Date of Hearing: June 28, 2023

ASSEMBLY COMMITTEE ON UTILITIES AND ENERGY
Eduardo Garcia, Chair
SB 605 (Padilla) – As Amended April 27, 2023

SENATE VOTE: 40-0

SUBJECT: Wave and tidal energy

SUMMARY: Requires the California Energy Commission (CEC), in consultation with specified agencies and stakeholders, to conduct a study on and, upon appropriation by the legislature, solicit and review applications for pilot projects to assess the feasibility and potential benefits of wave and tidal energy generation in California. The CEC is also required to, in cooperation with the Ocean Protection Council (OPC), submit a report to the Governor and the Legislature by January 1, 2025, outlining the findings of the study, data collected from the pilot projects, should any be funded and implemented, and recommendations for actions to facilitate the development of wave energy and tidal energy generation in the state.

EXISTING LAW:

1) Establishes the policy of the state that eligible renewable energy resources and zero-carbon resources supply 90% of all retail sales of electricity to California end-use customers by December 31, 2035, 95% of all retail sales of electricity to California end-use customers by December 31, 2040, 100% of all retail sales of electricity to California end-use customers by December 31, 2045, and 100% of electricity procured to serve all state agencies by December 31, 2035. (Public Utilities Code § 454.53)

2) Requires the California Public Utilities Commission (CPUC), CEC, and California Air Resources Board (CARB) to issue a joint report to the Legislature by January 1, 2021, and at least every four years thereafter, that includes, among other things, a review of the 100% Clean Energy policy and the barriers to, and benefits of, achieving the policy. (Public Utilities Code § 454.53)

3) Establishes the Ocean Protection Council (OPC) within state government and consists of the Secretary of the Natural Resources Agency, the Secretary for Environmental Protection, the Chair of the State Lands Commission, and two members of the public appointed by the governor. Requires the OPC to coordinate activities of state agencies that are related to the protection and conservation of coastal waters and ocean ecosystems to improve the effectiveness of state efforts to protect ocean resources. (Public Resources Code § 35600)

4) Defines "renewable energy generation facility" for eligibility in the Renewables Portfolio Standard (RPS) to include a facility that uses ocean waves, ocean thermal, or tidal currents. (Public Resources Code § 25741)

5) Establishes the Voluntary Offshore Wind and Coastal Resources Protection Program to fund assessments, studies of impacts, comprehensive environmental impacts monitoring, adaptive management, and to fulfill infrastructure readiness commitments, among other

activities, with the overall goal of avoiding and minimizing impacts to coastal resources from floating offshore wind. (Public Resources Code § 25992)

FISCAL EFFECT: According to the Senate Committee on Appropriations, costs to implement this bill are unknown but likely significant for the California Coastal Commission (CCC), the Ocean Protection Council, and the CEC, in addition to unknown but likely significant cost pressure to scale up or expand pilot projects deployed as a result of this bill.

BACKGROUND:

Wave and Tidal Energy – Ocean waves and tidal fluxes contain enormous amounts of kinetic energy which, if effectively harnessed to generate electricity, could contribute to California's renewable and zero-carbon energy goals.[1] A 2021 report by the National Renewable Energy Laboratory assessed the technical potential of US marine energy resources at the state, regional, and national scales using the best available data. The report found that the potential wave energy resources in California, out to 200 miles, is 140 terawatt hours per year (TWh/year) – equivalent to approximately 70% of California's total energy demand in 2019 and sufficient to power 13 million homes. While seemingly significant, this value represents the *technical* potential of wave energy; only a fraction of that total may be feasibly utilized. In addition to the wave energy potential of the state's Pacific coastline, the San Francisco Bay represents a potential tidal resource of about 1.6 TWh/year.[2] Wave and tidal energy generation technologies have the potential to reduce dependence on fossil fuels, provide predictable energy generation to complement other renewable energy resources, provide locally-sourced power for offshore industries, support coastal communities, and assist in disaster recovery.[3,4]

Wave and tidal energy generation technologies are in the early stages of commercialization. The deployment challenges include high development and maintenance costs, lack of infrastructure, regulatory challenges, and impacts on the surrounding environment.[5] The environmental effects include the potential for habitat disruption during installation, collisions between marine life and underwater turbines, disruption of water flow, and the creation of underwater noise.[6] Tidal energy development faces the additional issue of location limitations. The potential for tidal energy generation capacity is greatest in areas with large tidal fluctuations and locations where the tidal flux is channeled through narrow corridors.[7] Places which satisfy both conditions are limited and may not be located near suitable transmission infrastructure or electrical load centers, leaving any electricity generated with nowhere to go. The most effective methods for harnessing wave and tidal energy is the focus of much ongoing research at the federal level and

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[1] U.S. Energy Information Administration; "Hydropower explained"; August 2022; https://www.eia.gov/energyexplained/hydropower/wave-power.php
[2] National Renewable Energy Laboratory; "Marine Energy in the United States: An Overview of Opportunities"; February 2021; https://www.nrel.gov/docs/fy21osti/78773.pdf
[3] U.S. Government Accountability Office; Science and Tech Spotlight: Renewable Ocean Technology; June 2021; https://www.gao.gov/products/gao-21-533sp
[4] U.S. Department of Energy; "CalWave Launches California's First Long-Term Wave Energy Project"; March 2022; https://www.energy.gov/eere/water/articles/calwave-launches-californias-first-long-term-wave-energy-project
[5] U.S. Government Accountability Office; Science and Tech Spotlight: Renewable Ocean Technology; June 2021; https://www.gao.gov/products/gao-21-533sp
[6] Pacific Northwest National Laboratory; "Tidal Energy"; September 2021; https://www.pnnl.gov/explainer-articles/tidal-energy
[7] Pacific Northwest National Laboratory; "Tidal Energy"; September 2021; https://www.pnnl.gov/explainer-articles/tidal-energy

internationally, as well as the subject of many proposed but scuttled projects in recent decades. While a variety of means of energy generation from wave and tidal sources have been designed and tested, none have emerged as a market leader that could establish supply chains and begin reducing costs.

The cost of wave and tidal energy generation has been a significant barrier to more widespread development. According to a 2011 report by Pacific Gas & Electric (PG&E) on the WaveConnect Program, "It is unclear when or if wave power will become competitive with renewable energy alternatives. Significant additional investment in design, testing and demonstration will be needed to improve designs and reduce costs. Using a vendor-provided installed cost goal of $2500/kW for mature WECs (wave energy converters) in five to 10 years, PG&E concluded that their LCOE (levelized cost of energy[8]) would be in the range of $175–$250 per megawatt-hour ($/MWh), which is not competitive with current or near-term renewable alternatives such as wind or solar photovoltaics."[9] The report also indicated that European-based wave energy generation device manufacturers relied on high feed-in tariffs, further suggesting that wave energy was not financially viable at that time. The WaveConnect Program was discontinued prior to deploying any wave energy generating devices, with excessive cost cited as a primary reason for shutting down the program.[10] The International Energy Agency forecasted a levelized cost of energy (LCOE) for the first commercial-scale project of $120–470/MWh for wave energy and $130–280/MWh for tidal energy.[11] For comparison, the LCOE of utility-scale solar energy in the U.S. was $33/MWh in 2021.[12]

Deep Dives And Current Events – Wave and tidal energy projects in California have been limited to proposals and pilot studies. As noted above, the WaveConnect pilot project proposed by PG&E in 2007 aimed to provide a site to test wave energy generation technologies while providing electricity to a nearby coastal community in Humboldt County. However, the project was discontinued early in development due to permitting issues, high development costs, and forecasts that any electricity generated would be so expensive as to not be competitive with other renewable generation methods.[13] More recently, CalWave conducted a pilot project using its prototype Xwave device off a pier in San Diego in 2021[14] and, in January 2023, AltaSea announced a new wave energy generation pilot project to be developed near San Pedro.[15] To the committee's knowledge, these recent pilots were funded through federal monies or private investment.

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[8] An economic measure used to compare the lifetime costs of generating electricity across various generation technologies.
[9] Pg. ii; Pacific Gas & Electric; "PG&E WaveConnect Program Final Report"; December 2011; https://www.osti.gov/biblio/1032845
[10] Pacific Gas & Electric; "PG&E WaveConnect Program Final Report"; December 2011; https://www.osti.gov/biblio/1032845
[11] U.S. Department of Energy; "Powering the Blue Economy: Exploring Opportunities for Marine Renewable Energy in Maritime Markets: Appendices"; April 2019.
[12] Lawrence Berkeley National Laboratory; "Utility-Scale Solar"; https://emp.lbl.gov/utility-scale-solar
[13] Pacific Gas & Electric; "PG&E WaveConnect Program Final Report"; December 2011; https://www.osti.gov/biblio/1032845
[14] U.S. Department of Energy; "CalWave Launches California's First Long-Term Wave Energy Project"; March 2022; https://www.energy.gov/eere/water/articles/calwave-launches-californias-first-long-term-wave-energy-project
[15] Daily Breeze; "San Pedro's AltaSea unveils wave-energy pilot program, new campus tenant"; January 2023; https://www.dailybreeze.com/2023/01/13/san-pedros-altasea-unveils-wave-energy-pilot-program-new-campus-tenant/

The U.S. has only one active, grid-connected wave energy project, which has been operating since 2020 at the U.S. Navy Wave Energy Test Site in Hawaii.[16] However, in February 2021, the U.S. Bureau of Ocean Energy Management (BOEM) announced a lease for the first wave energy research project in federal waters off the U.S. West Coast. The lease, offered to Oregon State University, is for a proposed open ocean wave energy test center.[17] Up to twenty wave energy converter devices with an installed total capacity of up to 20 MW will be deployed at the site for research and testing, buoyed by a $25 million award from the U.S. Department of Energy (DOE).[18] In addition, in March 2023, the DOE announced a prize program to award up to $2.3 million to foster early stage development of technologies for harnessing wave energy.[19]

Internationally, wave and tidal energy have received considerable investment and is generating electricity at scale. A large tidal installation near La Rance, France, was built in 1966 and is still in operation with 240 MW of electricity generation capacity. A tidal power plant at Sihwa Lake, in South Korea, has a capacity of 254 MW.[20] The MeyGen tidal stream project, off the northern coast of Scotland, supplied 13.8 gigawatt-hours of electricity to the UK grid in 2019. It currently consists of four turbines with a total capacity of 6 MW, with 49 more turbines and a total additional capacity of 73.5 MW planned for the next stage of development.[21] Over the last decade, Europe has invested more than $414 million in ocean energy research and development, alongside a stated target of deploying 100 MW of wave and tidal energy capacity by 2025.[22] At least 17 major projects are already in development in Europe, representing over 160 MW of capacity and $1.2 billion of investment.[23]

Related Resources – California's coastline and ocean waters have historically helped support the state's energy needs in a variety of ways. Ocean waters have been used to facilitate electricity generation at several natural gas power plants (known as once-through-cooling plants, which have been scheduled to retire due to regulations), as well as at the Diablo Canyon nuclear power plant and the now-shuttered San Onofre Nuclear Generating Station. These facilities use ocean water to cool down and condense steam after it has been used to generate power by turning a steam turbine. Both the water intake and discharge of heated water can impact local marine

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[16] GreenBiz; "Wave energy sees ripples of activity in the U.S."; March 2022; https://www.greenbiz.com/article/wave-energy-sees-ripples-activity-us
[17] Bureau of Ocean Energy Management; "BOEM Issues Lease for First Wave Energy Research Project in Federal Waters Offshore the U.S. West Coast"; February 2021; https://www.boem.gov/boem-issues-lease-first-wave-energy-research-project-federal-waters
[18] Oregon Public Broadcasting; "US Department of Energy awards $25M for wave energy testing at first-in-nation Oregon facility"; February 2022; https://www.opb.org/article/2022/02/13/oregon-state-univiersity-wave-energy-facility-pacwave-project-federal-funding/
[19] U.S. Department of Energy; "DOE Launches Prize to Harness the Power of Ocean Waves with New Technologies"; March 2023; https://www.energy.gov/eere/water/articles/doe-launches-prize-harness-power-ocean-waves-new-technologies
[20] Pacific Northwest National Laboratory; "Tidal Energy"; September 2021; https://www.pnnl.gov/explainer-articles/tidal-energy
[21] CleanTechnica; "MeyGen Tidal Power Facility Exported 13.8 GWh Of Electricity To The UK Grid In 2019"; January 2020; https://cleantechnica.com/2020/01/29/meygen-tidal-power-facility-exported-13-8-gwh-of-electricity-to-the-uk-grid-in-2019/
[22] GreenBiz; "Wave energy sees ripples of activity in the U.S."; March 2022; https://www.greenbiz.com/article/wave-energy-sees-ripples-activity-us
[23] Power Technology; "Projects, pipelines and power: around the world's tidal projects"; January 2023; https://www.power-technology.com/features/tidal-power-development-projects/

ecosystems, as well as the fishing and tourism industries.[24] Assessments prior to the construction of these facilities and any data collected from monitoring efforts during their operation may inform the potential development of wave and tidal generation, as may recent CEC reports on the development of offshore wind energy in California.

AB 525 (Chiu, Chapter 231, Statutes of 2021) requires the CEC, in collaboration with the CCC and other agencies, to undertake specified studies to support the deployment of offshore wind energy off the coast of California, including evaluations of permitting challenges and the potential environmental impacts related to offshore wind development. Extrapolating from the CEC's Offshore Wind Energy Permitting Roadmap, technologies deployed in state or federal waters would likely require either a coastal development permit or a federal consistency determination by the CCC, as well as a tidelands lease of some form issued by the State Lands Commission (SLC).[25] In addition, the California Department of Fish and Wildlife would have an important role in at least addressing site-specific mitigation. Permitting issues have stymied past efforts to develop coastal energy development in California. A high-profile instance of permitting issues occurred nearly 15 years ago when the Federal Energy Regulatory Commission (FERC) granted preliminary permits for wave and tidal energy near-shore waters off much of the coast in California and Oregon without informing state and local officials.[26] Commercial fishers, environmentalists and others opposed the FERC permits, and FERC's failure to include the SLC in the process ultimately resulted in the project failing to proceed.

The potential for environmental damage associated with wave and tidal development may also be informed by recent efforts to develop offshore wind. In a recent CCC staff report evaluating federal leasing for offshore wind development, the potential impacts included "seafloor disturbance; turbine strikes; increased entanglement risk; marine species displacement, avoidance or attraction; increased ship strike risk; elevated levels of underwater sound; fish aggregation and the artificial reef effect; invasive species; weakened upwelling, and electromagnetic fields."[27] The staff report noted the potential impacts on commercial and recreational fishers, California Native American tribes, environmental justice communities, and other stakeholders, which may also be relevant to any wave and tidal energy development. While not wholly applicable, many of the potential impacts associated with offshore wind development may also apply to wave and tidal energy generation.

In addition to the ability of prior coastal energy projects to inform wave and tidal energy development, direct synergy among the projects may also be possible. The CEC established planning goals for offshore wind of 2,000 MW–5,000 MW for 2030 and 25,000 MW for 2045.[28] Reaching these targets for offshore wind will require a substantial transmission capacity in certain coastal areas of California. The California Independent System Operator (CAISO) has identified areas where existing transmission infrastructure may be repurposed to support offshore wind generation, but a significant buildout of transmission lines will be necessary to effectively

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[24] U.S. Energy Information Administration; "Over half the cooling systems at U.S. electric power plants reuse water"; November 2011; https://www.eia.gov/todayinenergy/detail.php?id=3950
[25] CEC; "Assembly Bill 525 Offshore Wind Energy Permitting Roadmap"; April 2023.
[26] Reuters; "U.S. cuts red tape on offshore renewable energy"; March 2009; https://www.reuters.com/article/btscenes-us-usa-renewables-offshore-idUKTRE52G50X20090317
[27] Pg. 4-5; California Coastal Commission; "Staff Report for CD-0001-22"; March 2022.
[28] CEC; "Offshore Wind Energy Development off the California Coast Maximum Feasible Capacity and Megawatt Planning Goals for 2030 and 2045"; August 2022.

realize California's planning goals for offshore wind.[29] Wave and tidal energy projects may be able to leverage some of the existing transmission capacity, particularly in areas with on-shore generation facilities that are, or will soon be, no longer operational, as well as potentially benefit from the anticipated transmission buildout in coastal California. Alternatively, projects which propose to attach wave energy devices to offshore wind farms or floating solar panels are already under consideration in Europe.[30]

COMMENTS:

1) *Author's Statement.* According to the author, "As California builds upon our ambitious climate goals, we need to take advantage of every opportunity to diversify our energy supply and reduce our dependence on fossil fuels. Wave and tidal energy is an abundant source of clean energy that California should study to continue our leadership and innovation in this space."

2) *Tides and Timelines.* The timeframe outlined in the bill allows approximately one year for the CEC to solicit applications and approve qualifying pilot projects before a report, which is meant to include data from the pilots, is due to the Legislature. The ability for those projects to be proposed, reviewed, funded, developed, implemented, and collect sufficient data to produce significant results within that timeframe is suspect. However, given the existence of a recent pilot project in California and more mature projects internationally, as well as the considerable amount of data gathered by the CEC related to offshore wind development which may also be relevant to wave and tidal energy, the report should be a valuable resource regardless of whether any data from the pilot studies proposed under this bill are yet available.

3) *An EPIC Shift.* The bill requires the CEC to study a variety of technologies and approaches to harnessing wave and tidal energy, as well as calling for new pilot projects for the energy resource. The study's set of methods, as previously or currently implemented, represent a generous selection of successes and failures, each of which may inform any further pursuit of wave and tidal energy generation. The existence of so many examples suggests that an inventory of the strengths of each may be prudent before mandating or funding wave and tidal projects with state dollars. Moreover, the installation of two wave pilots in Sothern California over the last two years could provide ample data to evaluate the opportunities for wave and tidal energy raised by this measure, without necessitating additional pilots. This bill seems to recognize this by making the pilots upon appropriation by the Legislature. However, such pilot proposals may be more suitable as part of the existing research and development work at the CEC, through their Electric Program Investment Charge (EPIC) program.

   The stated purpose of EPIC is to "fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to

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[29] California Independent System Operator; "Offshore wind could boost California's transition towards clean-energy future"; August 2022; http://www.caiso.com/about/Pages/Blog/Posts/Offshore-wind-could-boost-Californias-transition-towards-clean-energy-future.aspx
[30] GreenBiz; "Wave energy sees ripples of activity in the U.S."; March 2022; https://www.greenbiz.com/article/wave-energy-sees-ripples-activity-us

the marketplace."[31] Since 2012, EPIC has provided about $1.125 billion in funding for 474 projects, including $236 million to support the "clean energy Entrepreneurial Ecosystem, leveraging, aligning, and expanding California's existing assets to build a more interconnected and inclusive statewide ecosystem and helping bring innovations to market."[32] The CEC has identified designing mooring lines, anchors, and environmental monitoring technologies for floating offshore wind as priority investment for 2023, suggesting that research and development in marine energy generation infrastructure is well within the scope of the program.[33] *As such, the author and committee may wish to consider amendments to 25996.2(a) to strike the current language and instead ask the CEC to consider funding pilot projects under the EPIC program.*

4) *Findings and Clarifications.* Portions of this bill's language were unclear or presupposed a potential outcome of the wave and tidal energy study. *As such, the author and committee may wish to consider amendments to clarify or strike portions of the findings and declarations, as well as the factors to be studied as specified in 25996(b).*

5) *Related Legislation.*

AB 3 (Zbur), would require the CEC to develop a plan for seaport readiness for offshore wind energy developments by December 31, 2026, and to conduct a study on the feasibility of achieving specified in-state assembly and manufacturing goals, as well as federal domestic content thresholds, in the development of offshore wind energy by December 31, 2027. Status: *pending hearing* in the Senate Committee on Natural Resources and Water, after passage in the Senate Committee on Energy, Utilities, and Communications on a 18-0 vote.

AB 80 (Addis), would require the Ocean Protection Council, upon an appropriation by the Legislature, to establish and oversee a West Coast Offshore Wind Science Entity to ensure that comprehensive baseline assessments and ongoing monitoring data related to the California ocean ecosystem are available to inform state and federal decision-making. Status: *pending hearing* in the Senate Committee on Natural Resources and Water.

SB 286 (McGuire), would require that the State Lands Commission be the lead agency for purposes of environmental review for offshore wind energy projects, establish the California Offshore Wind Energy Fisheries Working and require the California Coastal Commission to convene the working group before January 1, 2025, to develop a statewide strategy for ensuring that offshore wind energy projects avoid, minimize, or fully mitigate impacts to ocean fisheries to be adopted by the California Coastal Commission by May 1, 2026, as well as create the Offshore Wind Energy Resiliency Fund and require the State Lands Commission to consider including measures in leases for offshore wind projects to generate revenue for the fund. Status: *pending hearing* in this committee.

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[31] Pg. ii; CEC; "Electric Program Investment Charge 2022 Annual Report"; April 2023.
[32] Pg. 3; CEC; "Electric Program Investment Charge 2022 Annual Report"; April 2023.
[33] CEC; "Electric Program Investment Charge 2022 Annual Report"; April 2023.

6) *Prior Legislation.*

AB 525 (Chiu) required the CEC to establish, by June 1, 2022, planning goals for the years 2030 and 2045 from electricity generated by OSW. The bill also requires the CEC, in coordination with specified agencies, to develop a strategic plan for OSW developments and to submit the plan to the Natural Resources Agency and the Legislature by June 30, 2023. Status: Chapter 231, Statutes of 2021.

SB 100 (De León) established the 100 Percent Clean Energy Act of 2017 which increases the RPS requirement from 50 percent by 2030 to 60 percent and creates the policy of planning to meet all of the state's retail electricity supply with a mix of RPS-eligible and zero-carbon resources by December 31, 2045, for a total of 100 percent clean energy. Status: Chapter 312, Statutes of 2018.

REGISTERED SUPPORT / OPPOSITION:

Support

AltaSea (sponsor)
Eco Equity
Eco Wave Power
Environment California
Tma Bluetech

Opposition

None on file.

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