Advanced Acoustic–Crystallization Technology for High-Purity Magnesium Hydroxide Production and Mercury Stabilization in Gas/Coal Co-Fired Power Plants

DE-FE0032734
Topic Area 1: Water Management and Advanced Wastewater Systems (Session 5)

University of Kentucky Research Foundation (UKRF)

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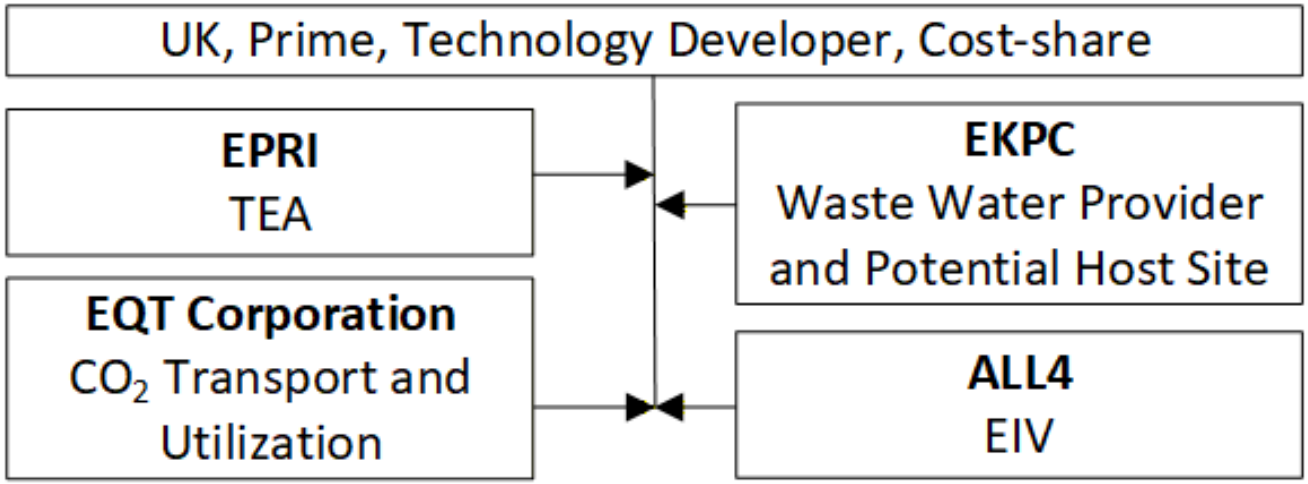
Project Overview

Project Location(s):	East Kentucky Power Cooperative Spurlock Generating Station, 1301 W 2nd St, Maysville, KY 41056
Project Goals:	Develop and deploy an integrated process consisting of a staged-pH adjustment, crystallizer-guided acoustic-purification system that transforms conventional physico-chemical steps in the ZLD into a selective, high-purity resource recovery process
Intended Impacts:	Modernization of the plant and improved cost of generation through resource recovery. Overall benefit to the region through improved efficiency and reliability of electricity generation and resulting economic benefits including job creation.

EAST KENTUCKY POWER COOPERATIVE
A Touchstone Energy® Cooperative

Project Overview

Project Performance Period:	Phase I of the project spans 9 months of technical performance and 12 months total (planned for Oct 1, 2026 – September 30, 2027)



Participate	*Federal*	*Cost-Share*
UKRF	$285,000	$81,250
EPRI	$75,000	$18,750
ALL4	$40,000	$0
Total	$400,000	$100,000

Project Background

Host Site Unit Summaries

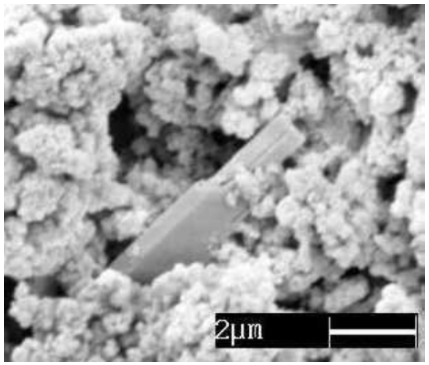
	Nominal Gross Capacity	*Net Capacity*	*COD*	*Technology*	*Flue Type*
Spurlock Unit 1	335 MW	300 MW	1977	Pulverized Coal	Bituminous
Spurlock Unit 2	560 MW	510 MW	1981	Pulverized Coal	Bituminous

Project Scope/Technical Approach

Major Activities	*Outcomes*
Identification of Optimal pH Setpoints and Thermodynamic Modeling	Chemical characterization of representative WFGD and WESP wastewater stream input for PHREEQC thermodynamic modeling
Experimental Verification of Controlled Gypsum Crystallization, $Mg(OH)_2$ Precipitation, Hg stabilization	Limited experiments for confirmation and pH adjustment; Experiments will evaluate the impact of seed surface area, residence time, mixing speed on the Crystal Size Distribution (CSD), and Hg stabilization
Resonant Acoustic® Mixing (RAM)-Assisted Purification	(RAM) to condition the $Mg(OH)_2$ slurry to confirm the effects of acoustic frequency, acceleration, and slurry solids loading (wt%) on the liberation of entrained impurities

RAM relies on resonance and acoustic fluid dynamics through; (1) **Acoustic Streaming:** operating at a resonant frequency (typically around 60 Hz), creating rapid compression and rarefaction waves. This induces micro-vortices at the boundary layers between solids and liquids, (2) **Mass Transfer Acceleration:** the intense localized mixing dramatically lowers the diffusion barrier, allowing solvents to interact with target compounds at near-instantaneous rates, (3) **Uniform Energy Distribution:** energy is transferred equally throughout the entire vessel, eliminating dead zones and maintaining strict temperature control.

RAM accelerates leaching, controlled nucleation and crystallization, and works in high viscosity slurry washing



SEM image of ZLD-derived solids showing a gypsum crystal embedded within fine aggregated $Mg(OH)_2$

Project Milestones

Milestone Description	***Planned Completion Timeline (Q)***
Submit finalized PMP and confirm Phase I schedule	2026-10-31
Team Formation & Coordination	2026-11-30
Validate PHREEQC Pitzer-based thermodynamic model	2026-12-30
Demonstrate controlled gypsum crystallization with low fines	2027-01-31
Demonstrate $Mg(OH)_2$ precipitation with ≥95% Mg recovery	2027-02-28
Demonstrate RAM-assisted impurity liberation and reduced wash-water demand	2027-03-20
Mercury Stabilization Testing	2027-04-30
Complete Aspen Plus integration and sensitivity analysis	2027-04-30
Deliver Phase II-ready Pre-FEED package (9 gpm)	2027-06-30
EIV Completion	2027-06-30
CCS Design Basis Completion	2027-06-30
Submit Final Phase I Technical Report	2027-06-30

Risk Management

Key Risk Criteria	*Mitigation Strategy*
Project Cost Overun	Use Earned Value Risk Management System (EVRMS) to manage cost and schedule risk; proactive identification of alternative suppliers
Subcontract Agreement Delay, Communication Problems Among Parties Involved	Careful coordination, routine meetings with entire project team
Incomplete decoupling of sulfate removal and $Mg(OH)_2$ precipitation	Early PHREEQC Pitzer modeling combined with experimental data to define selective precipitation envelopes
Limited impurity liberation during RAM-assisted purification	Systematic mapping of acoustic operating parameters within expanded operating windows; solid grinding for better particle size distribution
Handling of high-salinity wastewater, solids, and mercury-containing materials	Established laboratory safety procedures, trained personnel, and approved analytical protocols consistent with university EH&S.

Acknowledgement

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