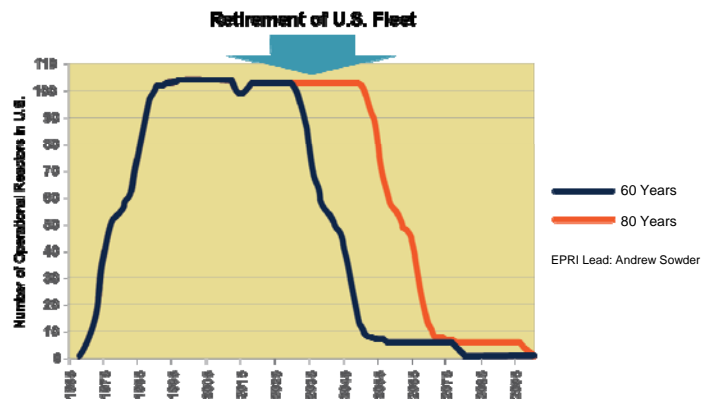


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## Strategic Program (2016–2019)



- **Articulate what the customer wants from GEN IV**

- Assemble expectations and desired technology attributes from owner/operator perspective

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## Strategic Program (2016–2019)

- **Identify RD&D pathways to deliver what the customer wants from GEN IV**
  - Collaboratively develop a utility-facing GEN IV technology RD&D roadmap to inform and prioritize deployment-driven, commercially-relevant implementation paths and programs
- **Scout global development of GEN IV systems and enabling technologies**
  - Track emerging technologies and innovation opportunities with potential to accelerate deployment
- **Assess and analyze**
  - Perform deep-dive technology assessments and case studies of promising GEN IV reactor concepts and enabling technologies



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## Anticipated 2016 ANT Membership and Participation

U.S. Operators	Non-U.S. Operators	Non-Operators

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## Engineering, Procurement and Construction–Concrete Projects

- **Self Consolidating Concrete (ongoing)**
  - Physical properties help ensure uniform consistency during transportation, placement, and over life
  - Particularly useful for heavily reinforced sections and complex shapes found in new plant construction
  - Little is known about reliability for complex nuclear structures and its mechanical properties vs. conventional concrete (invented in 1986)
  - Mixtures can be difficult to manage and sensitive to process variation
- **High Strength Rebar (ongoing)**
  - Higher Yield Strength -> 100–120 ksi
  - Reduce volume, construction time, material cost, congestion (voids)



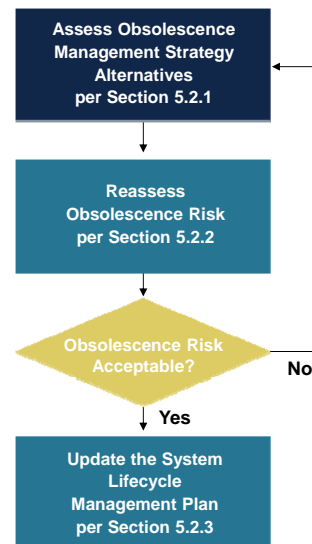
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## Modern Technology Application–I&C Related Projects

- **Requirements Engineering for Digital Systems (3002002843)**
  - Digital implementations have exhibited cost and schedule overruns, unexpected behaviors, and inadvertent plant trips
  - Many difficult digital implementations can be traced to problems in requirements specification, especially inadequate specification of what the system should **not** do
  - Report defines an iterative approach that includes hazard analysis, risk considerations, and conformance checks



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## Modern Technology Application–I&C Related Projects

- **Managing Digital I&C Obsolescence (3002002852)**

- Obsolescence of digital I&C equipment is inevitable
- Obsolescence is essentially guaranteed with the licensed lifetime of the plant
- Operators need an overall strategic plan that can mitigate obsolescence
- Report provides an innovative approach to maximizing the digital I&C lifecycle

- **Human Factors Guidelines Update (complete December 2015)**

- Guidance on applying HFE for plant reliability, productivity, and safety
- Guidance on how to design, not just review for acceptability
- Addresses new builds as well as current operating plants
- Addresses changes in regulatory guidance and new relevant industry standards
- Considers recent and potentially forthcoming technologies



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## Modern Technology Application – New and Emerging Concepts

- **Cyber Security for New and Operating Plants**

- Utilities are spending over \$1B to meet cyber security requirements for plants
- Cyber security during new plant construction
- Cyber security procurement guidelines

- **Sensors and Automated Technologies for New Plants**

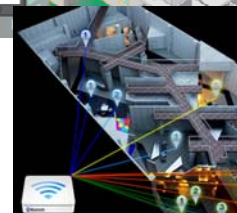
- Data management and automation can save money and optimize staff

- **Alarm Processing and Management**

- New plants are exclusively digital → 40,000+ alarms
- How alarms are suppressed and displayed; impact on control room operators

- **Internal Positioning Systems**

- GPS-level location accuracy *inside* plant containment
- Supports many other enabling technologies, but biggest impact is radiation protection



Source: Stanford University

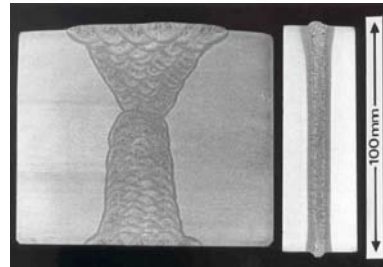
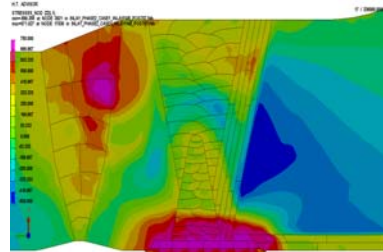
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## Materials and Components—Managing Residual Stress

- **ALWR Residual Stress Guidelines (3002005402 and ongoing)**
  - Account for residual stress in the design, not in O&M
  - FMEA methodology for identifying and quantifying RS risk
  - Guidance on management strategies and mitigation options
- **Thick Section Component Welding (ongoing)**
  - Current thick section joining techniques are time consuming and expensive
  - Advanced welding techniques exist that the Nuclear Industry could leverage
  - New techniques could provide a positive impact to weld residual stress



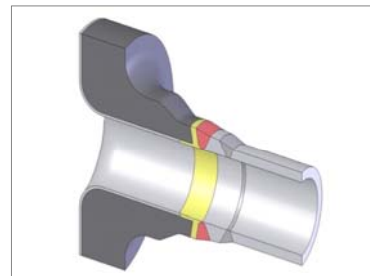
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## Materials and Components—Managing Residual Stress

- **Real Time NDE for Welding**
  - High weld residual stress on inside surface may lead to stress corrosion cracking
  - There is a risk of weld repairs inducing extensive stress on the ID of piping
  - Develop pass-by-pass inspection to catch defects early, repairing less 'material'
- **Powder Metallurgy-Hot Isostatic Processing (PM/HIP)**
  - Manufacture of large components such as pressure vessels nozzles valves, pumps, turbine rotors
  - Moves from forging, rolled and welded technologies to PM/HIP
  - Complex "Near-Net Shape" components enhancing inspectability
  - Alternate supply route for long-lead time components



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## SMR Staff Optimization Project

- **Supports Deployment of Small Modular Reactors**
  - SMR staff effectiveness, efficiency, and O&M cost control
  - Supports DOE efforts to deploy 2 SMR full-scale pilot SMR projects
  - Advises and informs SMR designers of technologies and design details of import to SMR staffing
  - Advises and informs EPRI and DOE of development efforts of import to SMR staffing
  - Provides insights to other reactor designs of technologies and design details that can impact staffing
- **Subject Matter Expert, SMR Vendor and Industry Advisor Elicitation by Plant Function Area**
  - Chemistry, radiation protection, engineering, maintenance, operations, training and outage management, security (NEI input), emergency preparedness, and technical oversight



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## Nuclear Technology at EPRI – The Advanced Nuclear Technology (ANT) Program



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## Together...Shaping the Future of Electricity