ELECTRIC POWER RESEARCH INSTITUTE

Identifying Research Projects and Delivering the Results at EPRI

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EPRI 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 Nuclear Sector Research and 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

EPRI Nuclear R&D: Global Collaboration and Reach

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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Key EPRI Nuclear Interfaces

INPO®

U.S.NRC

WANO

ÚJV ŘEŽ

KHNP Nuclear Engineering & Technology Institute

CRIEPI

NEA NUCLEAR ENERGY AGENCY

EPRI ELECTRIC POWER RESEARCH INSTITUTE

NEI NUCLEAR ENERGY INSTITUTE

U.S. DEPARTMENT OF ENERGY

DE LA RECHERCHE À L'INDUSTRIE cea

MIT Massachusetts Institute of Technology

EDF

IAEA International Atomic Energy Agency

NMI materials ageing institute

INDUSTRY COLLABORATION

STRATEGIC ALIGNMENT

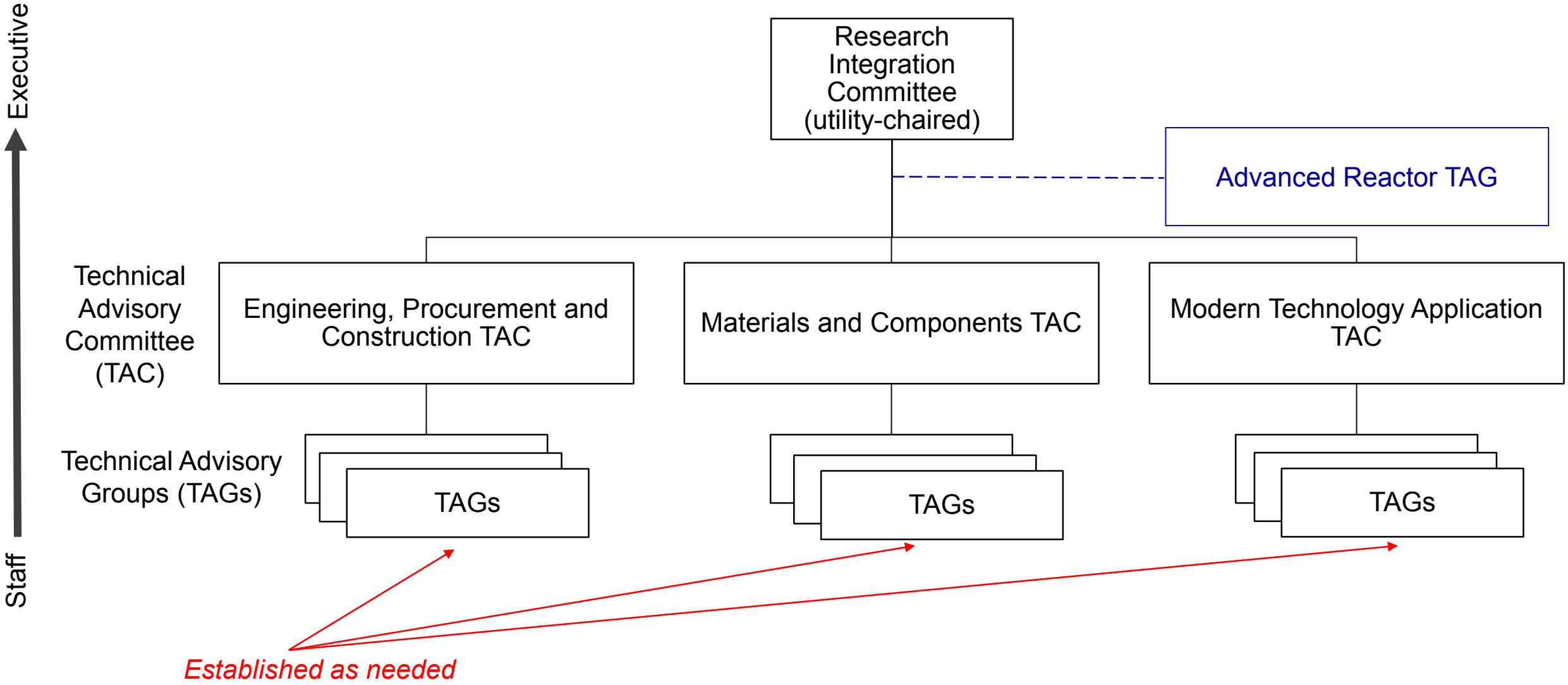
ACTIVE ENGAGEMENT

FREQUENT COMMUNICATIONS

EPRI Is All About Input

- Board of Directors
- Advisory Council
- Research Advisory Committee
- Technology Management Committee
- Sector Councils (Nuclear, Generation, Energy and Environment, Transmission and Distribution)
- Program Committees (next slide)

Advanced Nuclear Technology (ANT) Program Advisory Structure



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ANT Research Focus Areas for Balanced R&D Portfolio

TAC	Research Focus Area
Engineering, Procurement & Construction (EPC)	Increase Efficiency and Reduce Cost of New Nuclear Construction
	Development of Collaborative Engineering, Design Tools, and Processes
	Improve Quality of Supply Chain for Nuclear
Modern Technology Application (MTA)	Advanced Monitoring Technology and Data Management
	Technologies to Improve Human Performance, Machine Interaction, and Operational Effectiveness
	Gaps for Use of Digital Systems Technologies in New Plants
Materials and Components (M&C)	Advanced Fabrication and Manufacturing Techniques
	Material Performance and Inspection
	New Materials Development

Two-Year Project Planning Cycle To Keep Pipeline Filled

EPC	M&C	MTA
	Target 2019	
Advanced Welding for Infrastructure and Construction	A Pathway to Factory Fabrication for Modules and Components	Gaps and Opportunities for Sensor Applications
Automated Quality Assurance Inspection for Embedded Items in Concrete Members	Additive Manufacturing Development Strategic Focus Area	Applications for Commercial Common Platform Robotic Systems
Best Practices for Self-Consolidating Concrete as Mass Concrete	Value Comparison between Manufacturing Techniques	Assessment of Advanced Security Technologies
Prefabricated Structural Modules for Nuclear Construction	New Materials Scoping Assessment	Investigation of Virtual Technical Assistant
	Target 2020	
Enhanced Concrete Formwork Technologies	Development of Adaptive Feedback Welding for Repair and Fabrication	Guidance for Wired and Wireless Sensor Applications
Alternative Methods and Materials to Reinforce Concrete	Applicability of EPRI ASME Focused Products with International Codes	Updates to HFE Guidelines
Performance-Based Design for Civil and Structural Applications	Risk Informed Strategies Small Modular Reactors (SMRs)	Identification of Regulatory Challenges for Advanced Plant Data Models
Guide to Evaluating and Developing Supplier and Vendors	Advanced Reactor Material Development Strategic Focus Area	Investigation of Remote Shift Technical Advisor (STA)

Longer Range Multiyear Plan To Maintain Strategic Vision

Activity	Technical Topic	Completed Projects	Current Projects	2019	2020	2021	2022	2023+
1. Scouting			Scouting for EPRI Technology Innovation Program					
2. Owner-Op Req.		Scoping Study	AR owner-operator requirements guide (ORG) Rev0	ORG Rev 1		*ORG Rev 2*		
3. Technology Assessment and Tool Development	Technology Assessment			*Revise EPRI siting guide for application to adv reactor deployment*	*Evaluation of advanced power conversion technologies for ARs*	*Evaluation of dry/hybrid cooling systems for ARs*		
	Fuel Cycle Analysis	Fuel cycle mod/sim capabilities		*Evaluation of AR back-end waste streams*	*Fuel cycle analysis of front-end and back-end impacts of new technologies*			
	Safety Assessment and Risk Informed Methods			*Extending EPRI Safety Assessment Tools to ARs*				*Advanced Reactor Risk and Safety Assessment Modeling Tool Box*
			PHA to PRA: Best practices and methodology		*Risk informed Strategies for ARs (50.69)*	*Pilot ANS 30.1 implementation*	*Alternative end state PRA for ARs*	
					MSR component reliability database development		*AR seismic design and analysis*	
4. Strategic Analysis and Thought Leadership	Techno-Economic Analysis		Economic analysis for AR competitiveness	*Quantifying value of advanced nuclear energy systems*		*Expansion of techno-economic modeling tools*		
				Improved cost model for new nuclear construction	*Refining flexibility attributes for ARs*			
	Thought Leadership	Historical Review of Gov't/Industry Roles		Reasonable build rates for new nuclear	*AR attributes supporting energy network resiliency*	*Rethinking AR design-life*		
		AR Flexibility		Feasibility of MW-scale reactors for utility applications	*Demo plan for MW-scale reactor*			
5. Targeted Technology Development	Construction and Constructability				*High temperature concrete for AR applications*			
	Advanced Materials and Mfrg		GEN IV Materials: Gap analysis, fabricability assessment and material optimization		*Advanced material and manufacturing development program*		*Program on Materials and Manufacturing for Advanced Reactor*	
Completed	Advanced Technology R&D			*I&C for high temp, non-LWR systems*				
Current				*NDE for advanced reactors*		*Primary system chemistry control and rad protection R&D for non-LWRs*		
Scoped	Qualification and Licensing Support			Limited scope TRISO/particle fuel topical report (AGR)	*Topical reports on key R&D issues for advanced reactor designs and classes, e.g., nuclear grade graphite (AGC), qualification of liquid fuels…*			*Code case support for new materials for AR designs and applications*
Planned								

Considerations in Proposal and Prioritization of R&D

- Current or emerging issue
- Importance or severity of issue
- Value across stakeholders, nuclear plant designs, geographical boundaries
- Available resources
- Timing (available soon enough?)
- Tactical-strategic balance in R&D portfolio
- Opportunities for collaborations and leveraging of resources and impact (e.g., standards)

EPRI Product Availability

- "As a non-profit scientific research 501(c)(3) organization, EPRI has an obligation to make the results of its scientific research available to the public on a non-discriminatory basis."
  - Most EPRI research is available to the public, but not necessarily for free
  - Pricing intended to fairly reflect cost to funders who supported research (among other considerations)
  - EPRI annually evaluates products older than five years for reduced or zero pricing

- Other circumstances may also compel public release at reduced or zero pricing
  - The value of the report depends on public access or use in a public forum
  - Examples include standards and code development or to inform regulatory process

- Presence of proprietary or third-party intellectual property (IP) generally precludes public release unless…
  - A non-proprietary public version can be prepared
  - Permission for release is granted by IP holders

Selected Examples of Current ANT Program Projects

Integration of Safety Assessment into AR Design Process

Scope

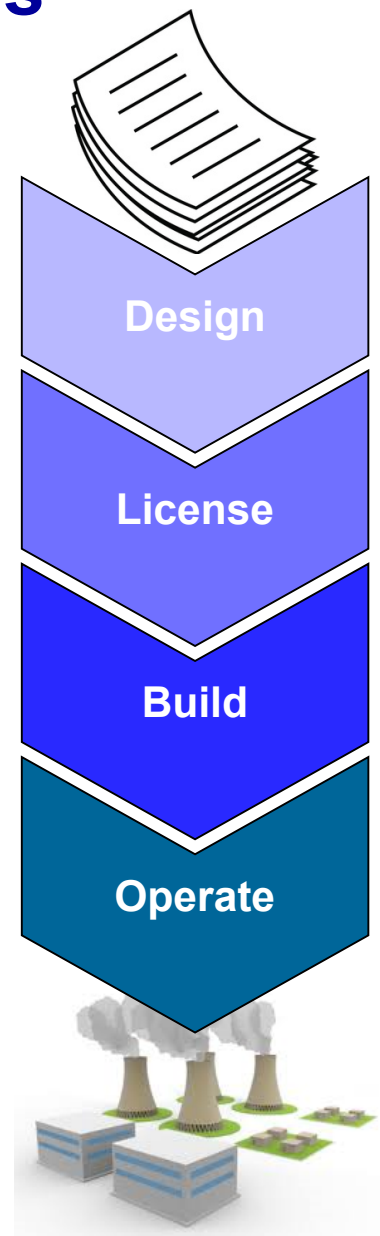
- Assemble a “body of knowledge” on application of PHA and PRA methods
- Develop, describe methodology to support design-license-build-operate lifecycle
- Demonstrate application of approach with use cases
- Demonstrate utility of approach via pilot application

Value

- Leverages investment in design over entire lifecycle
- Supports more incremental step-wise approach to licensing
- Supports risk informed and performance based licensing framework
- **Leverages and informs development of ANSI/ANS Standard 30.1 on risk informed advanced reactor design**

Deliverables

- Preliminary methodology and best practices (September 2018)
- Case studies illustrating application for analysis of unique molten salt reactor systems (March 2019)



Advanced Manufacturing Strategic Program

- Objectives
  - Develop/demonstrate new methods for manufacture/ fabrication of a reactor pressure vessel (RPV) in **<12 months**
  - **Eliminate a minimum of 40%** from the cost of an SMR RPV, while **reducing** the schedule significantly

What once took weeks can now be done in hours.

- Scope
  - Manufacture major critical components to **assemble a 2/3-scale SMR reactor pressure vessel**
  - Jointly funded collaboration
    - EPRI, Nuclear-AMRC (UK), USDOE, NuScale Power
  - Advanced processes employed
    - PM-HIP
    - Electron Beam Welding
    - Diode Laser Cladding
  - ASME code development included

Representative Model of NuScale Power Reactor Vessel

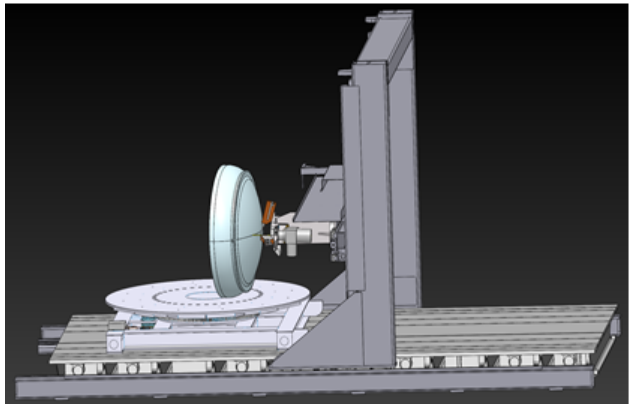
Highlights and Accomplishments to Date

- 44% diameter (50-inch) A508 top head has been completed
- One-half section A508 lower head has been completed and dimensioned
- Forgings for flanges, PZR shell, lower RPV section, and HT have been completed
- EB welding parameters and geometry for SA508 Grade 3 Class 1 girth welds were established and demonstrated
- Diode laser cladding key performance variables (KPVs) were established for SA508 substrates and it was determined that it is possible to produce both 1-layer and 2-layer clads that meet ASME IX requirements
- Heat treatment work package developed for localized HT

44% Upper Head (PM-HIP)

Flange Forging

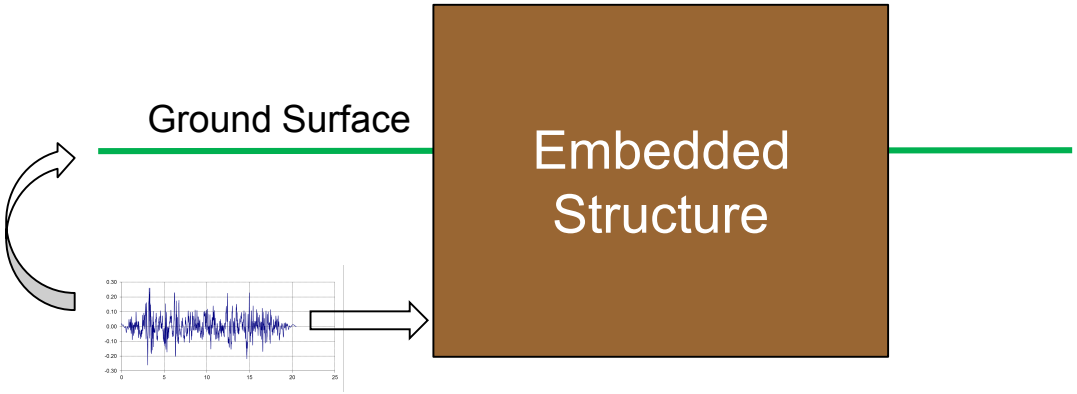
One Half Lower Head (PM-HIP)

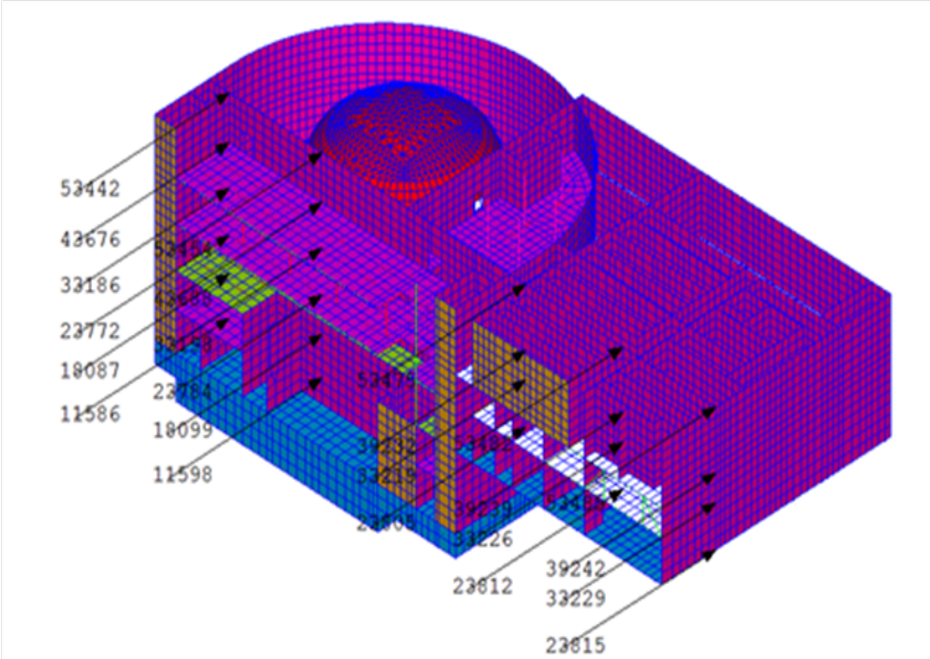


Electron Beam Welding Development

New Vertical Response Motion Computation in SSI Analysis of Embedded Structures

- Objective: Develop a more accurate vertical motion model for soil-structure interaction (SSI) analysis for embedded structures to reduce unintended conservatism of existing methods
- New Method: Horizontal motions are amplified through the soil and vertical motions are calculated as a ratio of the horizontal motions (V/H ratio), consistent with calculation of design basis motions
- Findings: Traditional vertical amplification for embedded structures overestimates vertical ground motion; proposed new method estimates smaller vertical motions and resulting structural responses
- ASCE 4 and ASCE 43 committees aware of work and further standards development planned
- Technical report published March 2018: *Advanced Nuclear Technology: Modeling Vertical Free-Field Motion of Soil-Structure Interaction Analysis Consistent with Vertical Design Motion Development* [3002011804]





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Together…Shaping the Future of Electricity

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