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RAMBOLL

Via e-commenting feature
California Energy Commission
Docket Unit, MS-4
715 P Street
Sacramento, CA 95814-5512

Re: Docket No. 23-ERDD-01
RFI Deep-Water HVDC Substations for Offshore Wind

Dear Sir/Madam:

Please accept this letter as Ramboll's response to the California Energy Commission (CEC)'s Request for Information (RFI) to gather input regarding deep-water High-Voltage Direct Current (HVDC) substations for floating offshore wind projects.

15 August 2024

Question 1. What information or analysis is needed to inform timely and cost-effective development and deployment of deep-water substations and associated offshore electrical infrastructure in existing and future California WEAs? How can publicly funded research and development (R&D) address technological, economic, and environmental uncertainties and better inform strategic technology advancement, feasibility, standards development, and component selection and procurement?

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At present, no floating or subsea deep-water HVDC substation has been designed and deployed. It is Ramboll's opinion that subsea HVAC for floating offshore applications is at early stages of development and technology readiness levels. As such, there are numerous opportunities for research and development across various disciplines (e.g., electrical, mechanical, structural, and material science engineering) related to offshore substations for floating wind projects. Topics include (i) sensitivity of high-voltage equipment deployed on floating platforms to dynamic marine and environmental loading (e.g., extreme waves, currents, wind, earthquakes, etc.), (ii) development of high-voltage dynamic cables with special mechanical and electrical connections and attachments that can accommodate various sea states, (iii) lack of existing design standards for floating/subsea offshore substations, (iv) opportunities for cost reductions, (v) shielding of energized high-voltage equipment on a floating platform, and more.

To highlight one example, a floating HVDC offshore substation is unique from a structural engineering perspective. It requires careful design of the topside, the substructure, and of the overall integrated offshore substation system (topside and substructure combined).

Special and novel design approaches would be necessary to ensure safe and operational conditions for the mechanical high-voltage equipment under various environmental loads. Currently, overall integrated design of topside and substructure is not common practice for offshore substations. Publicly-funded research & development efforts can significantly contribute to advancing this technology from concept towards commercial-scale deployment. Federal and state (public and private) research entities can work collaboratively and guide the R&D through incentives and sponsorship.

Question 3. What specific technical, economic, or other factors are crucial for understanding the viability and success of offshore electrical infrastructure technologies for FOSW development in California? What key performance characteristics and metrics are anticipated to be challenging for California's existing and future WEAs?

Generally speaking, key factors for offshore electrical infrastructure include (but are not limited to) (i) technology readiness level, (ii) reliability, (iii) cost, (iv) extent of demonstration/experience, (v) standardization and scalability, and (vi) supply chain availability. From a station-keeping perspective, a floating HVDC offshore substation is a huge platform. Accordingly, seismic activity will need to be considered in designing mooring and anchoring systems. Distance to landfall point is another key factor that directly impacts project cost, as it is a key element in determining whether to proceed with an HVDC or HVAC transmission configuration. Furthermore, although these offshore substations will be sited on federally-regulated portions of the Outer Continental Shelf, they will still be required to interconnect to California's onshore electricity grid. As a result, projects will need to consider the onshore interconnection requirements set forth by the California Public Utilities Commission (CPUC) and California Independent System Operator (CAISO). It is Ramboll's opinion that the availability, standardization, and scalability of the electrical component supply chain would be among the key challenges to developing floating offshore wind projects within California's existing and future WEAs.

Question 5. Are there other pressing needs or challenges relating to FOSW electrical infrastructure or transmission R&D that EPIC should consider?

Pressing needs and challenges for floating offshore wind electrical infrastructure include:

- Lack of high-voltage dynamic cables
- Wet connector technology
- Standards/certification of high-voltage equipment on floating and subsea offshore substations
- Overall demonstration of successful deployment of floating and subsea offshore substations
- Transmission system design/topology (development of networked/coordinated offshore grid vs. reinforcement/expansion of onshore grid)

Question 6. What technical barriers will have the largest impact on development of deep-water HVDC substations in California? How could publicly funded R&D be most effectively applied to help increase timely and cost-effective deployment of new offshore deep-water HVDC substations in existing or future California WEAs?

Demonstrating overall reliability and robustness of offshore deep-water HVDC substations – whether floating or subsea – for commercial-scale floating wind projects is the key technical barrier. This includes the sensitive high-voltage equipment, which is exposed to relatively high motions and accelerations on the floating platform. These motions and accelerations are not typical design requirements for high-voltage

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equipment. Another technical barrier concerns demonstrating reliability of dynamic high-voltage export cables (which do not yet exist). The offshore substation is indispensable to an offshore wind project's ability to deliver power to the onshore grid. Failure of this component likely means considerable downtimes, loss of revenue, and less power generation. Minimizing offshore substation downtime is critical. Finally, the lack of dedicated standards for offshore deep-water HVDC substations in general, and lack of U.S. specific rules and regulations, presents a challenge for both design and permitting.

Question 7. What key cost factors are critical to the timely deployment of deep-water HVDC substations and associated offshore electrical infrastructure that could be addressed through technology advancement or analysis?

Lack of local fabrication facility as well as transportation and installation (T&I) vessels for deep-water HVDC substations and associated offshore electrical infrastructure are critical factors to both cost and timely deployment. Currently, California lacks port facilities that are set up to support local construction, marshalling, and/or load-out of HVDC offshore substations at the scale needed to reach California's offshore wind targets. Foreign suppliers of offshore substation components may not have availability to supply California offshore wind projects. Further, the previously addressed challenges related to dynamic cables, including lack of demonstration low level of technology maturity, lead to currently very expensive conceptual designs. There is considerable room for R&D initiatives to focus on cost optimization.

Question 8. What novel technologies or design concepts proposed for HVDC substations have been successfully demonstrated in a physical or simulated dynamic offshore environment and can provide economic benefits and cost savings for California ratepayers? Are there any specific substation platforms, mooring systems, HVDC electrical components, or other substation technologies that provide clear benefits and advantages for use in the existing or future California WEAs? How could R&D funding be most effectively applied to improve and optimize these technologies further to reduce costs and improve their technical suitability for California's WEAs?

To Ramboll's knowledge, no floating deep-water HVDC or HVAC substations have been designed and deployed. In general, HVDC is still relatively anomalous even in fixed-bottom offshore wind projects. Only 11 HVDC substations were commissioned in European waters as of the end of 2023.

Question 9. What key technologies or capabilities are needed in-state, regionally, and nationally to facilitate supply chain, manufacturing, installation, and operations and maintenance needs for deep-water HVDC substations and associated electrical infrastructure? What are the environmental, ecosystem, health, and social impacts associated with these technologies or that should be evaluated for these technologies?

California currently lacks the port facilities needed to fabricate, marshal, and install deep-water HVDC substations. Upgrades would need to be made to site load-bearing capacity, and larger cranes than those presently available at any California port would be needed. Many of the subcomponents of the offshore substation are highly specialized products whose fabrication is presently performed out of key global strongholds. Additionally, those strongholds rely upon on long-standing and complex supply chains that crisscross the globe. In terms of fabrication of deep-water HVDC substations, this activity would require heavy steel handling and fabrication at a level not presently performed in California anywhere other than for military vessels in San Diego. Existing manufacturing facilities in the Gulf of Mexico region (e.g., Louisiana, Texas) could provide support for steel fabrication for the integrated floating platform housing the deep-water HVDC substations.

Question 10. What technologies or processes can monitor the condition and performance of deep-water HVDC substations and offshore electrical infrastructure? What are the current resolution capabilities of these technologies? Are these technologies or processes adequate for application in existing or future California WEAs? What are additional operations and maintenance needs for deep-water HVDC substations?

At this time, it is not expected that new sensors or monitoring technologies will need to be developed. Rather, the key would be to properly define/scope which parameters need to be measured. Thereafter, the information gathered can be leveraged and applied to increase project uptime (for example, performance-based/predictive operations and maintenance scheme using digital twin technology) and minimize operational expenditures.

Question 11. Are there any other questions or information the CEC should consider for research on deep-water HVDC substations for offshore wind that is not otherwise covered by the questions above?

- Carbon Trust
  - **Floating Wind Joint Industry Program** (JIP)
  - Collaborative R&D initiative focused on commercializing floating offshore wind
  - Started in 2016, has run five (5) phases
  - Currently investigating higher-voltage dynamic cable

- COREWIND
  - **Deliverables**
  - Funded by European Commission
  - Aimed at achieving significant cost reductions for floating offshore wind projects through research and optimization of mooring and anchoring systems and dynamic cables

- Offshore Renewable Energy Catapult
  - **Floating Offshore Wind Centre of Excellence**

- World Forum Offshore Wind
  - **Floating Offshore Wind Dynamic Cables: Overview of Design and Risks**

- CORE Initiative
  - **About the HVDC COst REduction (CORE) Initiative**
  - Supported by the U.S. Department of Energy's Office of Electricity
  - Funds research & development to reduce HVDC technology and long-distance transmission costs by 35% by 2035
  - Key objective is to develop and domestically manufacture HVDC transmission technologies

Ramboll thanks the California Energy Commission for the opportunity to provide these comments regarding deep-water HVDC substations for floating offshore wind, and we look forward to continued engagement.

Yours sincerely,

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