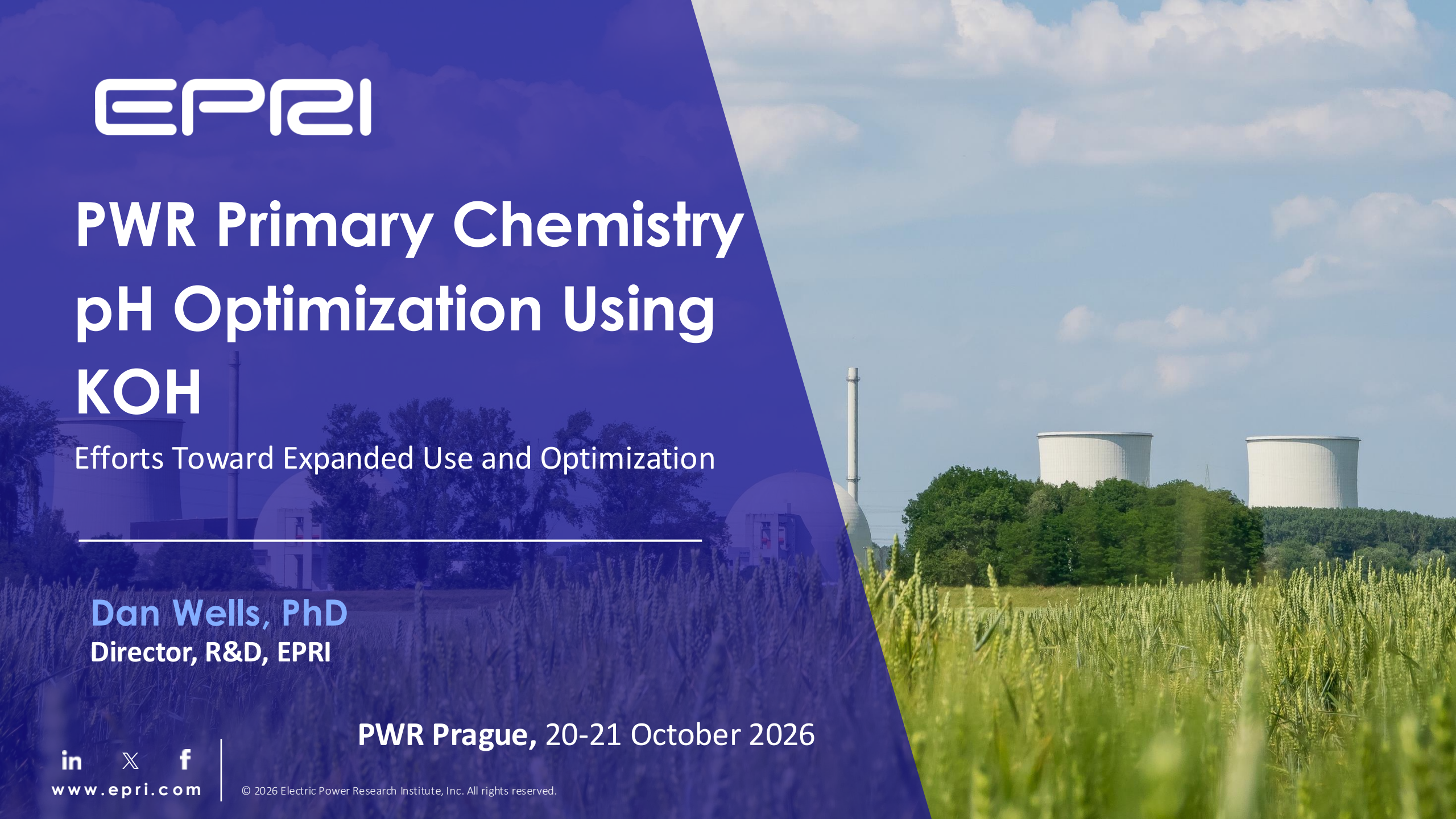
PWR Primary Chemistry pH Optimization Using KOH

Efforts Toward Expanded Use and Optimization

Dan Wells, PhD
Director, R&D, EPRI

PWR Prague, 20-21 October 2026



www.epri.com

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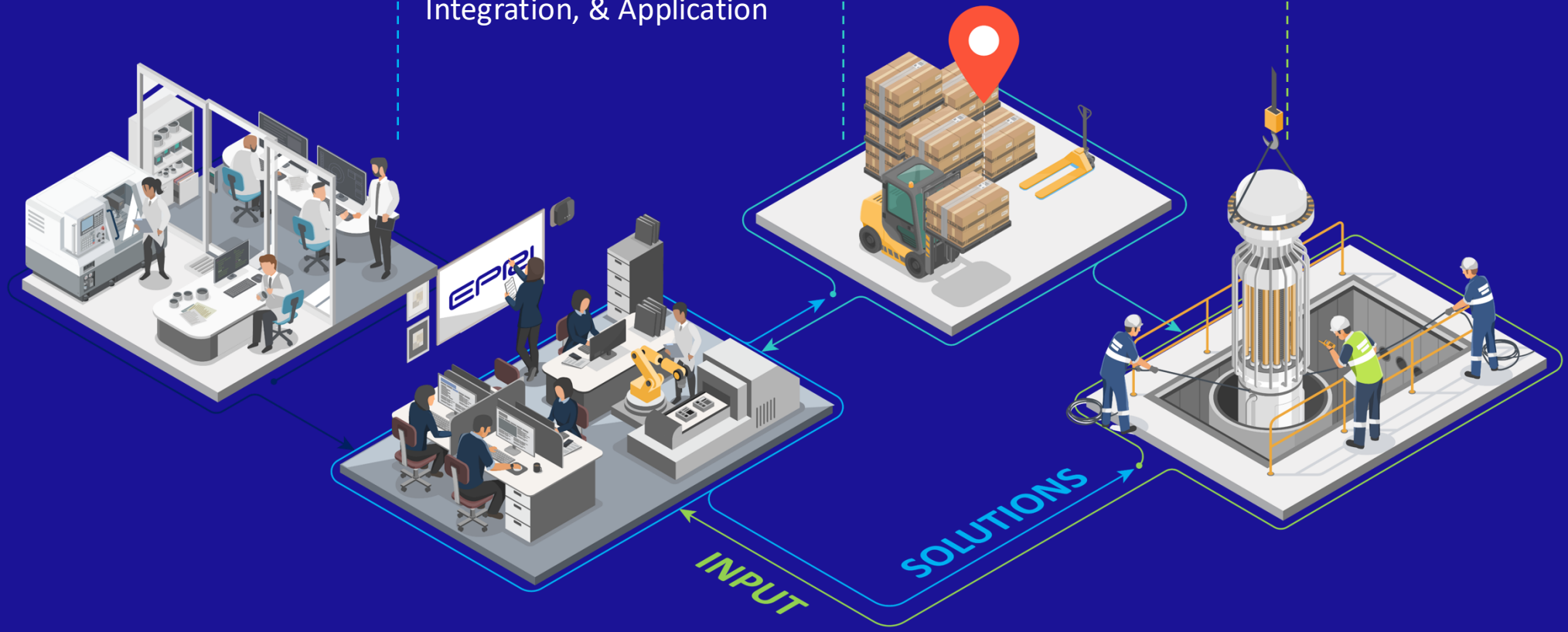
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32 non-U.S.-based

21 U.S.-based





AP1000



CANDU



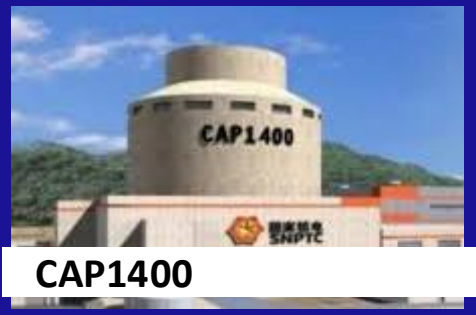
VVER



BWR



CPR1000

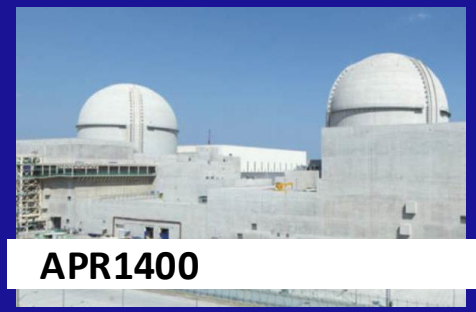


CAP1400

EPRI's Nuclear funders represent:

>80% of the world's commercial reactors

>360 reactors globally



APR1400



PWR

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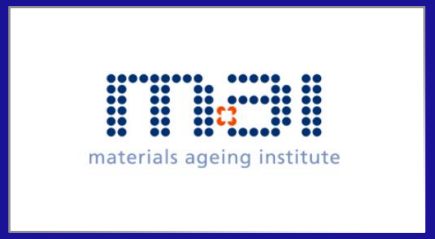










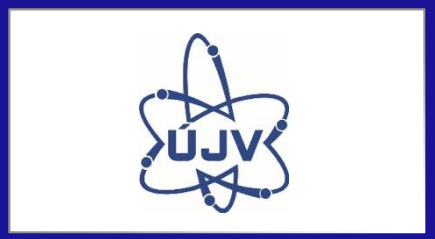












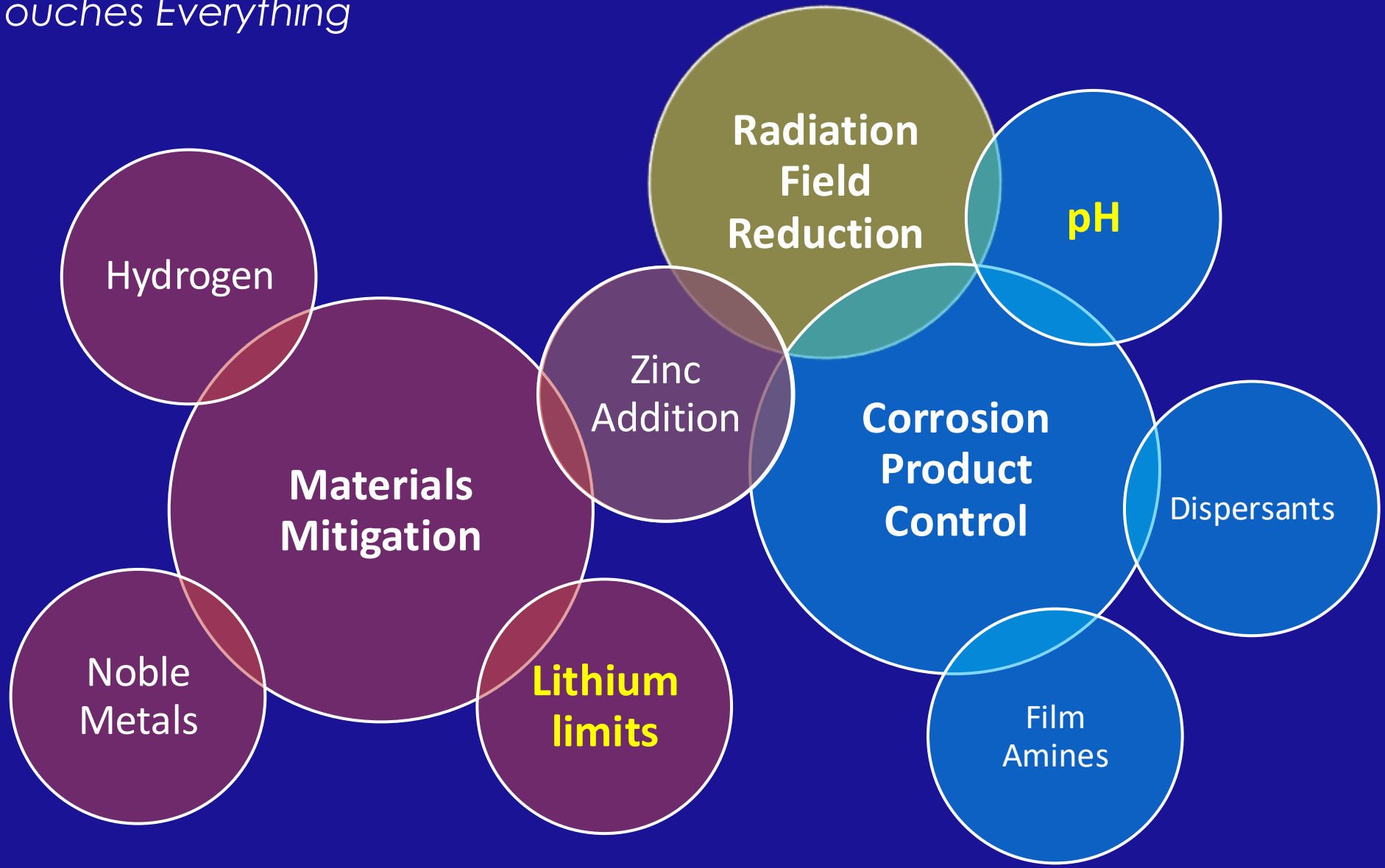




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Chemistry Control Technologies for Optimization

Chemistry Touches Everything



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Benefits of KOH for Western-style PWRs

Eliminate vulnerability to enriched Li-7

- Limited production
- Expected increased demand

Reduced operational cost

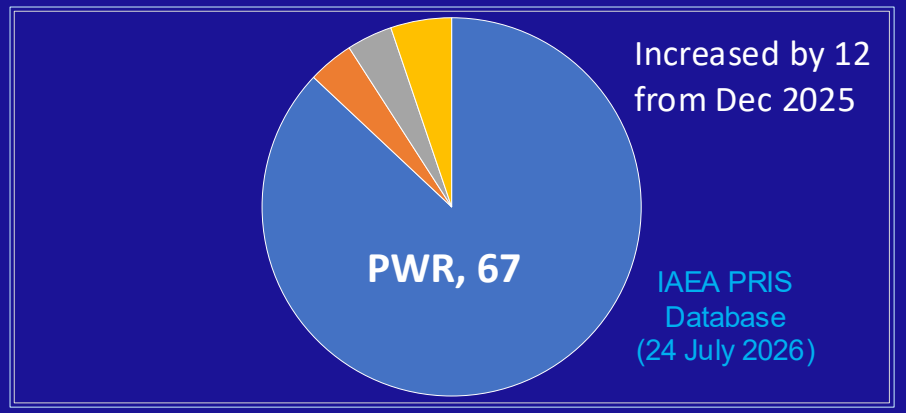
- Estimated potential savings per fuel cycle of about $116k/unit (validated for Sequoyah in Jan 2026)

Molten Salt Reactor consideration

Current world demand of enriched Li-7 for PWRs is about 1 metric ton per year

Kairos ETU 1.0 (full-scale non-nuclear Engineering Test Unit) used 1.7 metric tons of naturally occurring Li in the FLiBe molten salt. It would need enriched Li-7 in nuclear operation.

Reactors Under Construction



Nuclear Energy
U.S. Department of Energy
Supply Chain Deep Dive Assessment
February 24, 2022

Most Important Supply Chain Issues

Current Large Reactors: Enriched Lithium (#2)

Advanced Reactors: Lithium/Enriched Lithium (#4/#5)

KOH provides optimization value and has been used for decades

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KOH Application in Western-style PWRs

A Decade of Testing & Assessments (20 EPRI Reports, 2015-2024)

Chemistry

- System review and impacts
- **High temperature chemistry (MULTEQ)**
- Purity specifications
- Dual alkali modeling and control
- PWR Primary Guideline Interim Guidance (SGMP-24-10)

Radiation Safety

- **Activation species**
- Impact on plant radiation fields
- Radioactive waste management
- Plant effluents and environmental monitoring

Fuels

- Vendor assessments
- **Experimental loop testing**
- Experimental autoclave testing

Materials

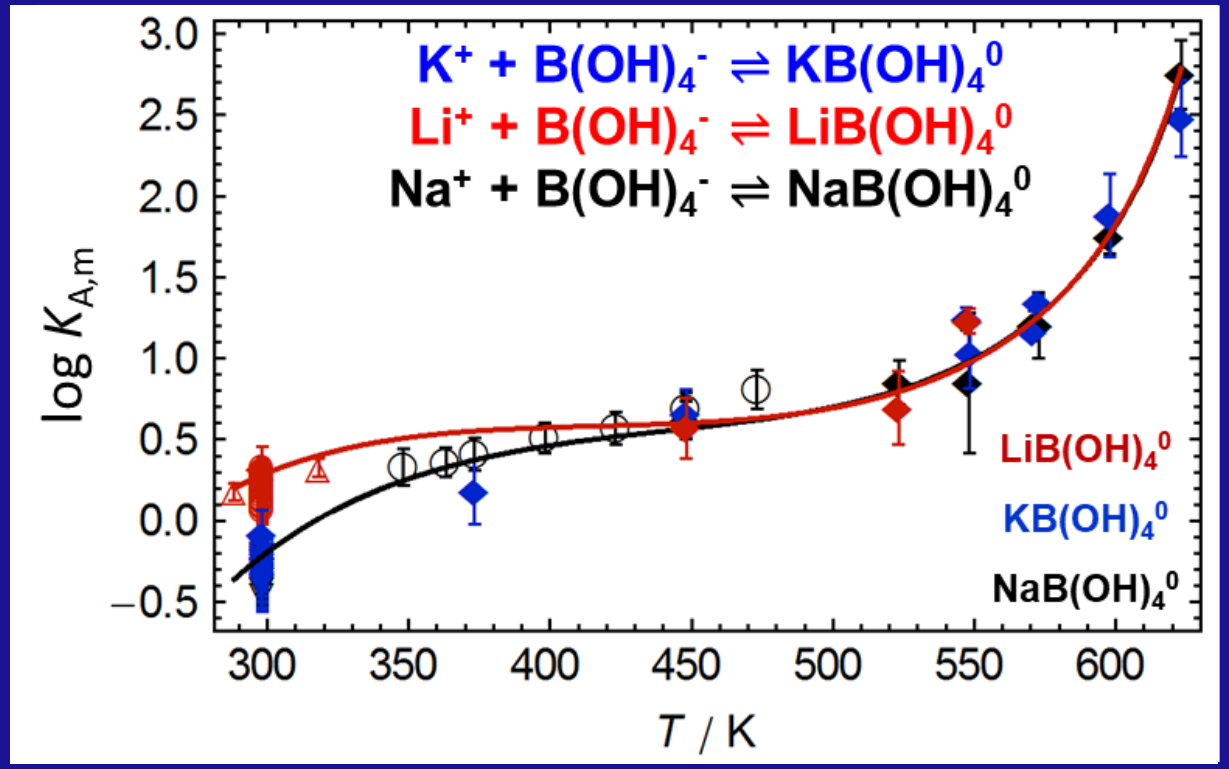
- Initiation & Crack Growth Rate (CGR) Testing
  - Non-irradiated
    - **Stainless Steel (SS), Alloy 600**, Alloy A-286; and Alloy 182 (CGR only)
  - Irradiated
    - Stainless Steel

✓ VVER Operational Experience Leveraged ✓ Training to support successful application

No Significant Differences or Challenges with KOH Control Identified

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Chemistry Control: KOH and Boric Acid Modeling



Advances in high temperature boric acid speciation

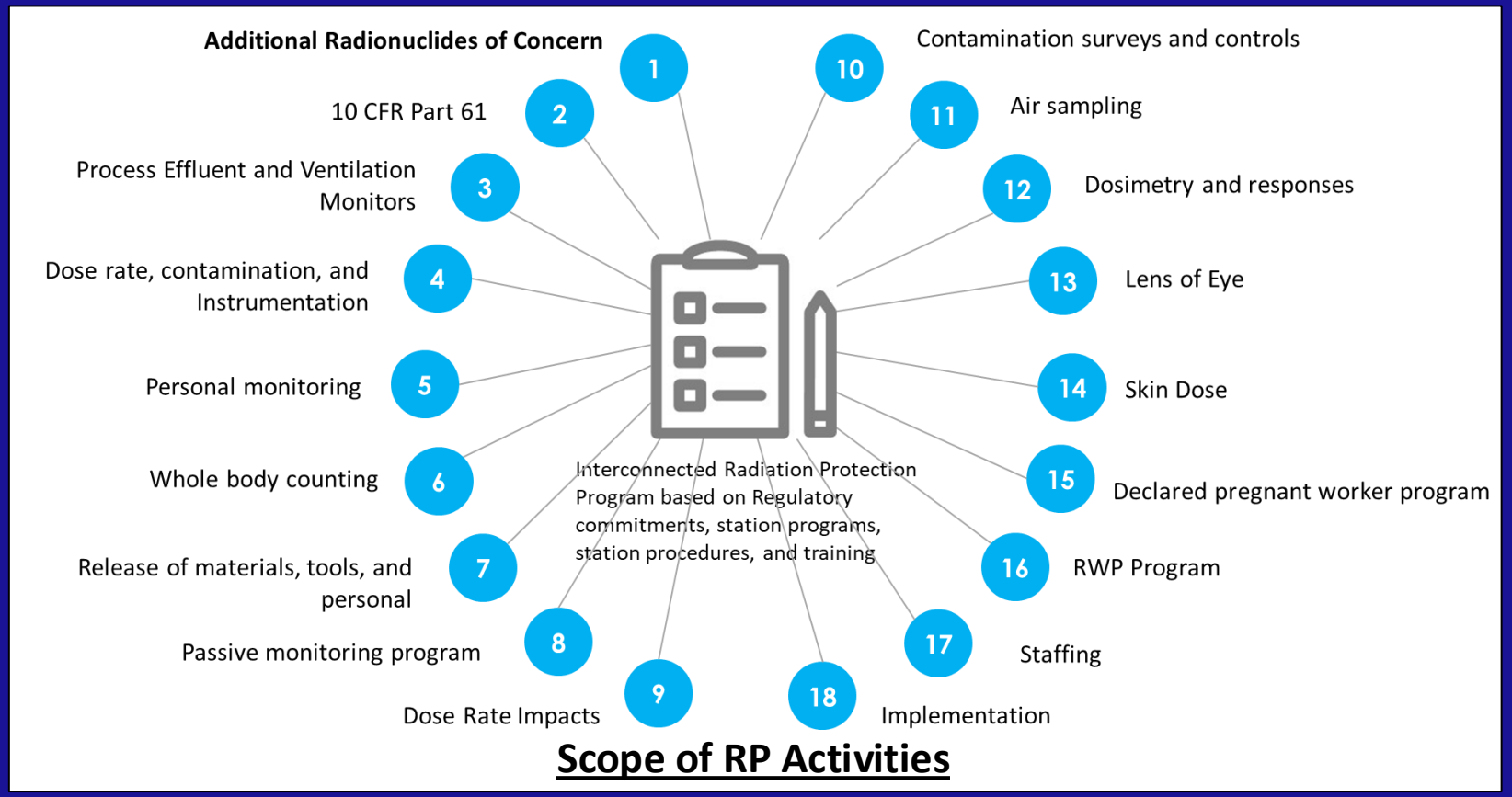
- Improved modeling of **boric speciation**
- Improved **K_w correlations**
- **Ion-pair formation** modeling
- Improved **accuracy of high temperature pH** calculation

Mesmer et al. *Inorg. Chem.* (1972); Palmer et al. *PowerPlant Chem.* (2000); Arcis et al. *J. Chem. Thermodyn.* (2017); Sasidharanpillai et al. *J. Phys. Chem. B* 2019; Wang et al. *Ind. Eng. Chem. Res.* 2023; Raynaud et al. *J. Solution Chem.* 2024; Sasidharanpillai et al. *Dalton Transactions* 2024; Arcis et al. *J. Phys. Chem. Ref. Data 2026*

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Radiation Protection (RP) Summary of Scope

- Effluents monitoring and offsite dose consequences present unique factors
- The radionuclides of particular note:
  - Potassium: K-40, K-42, K-43
  - Chlorine: Cl-36
  - Argon: Ar-39, Ar-42



License Amendment Request (LAR) submitted by TVA in January 2026

Current Status: Approved.

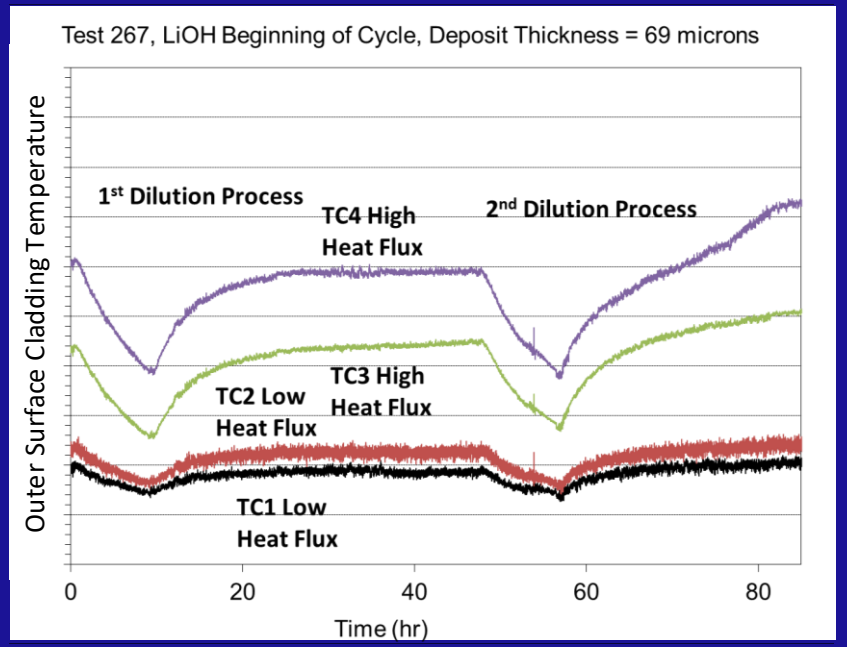
Effluents programs at most U.S. utilities are based on aged regulatory requirements* and do not include dose conversion factors for key radionuclides.
Thus, dose conversion factors were developed based upon newer ICRPs.

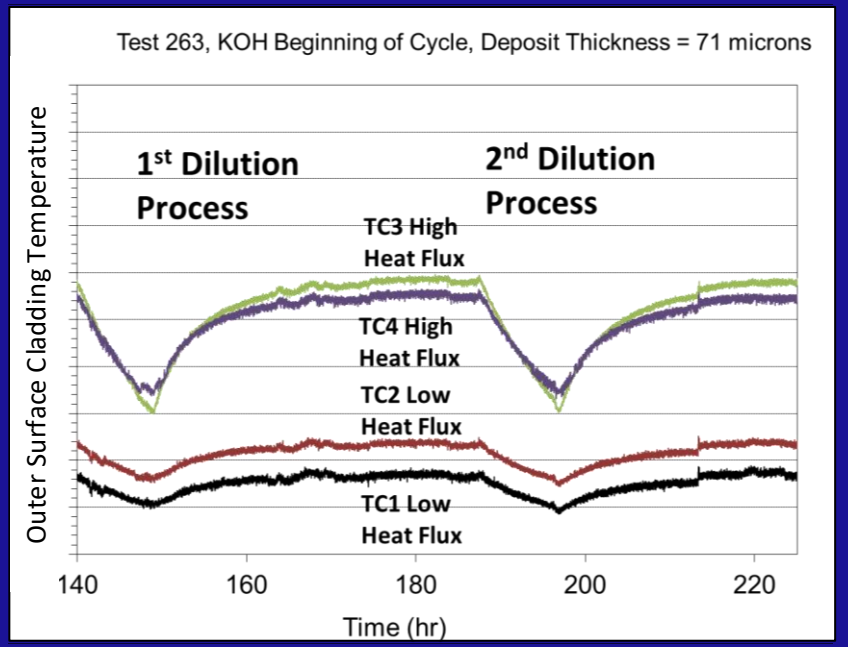
* ICRP: International Commission on Radiological Protection, Publication 2

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KOH/LiOH Fuel Loop Test Results

- WALT loop tests measuring clad temperature of a crudded rods
  - **Comparable** temperature results for KOH and LiOH chemistries and transitions
  - Test run with low and high heat flux also had **comparable** results

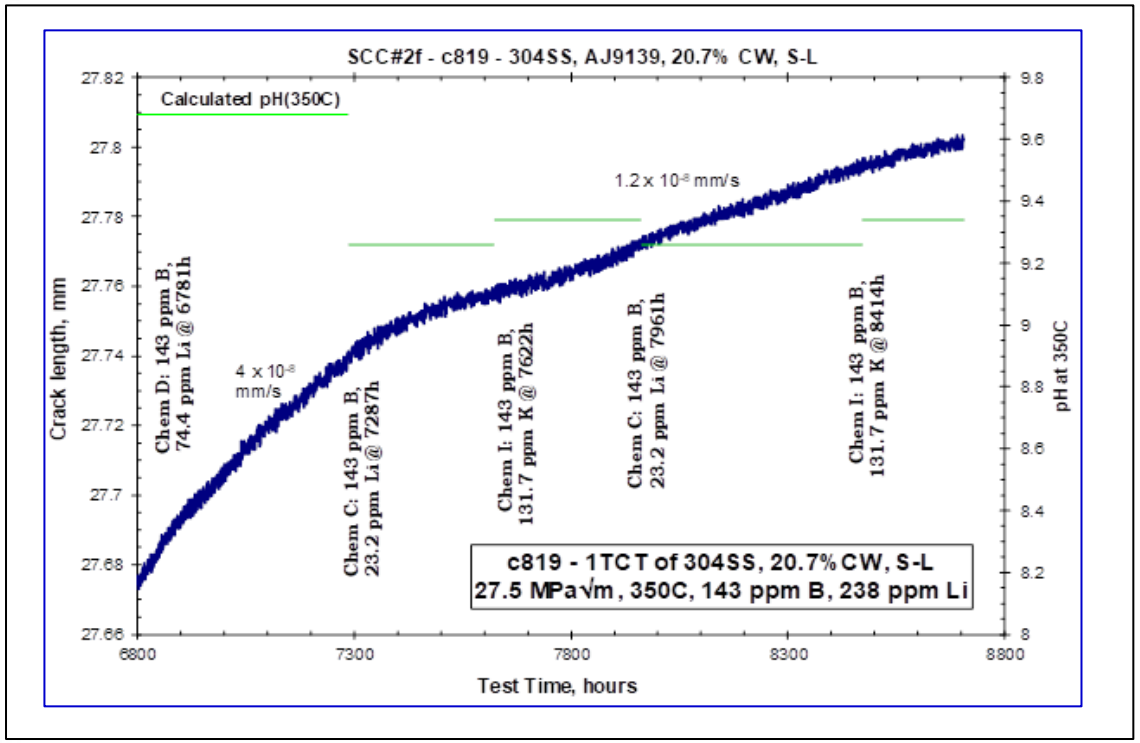




Refer to EPRI WALT Reports 3002020958, 3002023963 and 3002031678 for details

No detrimental impact on fuel cladding performance or deposit chemistry

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- Results relative to LiOH chemistry
  - A600: no appreciable difference in crack initiation susceptibility up to a CF of ~300
  - SS: no observable impact on CGR up to CF ~30, CGR higher with CF≥100
- Observed correlation between crack growth and crack initiation behavior for SS

Materials Testing in Aggressive Chemistry

- Crack growth rate (CGR) and initiation under potentially aggressive crevice conditions (pressurizer)
  - Concentration factor (CF) of 20 considered conservative (10x higher than expected by modeling)
  - Data gap for non-irradiated stainless steel and nickel-based alloy 600 identified
  - Direct Current Potential Drop (DCDP) with water chemistry changes “on the fly” were conducted for CGR

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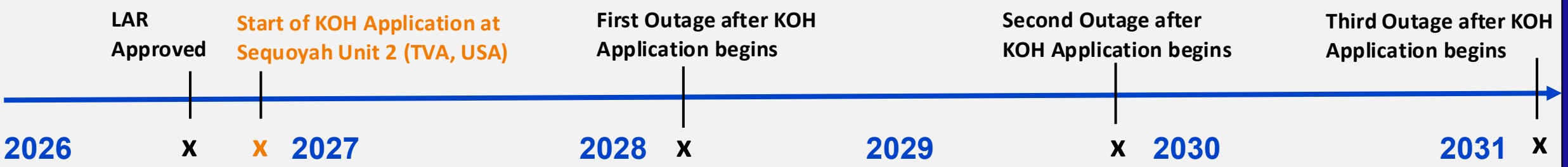
Western-PWR 1st Transition Major Milestones

LAR: License Amendment Request

Pre-Application Timeline



Application Timeline



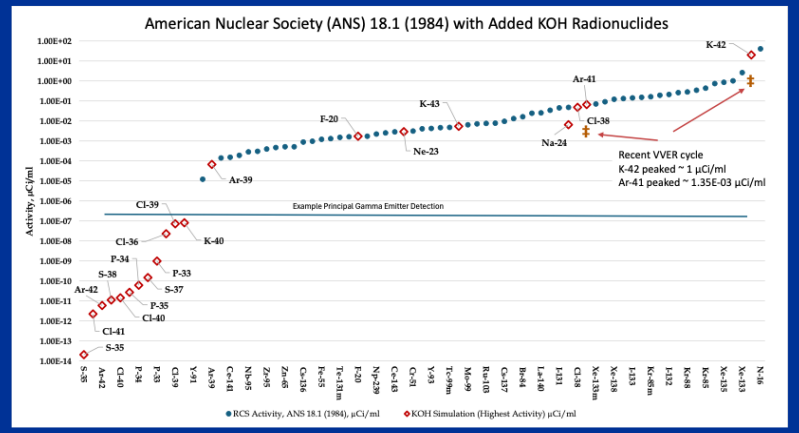
Planned EPRI Reports:

- Pre-Application Assessments (10CFR50.59, Engineering Change Package) [3002035031, Nov 2026]
- First Cycle Application Report [Dec 2028], First Cycle Fuel Exam Report [Dec 2028]
- Second Cycle Application Report [June 2030] , Second Cycle Fuel Exam Report [July 2030]
- Third Cycle Application Report [Dec 2031]

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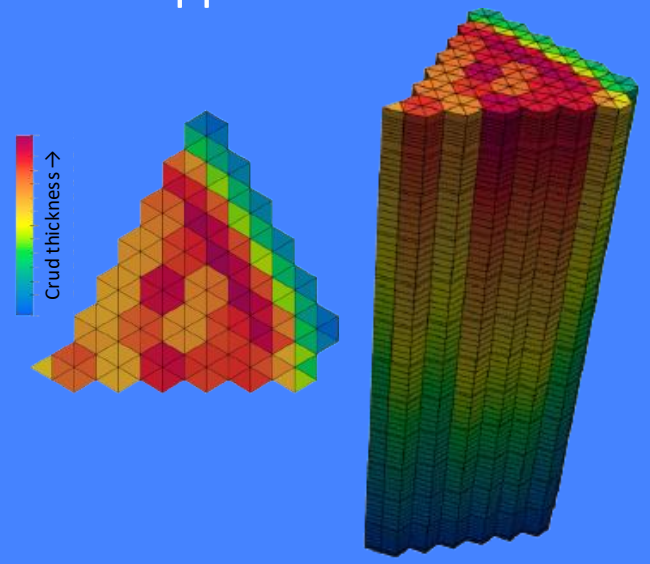
Complementary Scope to Support Optimized Use

- Radiation Safety Management
  - Cl-36 and Ar-39/42 management and quantification
  - Evaluation of source term changes with newly generated radionuclides



- Chemistry, Materials Degradation, and Issue Management
  - Address VVER primary chemistry gaps previously identified (3002026589)
  - Continue management of VVER materials aging
    - For example, VVER Issue Management Tables (3002021033) note susceptibility to SCC in highly caustic environments*

- Fuel Performance Optimization
  - Crud deposition modeling (BOAv4.1) theory and proof of concept published (3002029306)
  - Perform plant validation of application



*See Huotilainen, S. (EPRI) Presentation 21Oct26, "Safe Long Term Operation" Session

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Future Tools for Optimization and Use



VVER
OPEX

Western-style
PWR OPEX

Guidance for Operation with KOH Appliable to Western-style PWRs and VVERs

- ❑ PWR primary chemistry optimization
- ❑ PWR fuel cladding and corrosion mitigation
- ❑ PWR fuel crudding risk assessment
- ❑ Materials aging management
- ❑ PWR radiation field mitigation
- ❑ Effluent and waste management

Path to Chemistry Optionality and Optimization

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Appendix

EPRI Report References (1/4)

Report Title	Product ID	Publication Year
Potassium Hydroxide: A Potential Mitigation for AOA	TE-114158	1999
Review of VVER Primary Water Chemistry and the Potential for its Use in PWRs: Potassium Hydroxide and/or Ammonia Based Water Chemistries	1003382	2002
Feasibility of Using Potassium Hydroxide for Primary Coolant pHT Control in Pressurized Water Reactors	3002005408	2015
Modeling of Multiple Alkali Management in the PWR Primary System—PWR Chemistry Technical Strategy Group	3002010650	2017
Fuel Reliability Assessment of PWR Potassium Hydroxide Primary Chemistry: Gap Identification and Development of Testing Requirements	3002013304	2018
PWR Primary Chemistry KOH Qualification: Materials Testing: Alloy 600 and Alloy 182 Crack Growth	3002016005	2019
Use of Potassium Hydroxide in Western-Design Pressurized Water Reactors: Chemistry and Radiation Safety Assessments	3002015902	2019
Crack Growth Rate Testing of Irradiated Stainless Steels (MRP-454): Investigation of Effect of Potassium Hydroxide Primary Water Chemistry	3002018325	2020

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EPRI Report References (2/4)

Report Title	Product ID	Publication Year
Experimental Investigation of Coated and Uncoated Cladding Designs Under Aggressive Potassium Hydroxide and Lithium Hydroxide Environments	3002018695	2020
Nuclear Steam Supply System Vendor Evaluation of Potassium Hydroxide for Primary System pH Control in Pressurized Water Reactors: Identification of Materials Testing Needed before Application at Babcock & Wilcox Plants	3002018429	2020
Nuclear Steam Supply System Vendor Evaluation of Potassium Hydroxide for Primary System pH Control in Pressurized Water Reactors: Westinghouse and Combustion Engineering Plants.	3002018427	2020
PWR Primary Chemistry KOH Qualification: Alloy 600 Crack Initiation	3002020893	2021
PWR Primary Chemistry KOH Qualification: A-286 Crack Initiation and Crack Growth	3002020894	2021
Simulated Fuel Deposit Chemistry Responses to PWR Lithium Hydroxide and Potassium Hydroxide Conditions: Reference LiOH runs in the WALT Loop and Comparison to Equivalent KOH Runs	3002020958	2021
Chemistry and Radiological Source Term Considerations Supporting a Plant Demonstration of Potassium Hydroxide for a Western-design PWR: Westinghouse and Combustion Engineering Plants	3002020959	2021
Experimental Investigation of Coated and Uncoated Cladding Designs Under Aggressive Potassium Hydroxide and Lithium Hydroxide Environments -Final Report (Phase 2)	3002020950	2021

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EPRI Report References (3/4)

Report Title	Product ID	Publication Year
PWR Primary Chemistry KOH Qualification: Evaluation of Crack Morphology in IASCC CGR Specimens: Effects of Crack Branching on In-Situ Crack Length Measurement	3002020957	2021
PWR Primary Chemistry KOH Qualification: Crack Initiation of Sensitized Stainless Steel in Oxygenated Beginning of Cycle Water Chemistry	3002023897	2022
Crack Initiation Testing of Irradiated Stainless Steels (MRP-465): Investigation of Effect of Potassium Hydroxide Primary Water Chemistry	3002020941	2022
Simulated Fuel Deposit Chemistry Responses to PWR Lithium Hydroxide and Potassium Hydroxide Conditions	3002023963	2022
Phase III of Experimental Study of Coated Cladding Materials for Interactions with Potassium Hydroxide	3002026545	2023
PWR Primary Chemistry KOH Qualification: Crack Initiation and Crack Growth Testing of Non-sensitized Stainless Steel and Crack Initiation Testing of a Ni-base Alloy in Hydrogenated Crevice Water Chemistries	3002028926	2024
Evaluation of Potassium Hydroxide for Western-Design Pressurized Water Reactor (PWR) Primary System pH Control: A Generic 10 CFR 50.59 Evaluation for Westinghouse and Combustion Engineering Designed PWRs.	3002029322	2024
PWR Argon Effluent Release Mechanisms and Impacts on Dose Rates Due to Potassium Hydroxide Injection: Proposed Argon Dose Conversion Factor Considerations	3002031977	2025

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EPRI Report References (4/4)

Report Title	Product ID	Publication Year
Potassium Hydroxide Demonstration: Heated Rod Loop Tests—High Heat Flux and Transient Chemistry Conditions	3002031678	2025
Proposed Cl-K Dose Conversion Factors Considerations for Potassium Generated Radionuclides: Application of ICRP-72 and ICRP-119 Dose Conversion Factors to Support KOH Addition and the Radiological Environmental Monitoring Program Dose Calculations	3002032484	2025

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