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25-EPIC-01 Research Idea - PFAS

See attached file

Additional submitted attachment is included below.

Electric Program Investment Charge 2026–2030 (EPIC 5) Research Concept Proposal Form

The California Energy Commission (CEC) is currently soliciting research concept ideas and other input for the Electric Program Investment Charge 2026–2030 (EPIC 5) Investment Plan. For those who would like to submit an idea for consideration, please complete this form and submit it to the CEC by **August 8, 2025**. More information about EPIC 5 is available below.

To submit the form, please visit the e-commenting link: https://efiling.energy.ca.gov/EComment/ECommentSelectProceeding.aspx and select the Docket **25-EPIC-01**. Enter your contact information and then use the "choose file" button at the bottom of the page to upload and submit the completed form. Thank you in advance for your input.

1. ***Please provide the name, email, and phone number of the best person to contact should the CEC have additional questions regarding the research concept:***

Name: Derya Dursun Balci, PhD. PE
Email: derya@cwatertech.com
Phone: 407-7658693

2. ***Please provide the name of the contact person's organization or affiliation:***

Organization: Caliskaner Water Technologies Inc.
Address: 2733 Brookshire Cir., Woodland, CA, 95776

3. ***Please provide a brief description of the proposed concept that you would like the CEC to consider as part of the EPIC 5 Investment Plan. What is the purpose of the concept, and what would it seek to do? Why are EPIC funds needed to support the concept?***

California faces a significant challenge with PFAS—per- and polyfluoroalkyl substances—commonly known as "forever chemicals" due to their persistence in the environment. PFAS-related healthcare impacts could cost billions of dollars unless exposure is reduced. California's Water Boards and

PFAS task forces have not yet published statewide energy estimates for PFAS treatment infrastructure. However, given the scale of contamination and the energy intensity of viable treatment options, the cumulative burden likely reaches into the hundreds of MWs when scaled across municipal systems.

Our proposed concept aims to demonstrate energy efficient technologies for PFAS removal from wastewater in California. With rising health risks, regulatory pressures, and escalating treatment costs, utilities urgently need scalable, low-energy solutions that maintain high PFAS removal efficiency while minimizing operational burdens. This concept focuses on advancing and integrating innovative treatment systems that reduce electricity use and carbon emissions, offering a sustainable approach to protecting public health and water quality.

This concept seeks to develop and demonstrate energy-efficient, scalable technologies for removing PFAS from wastewater in a way that reduces treatment costs, lowers energy use, and supports compliance with emerging regulations. It aims to address the environmental and public health risks posed by PFAS contamination while helping utilities adopt more sustainable and cost-effective treatment systems.

Funding is needed to support this concept because developing and demonstrating energy-efficient PFAS removal technologies requires significant investment in research, pilot-scale testing, and system optimization. Utilities currently face high costs and operational challenges with existing treatment methods, which are energy-intensive and expensive to scale. Financial support will enable the advancement of innovative, low-energy solutions that can be integrated into existing infrastructure, helping utilities meet stricter regulations while reducing carbon footprints and overall treatment expenses. Additionally, funding is crucial to overcome technical barriers, validate performance in real-world conditions, and accelerate adoption of sustainable PFAS treatment technologies.

4. ***In accordance with Senate Bill 96[i], please describe how the proposed concept will "lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory energy goals." For example, what technical and/or market barriers or customer pain points would the proposed concept address that would lead to increased adoption of clean energy technology or innovation? Where possible, please provide specific cost and performance targets that need to be met for increased***

industry and consumer acceptance. For scientific analysis and tools, provide more information on what data and information gaps the proposed concept would help fill, and which specific parties or end users would benefit from the results, and for what purpose(s)?

Technical Barriers: PFAS are difficult to break down due to their extremely strong carbon–fluorine bonds—some of the strongest in organic chemistry. This makes degradation energy-intensive or incomplete, often leading to only partial breakdown or formation of smaller, potentially harmful by-products. Most operations begin with concentrating PFAS via methods like granular activated carbon (GAC), ion exchange (IX), reverse osmosis (RO), or nanofiltration (NF)—but these only sequester, not destroy, PFAS. They're also expensive (almost cost-prohibitive in most cases) and often impractical, especially for high-volume, dilute wastewater streams.

Engineering Limitations: Destructive treatment technologies for PFAS in wastewater face significant engineering limitations that hinder widespread implementation. Supercritical Water Oxidation (SCWO) achieves high destruction efficiency (up to 99.99%) but requires specialized, corrosion-resistant reactors capable of withstanding extreme temperatures and pressures, making it capital- and maintenance-intensive. Advanced Oxidation Processes (AOPs)—such as electrochemical oxidation, UV/H_2O_2, and sonolysis—are energy-intensive and often require pre-treatment; their effectiveness is also reduced by common wastewater constituents like bicarbonates and natural organic matter, which interfere with radical generation (Ross et al, 2018). Emerging methods like plasma treatment, high-energy UV photolysis, and Hydrothermal Alkaline Treatment (HALT) show promise but remain in early development stages, with ongoing challenges related to energy demands, corrosion, scalability, and cost-effectiveness (Singh et al, 2019). Collectively, these methods struggle to balance treatment efficiency, operational complexity, and economic feasibility, especially when applied to the variable and complex nature of real-world wastewater.

Market Barriers: PFAS removal technologies face several market barriers that limit their widespread adoption. High capital and operating costs make these solutions financially challenging, particularly for small or underfunded utilities (EWG, 2023). Regulatory uncertainty—due to inconsistent or evolving standards across regions—discourages long-term investment, while concerns over legal liability for residual contamination create additional risk for adopters. Many technologies remain in early development stages, lacking commercial readiness and proven performance at scale. Therefore, EPIC funding will be critical to push these technologies on a commercial scale. The complex and variable nature of real-world wastewater further complicates implementation, requiring costly, site-specific customization. Additionally, the lack of immediate economic returns and limited public or political pressure in some areas reduces motivation for utilities and industries to prioritize PFAS treatment. Together, these factors hinder the commercialization and deployment of PFAS removal technologies.

Customer Pain Points: Treating PFAS in wastewater is a growing financial and technical burden for utilities across California and the U.S. Wastewater treatment plants were not originally designed to remove these persistent chemicals, which enter the system through industrial discharge, landfill leachate, and household products. According to recent reports, PFAS treatment technologies—such as reverse osmosis, granular activated carbon (GAC), and ion exchange—require substantial capital investment and ongoing operational costs that can strain municipal budgets (MPCA,2023 and ITRC, 2020). While exact figures vary by plant size and treatment method, the EPA notes that even modest upgrades can cost millions, and full-scale implementation may be financially devastating for smaller agencies (EPA,2023).

5. ***Please describe the anticipated outcomes if this research concept is successful, either fully or partially. For example, to what extent would the research reduce technology or ratepayer costs and/or increase performance to improve the overall value proposition of the technology? What is the potential of the innovation at scale? How will the innovation lead to ratepayer benefits in alignment with EPIC's guiding principles to improve safety,[ii] reliability,[iii] affordability,[iv] environmental sustainability,[v] and equity?[vi]***

If proposed research in wastewater treatment proves successful, it would lead to safer, more effective, and affordable solutions for removing and destroying these persistent contaminants. This would significantly improve public and environmental health, enable utilities and industries to comply with evolving regulations, and reduce legal and financial risks. Scalable, cost-efficient technologies could transform PFAS management into a commercially viable sector, stimulating market growth and innovation. Additionally, improved treatment would reduce the burden of handling PFAS-laden residuals and enable global application of these solutions, making a substantial contribution to addressing one of the most pressing environmental health challenges of our time.

- **Safety:** Proposed research would reduce the exposure to harmful PFAS compounds in water resources. This would lower the risk of serious health effects such as cancer, immune suppression, and developmental issues.

Enhanced treatment would also ensure safer handling and disposal of contaminated residuals, reducing the chance of secondary environmental contamination. Overall, these advancements would enhance water safety, protect ecosystems, and support healthier communities.

- **Reliability:** Proposed research would lead to treatment solutions that consistently perform under varying wastewater conditions and contaminant loads. Technologies would be robust, adaptable, and capable of achieving high removal or destruction efficiencies across a wide range of PFAS compounds, including both long- and short-chain variants. It would also reduce the need for frequent system adjustments or costly retreatment, resulting in more predictable performance and long-term operational stability.
- **Affordability:** The project would lead to the development of cost-effective treatment solutions that are financially viable for a wide range of facilities, including small and rural utilities. Advances in energy efficiency, materials, and system design would help lower both capital and operational costs, making PFAS treatment more accessible and sustainable. Affordable technologies would also reduce the economic burden of compliance with regulations and decrease reliance on expensive disposal methods for PFAS-contaminated waste. Ultimately, this would enable broader adoption of PFAS treatment, protecting public and environmental health without imposing excessive financial strain on communities or industries
- **Environmental Sustainability:** Successful project would enable efficient removal and destruction of PFAS with minimal environmental impact. It would reduce energy use (NREL, 2023) and prevent harmful by-products or secondary pollution. Safer disposal of PFAS waste would protect soil and ecosystems, helping preserve biodiversity and water quality (EPA, 2021). Overall, this would support long-term ecological health and sustainable water management.
- **Equity:** The project would enable affordable, scalable treatment accessible to all communities, including underserved and vulnerable populations. It would reduce disparities in PFAS exposure and ensure equitable protection of water quality and public health (EPA, 2022). This would help close environmental justice gaps linked to pollution and infrastructure inequality (EJHA, 2021). Ultimately, it would promote fair and inclusive access to safe water for all.

6. ***Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed research concept.***

Both quantitative and qualitative metrics are essential to evaluate the impacts of the proposed research. Below present some quantitative and qualitative metrics that will be considered.

Quantitative Metrics:
PFAS Removal Efficiency (%): Percentage reduction of total PFAS concentration (measured in ng/L or ppt) from influent to effluent.

Mineralization Rate: Percentage of PFAS fully broken down to harmless end-products (e.g., fluoride ions, CO_2).

Energy Consumption (kWh/MGD): Energy required per volume of treated wastewater, indicating operational efficiency.

Operating and Capital Costs ($/MGD or $/lbs PFAS removed):Financial metrics to assess economic feasibility.

By-product Formation and Toxicity:Concentration and toxicity assessment of any intermediate or residual compounds formed during treatment.

Treatment Throughput (MGD/day):Volume of wastewater treated per unit time, reflecting scalability.

System Reliability Indicators: Metrics like uptime percentage, maintenance frequency, and lifespan of key components.

Qualitative Metrics:
Ease of Integration: How readily technology fits within existing wastewater infrastructure.

Operational Complexity: Level of technical expertise and labor required for operation and maintenance.

Regulatory Compliance: Alignment with current and anticipated PFAS discharge standards.

Community and Stakeholder Acceptance: Perceptions and trust in the technology from local communities and regulators.

Environmental and Social Impact: Broader sustainability implications including waste handling, resource use, and equity considerations.

7. ***Please provide references to any information provided in the form that supports the research concept's merits. This can include references to cost targets, technical potential, market barriers, equity benefits, etc.***

Recently, PFAS have been detected in at least 146 public water systems, affecting over 16 million residents (Clean Water Action, 2022). PFAS contamination stems from industrial discharge, consumer products, and wastewater effluent, and has been linked to serious health risks including cancer, liver damage, and developmental issues. The cost of addressing PFAS in California is staggering. Health-related impacts alone are estimated to exceed $5.5 to $8.7 billion annually, while treatment costs are mounting rapidly (Stuart et al, 2025).

PFAS treatment technologies for wastewater are often energy-intensive, posing a major challenge for utilities trying to balance environmental compliance with operational sustainability. Traditional methods like thermal destruction processes (incineration, pyrolysis, gasification etc.) consume large amounts of electricity, driving up costs and carbon footprint. Recent developments are focusing on low-energy PFAS removal systems, which use advanced adsorbents and membrane technologies designed to operate at lower pressures or with passive filtration. These systems can reduce electricity consumption and maintenance costs while maintaining high removal efficiency, often exceeding 99% for certain PFAS compounds.

However, full-scale implementation remains limited, and scalability is constrained by reactor design, competing background compounds, and the complexity of PFAS mixtures (Stangana et al, 2025). As regulatory pressure increases, utilities are exploring integrated systems that combine low-energy technologies with conventional treatment to optimize performance and reduce energy intensity. As new regulations under CERCLA and RCRA take effect, wastewater utilities will need to reassess infrastructure, secure funding, and adopt advanced treatment processes to meet compliance and protect downstream water quality.

The references below support the in-text citations and provide the scientific, regulatory, and technical basis for the proposed research.

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National Academies of Sciences, Engineering, and Medicine. (2022). *Guidance on PFAS exposure, testing, and clinical follow-up*. The National Academies Press. https://www.nationalacademies.org/our-work/guidance-on-pfas-exposure-testing-and-clinical-follow-up

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https://www.nrel.gov/news/program/2023/decarbonizing-water-and-wastewater-treatment.html

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Singh, R. K., Fernando, S., Baygi, S. F., Multari, N., Thagard, S. M., & Holsen, T. M. (2019). Rapid destruction of perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in aqueous film forming foam waste using a pilot scale plasma reactor. *Environmental Science & Technology, 53*(19), 11375–11382. https://doi.org/10.1021/acs.est.9b02932

8. ***The EPIC 5 Investment Plan must support at least one of five Strategic Goals:[vii]***
    a. ***Transportation Electrification***
    b. ***Distributed Energy Resource Integration***
    c. ***Building Decarbonization***
    d. ***Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas***
    e. ***Climate Adaptation***

    Please describe in as much detail as possible how your proposed concept would support these goals.

d. Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas

Proposed research supports the net-zero carbon emissions goal by developing more energy-efficient treatment technologies that minimize greenhouse gas emissions during operation. By optimizing processes to reduce energy consumption—such as lowering power needs for advanced technologies or improving reactor designs- these technologies help decrease the carbon footprint of wastewater treatment facilities. Additionally, successful PFAS destruction methods that avoid reliance on high-emission disposal practices (like incineration of contaminated solids) further contribute to lowering overall emissions. Integrating sustainable materials and renewable energy sources into treatment systems can also enhance their climate benefits, aligning PFAS management with broader efforts to achieve net-zero carbon targets.

e. Climate Adaptation

Proposed research contributes to climate adaptation by strengthening the ability of wastewater treatment to maintain safe and clean water despite the increasing stresses caused by climate change. Climate change brings more frequent extreme weather events such as floods, droughts, and storms, which can alter influent water characteristics and increase the variability of contaminants, including PFAS, in wastewater and surface waters. By developing robust, flexible, and scalable PFAS treatment technologies, communities can better respond to these fluctuations and ensure continuous removal of harmful pollutants. This adaptability is especially critical for vulnerable populations and smaller utilities that may face greater challenges during climate disruption.

Furthermore, effective PFAS management reduces the chemical burden on natural water bodies, helping protect aquatic ecosystems already stressed by changing temperatures and water flows. Overall, this research would support resilient water infrastructure in California that can withstand climate impacts while safeguarding public health and the environment.

About EPIC

The CEC is one of four EPIC administrators, funding research, development, and demonstrations of clean energy technologies and approaches that will benefit electricity ratepayers of California's three largest investor-owned electric utilities.

EPIC is funded by California utility customers under the auspices of the California Public Utilities Commission.

To learn more about EPIC, visit: https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program

EPIC 5 documents and event notices will be posted to: https://www.energy.ca.gov/proceeding/electric-program-investment-charge-2026-2030-investment-plan-epic-5

Subscribe to the EPIC mailing list to stay informed about future opportunities to inform the development of EPIC 5: https://public.govdelivery.com/accounts/CNRA/signup/31897

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i See section (a) (1) of Public Resources Code 25711.5 at: https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=PRC&sectionNum=25711.5.

ii EPIC innovations should improve the safety of operation of California's electric system in the face of climate change, wildfire, and emerging challenges.

iii EPIC innovations should increase the reliability of California's electric system while continuing to decarbonize California's electric power supply.

iv EPIC innovations should fund electric sector technologies and approaches that lower California electric rates and ratepayer costs and help enable the equitable adoption of clean energy technologies.

v EPIC innovations should continue to reduce greenhouse house gas emissions, criteria pollutant emissions, and the overall environmental impacts of California's electric system, including land and water use.

vi EPIC innovations should increasingly support, benefit, and engage disadvantaged vulnerable California communities (DVC). (D.20-08-046, Ordering Paragraph 1.) DVCs consist of communities in the 25 percent highest scoring census tracts according to the most recent version of the California Communities Environmental Health Screening Tool (CalEnviroScreen), as well as all California tribal lands, census tracts with median household incomes less than 60 percent of state median income, and census tracts that score in the highest 5 percent of Pollution Burden within CalEnviroScreen, but do not receive an overall CalEnviroScreen score due to unreliable public health and socioeconomic data.

vii In 2024 the CPUC adopted five Strategic Goals to guide development of the EPIC 5 Investment Plan. A description of the goals can be seen in Appendix A of CPUC Decision 24-03-007 available at:
https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M527/K228/527228647.PDF