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Dynamic intra-array and export cables for offshore wind farms

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:

   Ericka Lozon, ericka.lozon@nrel.gov, 269-384-9883

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

   National Renewable Energy Laboratory

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's floating offshore wind farms require cable solutions that reliably transmit power in the harsh, deep-water ocean environment. Within the floating wind farm, dynamic intra-array cables electrically connect adjacent floating turbines to each other and to the substation. Traditional configurations, such as lazy-wave cables, transfer power from the turbine to a static cable that runs along the seafloor. This approach is expensive in deep water because of the long cable lengths required. Fully suspended power cables directly connect adjacent turbines and are suspended high in the water column, presenting a possible cost benefit by reducing the cable length and eliminating the need for joints to join dynamic and static cable portions. However, suspended cables are challenged by extreme current loading and marine growth which can result in high tensions and vortex-induced vibration-based fatigue. Additionally, suspended cables pose impacts to navigational and co-use. On the export side, cables are required to transfer large amounts of power from the offshore wind farm substation to shore. In California water depths, the export cable must have a dynamic portion that can withstand the motions and loads of hanging freely in the water. This class of cable is not yet commercially available for HVDC systems, which are ideal for improving transmission efficiency. Further research is needed to develop intra-array and export cable solutions that meet California's needs.

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)?

   California's offshore wind development is necessary to advance toward the state goal of 25 GW of offshore wind energy by 2045. However, offshore wind development is challenged by the need for dynamic intra-array and export cables that can survive 25-year project lifetimes in California's unique deep-water conditions. Suspended power cables within floating wind farms have the potential to lower costs through reduced cable lengths and connection joints but require further research to be realized. On the export side, HVDC grid connections present higher transmission efficiency and grid stability benefits, but dynamic HVDC export cables require detailed design, evaluation, and testing. For both intra-array and export cables, the designs are challenged by constraints around the tension and fatigue loading, which are exacerbated by the weight of marine growth and the extreme current speeds seen in California. This research would develop design solutions to mitigate performance concerns, while improving reliability and lowering cost. Additionally, by addressing concerns around co-use and navigation of floating offshore wind farms, this research will improve the accessibility and acceptance of California's offshore wind farms.

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]

   Approximately 80% of offshore wind insurance claims are related to cable failures, representing a high financial burden on the overall cost of offshore wind development.

Therefore, research into reliable, resilient cable design has the potential to significantly lower overall energy costs by bringing failure rates down, while also reducing material and component costs. By enabling HVDC transmission with the design of HVDC export cables, transmission efficiency is improved and transmission costs are reduced. Based on previous studies, HVDC is estimated to reduce transmission costs by 30% at a transmission distance of 150 km. This cost reduction increases as transmission distance increases, presenting a large benefit for future offshore wind farms that may be located further from shore. Additionally, HVDC transmission presents benefits for grid stability and reliability which are crucial as renewable energy grid penetration increases. HVDC transmission has shown improved frequency and voltage responses in the event of grid failures, and also provides ancillary benefits to support the grid during disturbances. More stable grid operation can reduce the risk of power outages, which improves safety for California's ratepayers.

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

   Innovation in dynamic intra-array and export cable design will be subject to performance and cost metrics. The cable component cost should be tracked and compared against more traditional cable designs (i.e. comparing suspended cable alternatives to lazy-wave). The performance of the cable designs should be evaluated in California's extreme wind, wave, and current conditions, considering extreme 50-year return periods as well as fatigue loading over the lifetime. For HVDC export cables, the transmission efficiency and transmission costs should be compared against traditional HVAC.

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.

   "The Cost of Offshore Wind Energy in the United States from 2025 to 2050"
   https://docs.nrel.gov/docs/fy24osti/88988.pdf

   "The IEA Wind Task 49 Reference Floating Wind Array Design Basis"
   https://docs.nrel.gov/docs/fy24osti/89709.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 research concept supports goal (d) of Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas, by enabling offshore wind development. This research will reduce barriers to California’s deep-water offshore wind development by providing the necessary intra-array and export cable solutions for reliable transmission.

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