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Joint Planning of Power Systems and Data Centers Considering Embodied Carbon

With the accelerating growth of artificial intelligence (AI) and cloud-based services, data centers have become critical infrastructures driving digital economies. Their surging energy demand has elevated concerns over electricity consumption and carbon emissions, underscoring the need for integrated, carbon-aware infrastructure planning. However, most existing studies adopt static power system assumptions, focus solely on operational emissions, and neglect the potential for co-optimization. We propose a dynamic joint planning framework that co-optimizes the long-term development of data centers and power systems. The model determines investment decisions for data center siting, capacity, and type, as well as power generation expansion, storage deployment, and generator retirements, while incorporating both operational and embodied carbon emissions. EPIC funds are needed to support the development of this innovative joint planning framework, which can lead to significant reduction in investment costs, operational costs and carbon emission.

Additional submitted attachment is included below.

CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

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:

   Nanpeng Yu, nyu@ece.ucr.edu, 626-720-7027

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

   University of California, Riverside

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?

   With the accelerating growth of artificial intelligence (AI) and cloud-based services, data centers have become critical infrastructures driving digital economies. Their surging energy demand has elevated concerns over electricity consumption and carbon emissions, underscoring the need for integrated, carbon-aware infrastructure planning. However, most existing studies adopt static power system assumptions, focus solely on operational emissions, and neglect the potential for co-optimization. We propose a dynamic joint planning framework that co-optimizes the long-term development of data centers and power systems. The model determines investment decisions for data center siting, capacity, and type,

as well as power generation expansion, storage deployment, and generator retirements, while incorporating both operational and embodied carbon emissions. EPIC funds are needed to support the development of this innovative joint planning framework, which can lead to significant reduction in investment costs, operational costs and carbon emission.

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)?

   Unlike prior models that optimize data center deployment based on a static power system, the proposed concept co-optimizes the investment trajectories of both power generation assets and data centers. The proposed concept captures the spatial and temporal interdependencies between power supply and digital demand, enabling coordinated infrastructure development. The proposed concept will incorporate both operational and embodied carbon emissions into joint infrastructure planning. By accounting for emissions from facility construction, equipment manufacturing, and long-term operations, the framework supports a more comprehensive and carbon-conscious planning pathway. The consideration of embodied carbon effectively promotes the development of renewable energy and thereby enables deeper decarbonization. The proposed concept can reduce investment and operation costs by around 10% and carbon emission by 5% for the entire state of California.

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]

The proposed technology would reduce the entire power system and data center investment and operation costs by up to 10%, which will lead to significant reduction in ratepayer costs. The proposed concept could be applied to the joint power system and data center planning for not only California but also the entire WECC area. It will lead to dramatic reduction in greenhouse gas emissions.

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

   Investment cost reduction. Operational cost reduction. Carbon emission reduction.

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.

   Zhentong Shao and Nanpeng Yu, "Stochastic Joint Planning of Power Systems and Data Centers Considering Embodied Carbon: A Case Study on PJM," 2025.

   https://intra.ece.ucr.edu/~nyu/papers/2025-Data-Center-Power-System-Planning.pdf

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.

The proposed joint power system and data center planning will help California achieve 100 percent non-zero carbon emissions while accommodating new data center load with lowest investment and operational costs.

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