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Comment Received From: Marcus Lehmann
Submitted On: 5/16/2025
Docket Number: 24-SB-605

Comments on the SB 605 Draft Consultant Report on Sea Space Analysis

Dear Chair Hochschild and Vice Chair Gunda:

CalWave Inc. (CalWave) is pleased to submit comments on the SB 605 Draft Consultant Report on Sea Space Analysis. CalWave worked with the National Hydropower Association (NHA) to submit responses to the California Energy Commission (CEC) Docket No. 24-IEPR-01 in April 2024, the CEC Docket No. 24-IEPR-04 in July 2024, and the CEC Docket No. 24-IEPR-01 in January 2025. Links to CalWaveâ€™s three prior submissions are linked here:

1) April 2024:
https://efiling.energy.ca.gov/GetDocument.aspx?tn=255544&DocumentContentId=91313
2) July 2024:
https://efiling.energy.ca.gov/GetDocument.aspx?tn=258151&DocumentContentId=94101
3) January 2025:
https://efiling.energy.ca.gov/GetDocument.aspx?tn=260875&DocumentContentId=97305

This fourth docket submission from CalWave is divided into three parts:

Part I discusses concerns CalWave has over one specific mention of the company within the report.

Part II discusses several other portions of the report that are not specific to CalWave.

Part III suggests potential next steps for California to continue establishing itself as a hub for marine energy innovation and deployment.

Thank you for providing another opportunity to participate in the SB 605 process, and we look forward to our continued engagement with the CEC.

Marcus Lehmann, PhD.
On behalf of CalWave Inc.

Additional submitted attachment is included below.

CALWAVE

5/16/2025

Chair David Hochschild
Vice Chair Siva Gunda
California Energy Commission
Docket Unit, MS-4
Docket No. 24-SB-605
715 P Street Sacramento, CA 95814-5512

Subject: Comments on the SB 605 Draft Consultant Report on Sea Space Analysis

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I. COMMENTS ON CALWAVE-SPECIFIC CONTENT

CalWave is pleased to be included in Section 2.3 of the report on "Previous Marine Energy Projects in California," especially given that our 10-month deployment off the coast of San Diego was such a success. However, two details are misleading.

1) Page 47 says that the x1 pilot was launched in 2022. It was actually launched in September 2021 and recovered in July 2022.

2) More importantly, page 48 says that the pilot "emerged after an extensive 11-year permitting process." ***This is incorrect.*** KQED, linked at the bottom of page 48, published the following sentence in their story: "Much is riding on the success of the project, which took 11 years to acquire permits." ***This sentence refers to the PacWave facility offshore Oregon, not CalWave's pilot offshore California.*** The wording in the KQED story is a bit confusing, especially given that this sentence was written directly beneath a photo of the CalWave x1 system, but we strongly request that the CEC make sure this is corrected.

Please find here a list of key facts about the project, also summarized in this DOE public repository: https://tethys.pnnl.gov/project-sites/calwave-xwave-demonstration

1) This open ocean sea trial was funded by the U.S. Department of Energy (DOE) Water Power Technologies Office (WPTO) in 2017 and permitting for the location at the Scripps Institution of Oceanography (SIO) started in 2018.

2) While initially scheduled for six months with time and budget for two interventions, the pilot operated for a total of 10 months with zero interventions, and was concluded as required by CalWave's DOE contract.

3) The system experienced over 99 percent uptime throughout the duration of the pilot.

4) The onboard controller took over full autonomous operations during the second month of the pilot and continued operating until the system was decommissioned. The controller operated the system for roughly 80 percent of the deployment.

5) The system survived and operated through multiple 10-year storm events, including 15-foot waves. Because this was a scaled environment, this performance is representative of a full-scale system operating through 60-foot waves.

More information can be found in CalWave's press release from September 1, 2022: https://calwave.energy/calwave-successfully-concludes-historic-wave-energy-pilot-in-california/

II. COMMENTS ON GENERAL CONTENT IN THE REPORT

Comments on the report are listed here in page number order:

Page 37: The lower overall energy demand in Northern California compared to Central and Southern California shouldn't necessarily be seen as a weakness or a reason not to prioritize the region for wave energy development, but rather as an opportunity to increase utilization of the planned 1.6-14.7 GW of transmission upgrades of the North Coast.

Several studies worldwide and CA specific have concluded that sharing on or offshore substations between Offshore Wind and Wave farms can significantly increase the joint capacity factor.

Sources:

- Offshore wind and wave energy can reduce total installed capacity required in zero-emissions grids | Nature Communications
- Publications | EU-SCORES
- Wave and Floating Wind Energy - Cost Benefit Analysis | WES
- StoutenburgIEEE11.pdf

The California Independent System Operator (CAISO) and the California Energy Commission (CEC) have dramatically increased their offshore wind targets for the North Coast:

Short-term (by 2035): The CAISO 2023–2024 Transmission Plan includes projects to connect 1.6 GW of offshore wind from the Humboldt call area, see Offshore wind big part of ISO's 2023-2024 Transmission Plan | California ISO

Long-term (by 2045): The CEC's updated strategic plan envisions up to 14,700 MW (14.7 GW) of offshore wind capacity on the North Coast, more than triple previous forecasts, see The ISO posts an updated 20-Year Transmission Outlook | California ISO

Page 43: "Powering the Blue Economy" infrastructure, like ports, shipyards, and other infrastructure that serves maritime industries, are generally positioned in sheltered areas away from significant wave energy resources. Breakwaters, jetties, and other coastal structures near this infrastructure only experience a few kilowatts per meter of wavefront, at best. To extract any meaningful amount of power for port or shipyard operations from this weak wave energy resource would require an immense spatial footprint and CAPEX while yielding a very low capacity factor. This is especially true in Southern California, where the Channel Islands block the attractive wave energy resource from reaching the mainland. For ports or shipyards to leverage wave energy systems in an economically viable way, there would likely need to be tens of megawatts deployed offshore (where there is a resource of at least 20 to 30 kilowatts per meter of wave front) with one single cable run back to shore.

Page 45: We have two separate comments with regard to "Colocation With Offshore Wind Infrastructure."

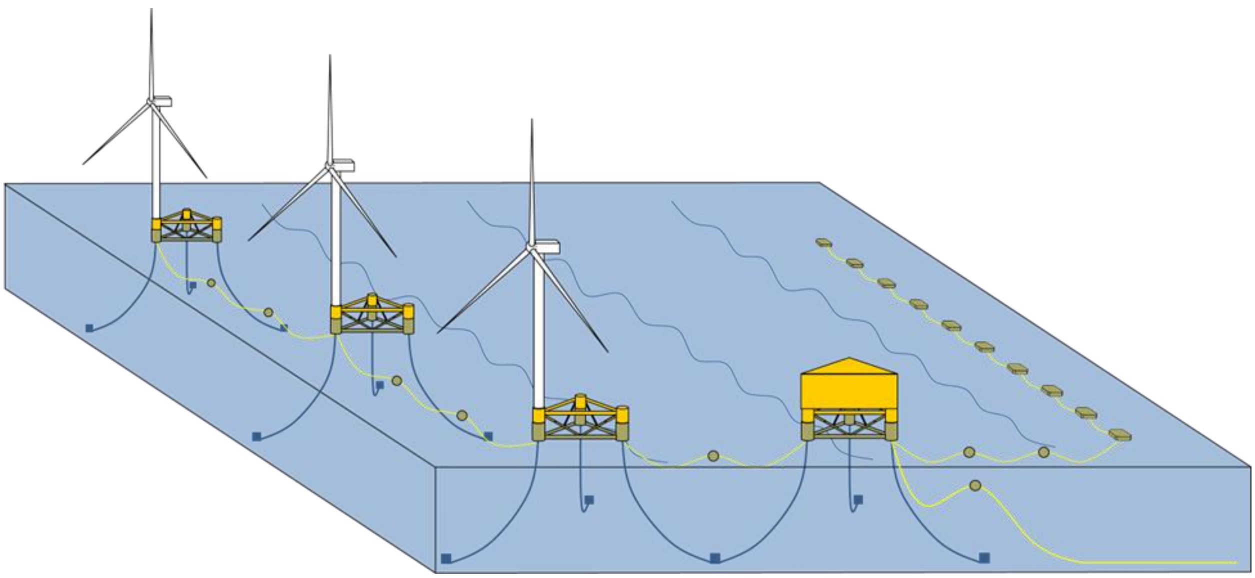

Fig. 1: Co-location of offshore wind and wave farms sharing balance of plant but in independent permit and area.

1) The report states that "The land-based and nearshore components of marine energy and wind energy operations could be colocated, potentially reducing the overall spatial and visual impact of that supporting infrastructure."

These are relevant benefits of colocation, but the more critical and relevant opportunities are the shared utilization of balance-of-plant including on and offshore substations. This has the opportunity to:

1. **Reduced costs for ratepayers:** Co-location with Offshore Wind will increase the joint capacity factor to close to baseload power on the offshore and onshore transmission lines and reduces the need to overbuild transmission and storage infrastructure. According to the Pacific Northwest National Laboratory (PNNL), the complementary generation profile

of marine renewable energy creates an opportunity to reduce the need for energy storage technologies, thus reducing overall system costs.

2. **Energy security and stability:** The increased join capacity factor resulting into base load clean energy supports consistency, predictability, and proximity of marine energy resources would flatten the Duck Curve, provide grid stability, and reduce transmission costs.
3. **Increase utilization of sea space**: Marine energy technologies may be permitted through the same leasing mechanisms as offshore wind.
4. **Economic Benefits:** Wind and wave energy farms have the potential to create local jobs, enhance local economic development, and increase supply chain demand. Wave energy can utilize the same onshore and offshore logistics including ports, vessels and workforce. The increased utilization of these will bring additional jobs and higher utilization.
5. **Increased sea space opportunities**: Wave energy technologies are more versatile than offshore wind turbines and can often go where offshore wind cannot. Our x-Wave systems operates submerged and does not require specialized vessels. This benefit gives developers the flexibility to deploy systems closer to shore than would be possible for offshore wind turbines, reducing IO&M costs and transmission losses.

Sources:

- Understanding the Grid Value Proposition of Marine Renewable Energy | PNNL
- Offshore wind and wave energy can reduce total installed capacity required in zero-emissions grids | Nature Communications
- Publications | EU-SCORES
- Wave and Floating Wind Energy - Cost Benefit Analysis | WES
- StoutenburgIEEE11.pdf
- Maximizing Ocean Energy Potential: A New Era in Offshore Renewable Energy - Oceantic Network

2) The report states that “all wind energy lease areas are in medium-high wave energy areas, meaning there is resource potential for colocation of electrical cable connections or integration of WECs either into the turbine platform infrastructure itself or in the area within the turbine arrays.” We would like to highlight the point that all five BOEM offshore wind leases (two in Northern California off the coast of Eureka and three in South-Central California off the coast of Morro Bay) have significant wave energy resources. However, it is important to recognize the difficulty of integrating into the floating wind platforms themselves, especially given that floating offshore wind platform OEMs are still early in their growth phases as well. The most likely scenario may instead be that some offshore infrastructure is shared, like substations, export cables, and potentially even anchors.

Page 70: We agree that it will be important to engage with both the commercial and recreational fishing communities throughout the marine energy project development process for projects offshore California. While the report generally talks about potential conflicts between marine energy devices and fishing efforts, the environmental data from CalWave's x1 pilot offshore San Diego suggests that the presence of slow-moving wave energy devices may increase local fish stocks through the artificial reef effect that often comes with offshore structures. More information can be found at: https://tethys.pnnl.gov/project-sites/calwave-xwave-demonstration

Page 84: We agree that "developers must address potential conflicts with U.S. Department of Defense (DoD) activities when siting wave and tidal energy near DoD properties and operations, particularly areas critical to national security," but we believe there should be a stronger emphasis on the fact that "the military could have use for marine energy technologies since the devices can be deployed in off-grid locations along the coast

Page 86: We support the statement that "placement of WECs and TECs on existing marine structures, such as a decommissioned oil and gas platform or an active platform, could reduce installation costs and reduce device footprints, thereby reducing the environmental impact of marine energy projects." Given that balance-of-system infrastructure is often what makes or breaks a project's economic viability, there should continue to be a focus on leveraging existing offshore and onshore infrastructure as much as possible to minimize project costs especially existing transmission lines.

Page 87: Because "coupling wave energy with wind energy allows for better energy yields and higher predictability," the price per MWh generated by co-located projects should reflect the value of the power being generated. Google and other large "hyperscalers" are starting to pay premiums for more consistent, predictable, clean power for the expansions of their data center portfolios. Wave energy projects (as well as co-located wave and offshore wind energy projects) generate power far more consistently than solar or wind alone.

Page 103: The statement that the "high cost of stand-alone wave energy conversion development has been an obstacle for large-scale application" is misleading.

Comparable to other renewables including offshore wind, large-scale application of wave farms allow to reduce the cost per kW per project due to economies of project scale, thus a single unit cost is not indicative for the cost of large scale farms e.g. single offshore wind turbines are also not in being built although the cost per MW of OSW has declined significantly.

While correct that co-location with other offshore infrastructure may reduce balance-of-system costs for all infrastructure involved, **this has not been an obstacle for large-scale application.** The main obstacle for large-scale application has been the lack of consistent funding support to advance technologies from 1) R&D to 2) single-unit demonstrations to 3) array deployments of many units. As technology developers build larger individual systems and larger projects, costs are expected to fall significantly for a few key reasons:

Wave energy represents a 20-60x more energy dense resource (20-60kW/m times depth compared to ~1kW/m^2, thus the amount of space and material needed to arrive at the same installed capacity compare to other renewables with lower density resources like wind and solar.

This is reflected in the lifecycle emissions as highlighted by the IPCC:

Options	Direct emissions	Infrastructure & supply chain emissions	Lifecycle emissions (incl. albedo effect)
	Min/Median/Max		Min/Median/Max
Currently Commercially Available Technologies			
Geothermal	0	45	6.0/38/79
Hydropower	0	19	1.0/24/2200
Nuclear	0	18	3.7/12/110
Concentrated Solar Power	0	29	8.8/27/63
Solar PV—rooftop	0	42	26/41/60
Solar PV—utility	0	66	18/48/180
Wind onshore	0	15	7.0/11/56
Wind offshore	0	17	8.0/12/35
Pre-commercial Technologies			
CCS—Coal—Oxyfuel	14/76/110	17	100/160/200
CCS—Coal—PC	95/120/140	28	190/220/250
CCS—Coal—IGCC	100/120/150	9.9	170/200/230
CCS—Gas—Combined Cycle	30/57/98	8.9	94/170/340
Ocean	0	17	5.6/17/28

Chapter 6: Energy systems

1) Leveraging economies of scale when scaling manufacturing capabilities

2) Deploying projects with many WECs to share the same balance-of-system infrastructure to reduce the overall percentage of CAPEX covered by balance-of-system

3) Learning from deployed systems how to more efficiently design future systems

III. Recommended policy and next steps

The SB 605 process has helped bring marine energy to the forefront of energy policy in California. In a time when the share of intermittent renewables on the grid is consistently rising, follow-on policy mechanisms to support more consistent clean energy sources, like marine energy, are crucial to maintaining a clean and reliable energy system. Following are suggestions for next steps the state of California could take with regard to marine energy R&D, demonstration, and deployment to both build a more resilient energy system in California and serve as a model for the rest of the country:

1) **Marine Energy Equivalent of AB 525**

In September 2021, the California Legislature passed and the Governor signed AB 525, which required CEC to work with a variety of federal, state, and local agencies "to develop a strategic plan for offshore wind energy developments installed off the California coast in federal waters, and submit it to the California Natural Resources Agency and the Legislature." **We recommend that the California Legislature introduce and pass a similar bill to AB 525 for marine energy development.** The Offshore Wind Strategic Plan, which was released in July 2024, stated that "the AB 525 suitable sea space identified in this report is intended to be a starting point for future BOEM activities related to offshore wind development off California's coast." We believe that "suitable sea space" work done for marine energy should also be a starting point for future BOEM activities. One way to engage with BOEM on this topic is to respond to its "Request for Information and Comments on the Preparation of the 11th National Outer Continental Shelf Oil and Gas Leasing Program," which explicitly asks for "comments and suggestions of national or regional application" relating to "wave, current, or other alternative energy sites." Here is a link to the RFI on the Federal Register:

https://www.federalregister.gov/documents/2025/04/30/2025-07479/request-for-information-and-comments-on-the-preparation-of-the-11th-national-outer-continental-shelf

2) **Supporting wave energy projects in California**

We recommend that the state through programs like CEC EPIC – through the marine energy equivalent of AB 525 suggested above – support a pathway for marine energy technologies and projects in California to advance from 1) R&D to 2) single-unit demonstrations to 3) array deployments of many units with funding support from the state.

3) When updating the CEC Utility-Scale Renewable Energy Generation Technology Roadmap and the EPIC 4 Investment Plan, we strongly recommend considering the global state of marine energy via e.g.:

a) OES | Ocean Energy Systems - an IEA Technology Collaboration Programme

b) Marine Energy - National Hydropower Association

c) Ocean Energy Europe - Ocean Energy Europe

Source: https://www.energy.ca.gov/publications/2021/electric-program-investment-charge-2021-2025-investment-plan-epic-4-investment

Wave Energy Resource Assessment

Along California's 1,200 kilometers of coastline, it is estimated that on the inner and outer shelves of California, there is a theoretical recoverable potential of 498 TWh (terawatt-hours) (EPRI 2011). The technically recoverable potential if wave energy converters are packed at a density of 20 MW per km is 295.2 TWh which is enough available energy to supply 91 percent of SB 100 2045 goals (supporting calculations in Appendix A). Based on a general literature assessment, a 30 percent capacity factor is an appropriate assumption for wave energy systems (Previsic et al 2012, Lewis, A. et al 2011, Chozas 2015, and Rusu and Onea 2018). These estimates are highly uncertain since few assessments are available for California's wave resource and few existing systems are available to demonstrate actual performance capabilities."

Source:Utility-Scale Renewable Energy Generation Technology Roadmap | California Energy Commission

4) Sharing of substations and cable compared to hybrid offshore wind and wave system platforms:

The CEC Supplement to the offshore wind section of the 2020 Utility-Scale Renewable Energy Generation Technology Roadmap recommends:

A hybrid floating offshore wind turbine and wave energy system provides a pathway to faster deployment and lower LCOE for wave energy systems.

The CEC Electric Program Investment Charge 2021–2025 Investment Plan: EPIC 4 Investment Plan

Initiative OSW.3: Develop Solutions for Integrating Wave Energy Systems with Floating Offshore Platforms

Although there are hybrid systems where a floating offshore wind platform incorporates wave energy under development, these systems will slow down the adoption of both industries as the combined maturity has to be considered.

We recommend investigating the shared utilization of offshore and onshore substations and export cables instead to accelerate adoption and simply project development of independent offshore wind and wave farms.

Sources:

- Utility-Scale Renewable Energy Generation Technology Roadmap | California Energy Commission
- https://www.energy.ca.gov/publications/2021/electric-program-investment-charge-2021-2025-investment-plan-epic-4-investment

5) NHA's submission to Docket No. 24-IEPR-04 in July 2024 included seven different state-level clean energy incentive programs that California can use as examples in scaling marine energy technologies and projects: 1) Deployment targets and centralized procurement; 2) Feed-in tariffs; 3) Renewable portfolio standard carve-outs; 4) Clean transition tariffs; 5) Production tax credits; 6) Investment tax credits; and 7) Innovation funds.

We recommend that a comparison to the support mechanisms that other renewables including offshore wind and solar have received to rank these mechanisms by effectiveness and resource efficiency when applying these on marine energy.