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Offshore Wind Industry Participants Comment on CEC Draft Renewable Generation Research Roadmap

Additional submitted attachment is included below.

July 12, 2019
California Energy Commission
Dockets Office
1516 Ninth Street,
Sacramento, CA 95814
Submitted via CEC Electronic Commenting System

Re: Research Idea Exchange, CEC Docket No. 19-ERDD-01 -- Joint Comments of Offshore Wind Industry Participants on the CEC's Draft Renewable Generation Research Roadmap

Dear CEC Managers of the Research Idea Exchange Project:

This letter sets out joint comments of eight offshore wind industry participants on the CEC's Preliminary Draft Utility-Scale Renewable Energy Generation Research Roadmap (*Draft Roadmap*),[1] docketed on June 27, 2019, and presented via webinar on July 1, 2019 (*Roadmap Presentation*).[2] The parties that have collaborated in providing these comments -- project developers, technology suppliers, and an industry-wide advocacy organization – have a shared belief in the potential for offshore wind power to become an important source of renewable energy and GHG emission reductions for California. We appreciate the CEC's consideration of offshore wind in the preparation of its *Draft Roadmap* and its comments from interested parties.

Our comments focus on the cost estimates and projections that the *Draft Roadmap* provides for offshore wind and other renewable energy sources. The *Draft Roadmap* relies on March 2018 Department of Energy (DOE) estimates of contemporaneous offshore wind costs and projections of future costs.[3] The DOE estimates and

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[1] Energetics, *Preliminary Draft Utility-Scale Renewable Energy Generation Research Roadmap* (June 2019), CEC Docket No. 19-ERDD-01, TN 228863. The *Draft Roadmap* draws upon a longer study document. Energetics, *Technical Assessment of Grid Connected Renewable Energy and Storage Technologies and Strategies* (Jan. 2019) (*Technical Assessment*), CEC Docket No. 19-ERDD-01,TN No. 228811. The CEC Docket with links to individual documents is available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-ERDD-01).

[2] Silvia Palma-Rojas, PhD., California Energy Commission, *Presentation Webinar for Public Comments on the Preliminary Draft*, CEC Docket No. 19-ERDD-01, TN 228811 (July 1, 2019).

[3] U.S. Department of Energy, *Department of Energy FY 2019 Congressional Budget Request* at 23 (March 2018) (*DOE Budget Request*) (presenting FY 2017 to FY 2019 LCOE estimates based on "[c]apacity weighted average installed CAPEX and OpEx values from European installations in 2016"), available at energy.gov/sites/prod/files/2018/03/f49/FY-2019-Volume-3-Part-2.pdf.

projections were in turn based on 2016 project data, which is now badly out of date due to sharp reductions in costs demonstrated by subsequent projects.

In addition to relying on the *DOE Budget Request*'s outdated baseline data for offshore wind costs, the *Draft Roadmap* also endorses DOE projections that the cost of offshore wind will fall more slowly than the cost of power from other, more mature renewable energy technologies. As a result, the *Draft Roadmap* creates an impression that bottom-fixed offshore wind will be substantially more expensive than other renewable power sources for the foreseeable future, and that floating foundation offshore wind, suited to California's deep coastal waters, will be more expensive still.

The DOE's method for projecting bottom-fixed offshore wind costs is not explained in the *DOE Budget Request*. Nor is it discussed in any of the roadmap documents that recite the DOE projections. For reasons discussed below, we believe that these projections are inconsistent with leading expert analysis of offshore wind cost curves, and that floating offshore wind in California, properly assessed, can be highly competitive within the time frame CEC is considering. If the final roadmap is to provide a reliable guide to energy policy decisions, it will need to incorporate current data on offshore wind costs and use the methods of leading experts to assess future costs.

The scope of this comment letter is limited. To finalize a joint comment within the CEC's prescribed comment period, the signatories to this submission have focused solely on the second question posed in the "Offshore Wind Initiative Discussion" during the July 1 webinar – "What are the cost/performance targets for each technology that should be considered in California?" (*Roadmap Presentation* at 39.) We recognize the importance of the other questions raised in the *Roadmap Presentation* and have agreed that each signatory to this joint submission retains the option of commenting separately on issues not addressed here.

The *Draft Roadmap*'s Cost Estimates and Projections for California Offshore Wind

The *Roadmap Presentation* presents tables of cost estimates and projections, adapted from the *DOE Budget Request*, for various renewable energy sources. Those tables, which we have combined below, depict offshore wind as among the most expensive renewable energy resource at present and the most expensive resource in 2030 (among resources for which 2030 projections are provided). According to the information presented in the cost tables, the cost of offshore wind is expected to decline at a slower rate than the cost of PV or geothermal. There is no explanation, in the *Roadmap Presentation*, the *Draft Roadmap*, the *Technical Assessment*, or *the DOE Budget Request*, of the method that DOE used to project Endpoint Target costs based on current estimates.

CEC Draft Roadmap's Renewable Energy Cost Estimates and Projections (in cents/kWh)

					End Value or "Endpoint Target"		
	2014	FY 2017	FY 2018	FY 2019	2020	2025	2030
Photovoltaic (PV)		7.0	6.0	5.5			3.0
Concentrating Solar Power		10.0		8.0			5.0
Land-Based		5.5	5.4	5.0	5.2		3.1
Offshore		17.2	16.2	15.7	14.9		9.3
Bioenergy	4.0 - 23.0					4.0 - 20.0	
Geothermal		22.0	21.8	21.7			6.0
Small Hydro		11.5	11.4	11.2	10.9		8.9

Source: *Draft Roadmap* at 11, 17, 22, 27, 34, 40, and 45.

The *Draft Roadmap* also provides a brief narrative overview of each covered renewable energy resource. The narrative relating to offshore wind cites a second estimate of offshore wind costs, referencing Lazard's most recent cost-of-energy report, which estimates an unsubsidized LCOE range of 6.2 to 12.1 cents per kWh for 2018 offshore wind, with a midpoint of 9.2 cents per kWh.[4] This is significantly below the lowest comparable estimate in the *DOE Budget Request*. In fact, the Lazard midpoint estimate for 2018 is 41% lower than DOE's estimate for FY 2019.

This disparity between the DOE and Lazard estimates is not discussed in the *Roadmap Presentation*, the *Draft Roadmap* or the *Technical Assessment*. Yet this unexamined disparity has important implications for the evaluation of offshore wind's potential role in California. The *DOE Budget Request* projected that the LCOE of offshore wind would fall by just over 40% between FY 2019 and 2030. If the offshore wind industry were projected to achieve that same rate of reduction starting from a baseline cost of 9.2 cents per kWh (the Lazard mid-point estimate), the 2030 projected cost would be under 5.5 cents per kWh.

The *Draft Roadmap* points out that wind farms off the coast of California will be deployed on floating foundations since waters there are too deep for conventional, bottom-fixed foundations. The *Draft Roadmap* states that floating foundations "are especially costly due to a lack of current development and understanding of platform design" (*Draft Roadmap* at 28) but does not attempt to quantify the existing cost disadvantage or assess prospects for cost reduction in light of current investment and innovation in floating foundation technology.

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[4] Lazard, *Lazard's Levelized Cost of Energy Analysis – Version 12.0* at 2, 17 (Nov. 2018) (*Lazard LCOE Analysis*), available at https://www.lazard.com/media/450784/lazards-levelized-cost-of-energy-version-120-vfinal.pdf (last accessed July 8, 2019) The combined energy and storage version of the Lazard report, cited in the *Draft Roadmap*, is no longer available on line. The version cited here provides the same estimated range for the current LCOE of offshore wind.

Suggestions for Improving the ***Draft Roadmap***’s Cost Estimates and Projections for California Offshore Wind

The final research roadmap should provide up-to-date estimates of current costs and informed analysis of predictive cost curves for different forms of renewable energy generation projections. It should include a clear description of methods used to estimate and predict costs, with particular attention to the uncertainties and limitations of those methods. Rigorous cost estimates and projections will enhance the roadmap’s value to the CEC as it makes research funding decisions. They can also provide important guidance to other policy decisions relating to California’s energy transition.

1. <u>Estimates of current offshore wind costs should be based on the latest available project data</u>

In analyzing the cost of offshore wind power in California, it is important to recognize that commencement of operations for the first California projects is probably several years away. Applicable leasing and permitting processes are unlikely to allow earlier deployment. However, during this pre-operational period, floating foundation offshore wind technology will continue to advance, and costs will continue to fall, based on research and project development work already underway in European and Asian jurisdictions. The California market will be a direct beneficiary of those advances. Accordingly, estimating the current cost of power from a bottom-fixed offshore wind farm is a preliminary, necessarily tentative step in any useful analysis of offshore wind’s potential significance in California.

Estimates of current bottom-fixed offshore wind costs can be used in two ways. One approach, adopted by the *Draft Roadmap*, examines current costs for utility-scale bottom-fixed projects and considers the adjustment required to substitute floating for fixed foundations. An alternative approach, employed by many experts, uses a line-item-by-line-item model to estimate the cost of constructing and operating a utility-scale floating foundation project today. Current bottom-fixed costs inform estimates of shared costs, such as wind turbine generators, cabling, and certain maintenance tasks. In either case, the cost of power from a hypothetical utility-scale floating offshore wind project entering operation today is important only insofar as it sheds light on the cost of projects that may actually be built in the future.

Regardless of how current bottom-fixed costs are used to assess future California offshore wind costs, reliance on the *DOE Budget Request* estimates is misguided. The DOE based its estimate on “[c]apacity weighted average installed CapEx and OpEx values derived from European Installations in 2016.” *DOE Budget Request* at 23.[5]

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[5] In addition to being outdated, the cost estimates recited in the *DOE Budget Request* apparently reflect financial and operating assumptions of questionable relevance to a comparative assessment of potential renewable energy for California. The DOE states that it estimated offshore wind costs using a “discount rate derived from empirical European

These data are badly outdated and unsuited to serve as a basis for cost estimates in the research roadmap.

The National Renewable Energy Laboratory's latest review of offshore wind technology and price trends for the DOE, issued in September 2018, emphasizes the significance of price reductions observed in tenders and auctions for major European projects during 2017 and 2018.[6] The NREL Offshore Update also presents supporting data, from the same period, documenting decreases in per MW CapEx and increases in capacity factors.

A more recent NREL study, published in February 2019, reinforces and extends the lessons of the update. In that study, NREL analyzed power purchase agreements executed in July 2018 for power from an 800 MW wind farm off Massachusetts developed by Vineyard Wind.[7] It found that the Massachusetts prices, adjusted to eliminate the effects of policy support, were consistent with the decreased prices seen in recent European tenders and auctions.[8]

The *DOE Budget Request*, although prepared in early 2018, did not account for important price information from 2017 onward. Recent NREL studies establish that the *Lazard LCOE Analysis* provides a more realistic estimate of the current cost of power from state-of-the-art bottom-fixed offshore wind farms. Although the *Draft Roadmap* cites the *Lazard LCOE Analysis*, it nevertheless emphasizes the outdated *DOE Budget Request* estimates and related projections, without any attempt to reconcile the disparate cost estimates. The final roadmap should reject the outdated *DOE Budget Request* estimates and, at a minimum, revise the related projections to account for current cost trends.

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installations," and a project with an "8.4 m/s Wind speed @ 50m hub height; and a 20 year plant life." *DOE Budget Request* at 23.

[6] P. Beiter, P. Spitsen, J. Nunemaker, T. Tian, W. Musial, E. Lantz, and V. Gevorgian, *National Renewable Energy Laboratory, 2017 Offshore Wind Technologies Market Update* (Sept. 2018) at 50 (*NREL Offshore Update*), available at https://www.energy.gov/sites/prod/files/2018/09/f55/71709_V4.pdf.

[7] P. Beiter, P. Spitsen, W.Musial, and E. Lantz, National Renewable Energy Laboratory, *The Vineyard Wind Power Purchase Agreement: Insights for Estimating Costs of U.S. Offshore Wind Projects* (Feb. 2019) (*NREL Vineyard Study*), available at https://www.nrel.gov/docs/fy19osti/72981.pdf.

[8] *NREL Vineyard Study* at 12. NREL's analysis contained a note of optimism for rapid progress on cost reduction in the U.S., observing that "generally anticipated price (and cost) premium for the nascent U.S. offshore wind industry in comparison to offshore wind projects in the established European markets might be much less pronounced than has widely been expected by many analysts." *Id.*

2. Research roadmap projections of future floating wind costs should be based on careful analysis of the nature and pace of relevant innovation and recent cost projections of offshore wind experts

Projecting future costs of power from floating wind farms requires analysis of two distinct categories of innovation. In many important respects, floating foundation projects can benefit from innovation driven by bottom-fixed projects. Improvements in the efficiency and reliability of turbines and blades are equally beneficial to floating and bottom-fixed projects. (Observed increases in net capacity factors and decreases in operation and maintenance costs are largely the result of these innovations.) Similarly, improvements in layout design, software for monitoring and controlling turbines, and operation and maintenance equipment and practices provide substantial benefits across the board. In other respects, however, floating wind is on its own. Innovations in floating structure design and manufacture, in dynamic cables and cable fittings, and in mooring technology are specific to floating wind installations.

Shared system innovation occurs in a large, well-established, though still rapidly growing, market. Last month, the Global Wind Energy Council, in the first edition of its global offshore wind report, stated that offshore wind capacity grew at an average annual rate of 21% from 2013 to 2018, and projected an additional eight-fold increase – from 23 GW to 190 GW of global capacity – between 2019 and 2030.[9] Deployments at this scale, with each installed GW representing roughly $2B to $3B in CapEx,[10] bring enormous resources to bear on efforts to improve maturing shared system technology.

Innovation specific to floating wind has a different profile. The emerging floating wind market is small, but growing and innovating rapidly. Installed floating wind capacity currently stands at just over 50 MW. However, recent investment in floating foundation technologies has brought a series of new designs to the verge of deployment. As set out in the table below, floating turbines using a series of new foundation designs and substantial improvements on existing designs are scheduled to begin operation by the end of 2022. These projects will more than triple the number of floating foundations in service. Moreover, as these projects are entering into service, other advanced designs will continue to progress.

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[9] Renewable Energy World, *Global Offshore Wind Installed Capacity up 21 Percent Since 2013* (June 27, 2019) (the 190 GW projection for 2030 is for a business-as-usual scenario, assuming no significant policy change or unforeseen technological breakthroughs), available at https://www.renewableenergyworld.com/articles/2019/06/global-offshore-wind-installed-capacity-up-21-percent-since-2013.html.

[10] This suggested range assumes steady improvement from Lazard's current estimated CapEx range -- $2.2B to $3.8B per GW. *Lazard LCOE Analysis* at 17.

Existing and Emerging Floating Foundation Technology -- Deployments and Projected Deployments Before 2022

Technology Developer	Design Name	Class	Location	Commision-Decommission Dates	Number of Foundations	Total Capacity MW
Equinor	Hywind 1	Spar	Norway	2009-	1	2.3
Principle Power	WindFloat 1	Semi-Sub	Portugal	2011-2016	1	2
Toda	Hybrid Spar	Spar	Japan	2013-	1	2
Fukushima Consortium	Mirai	Semi-Sub	Japan	2013-	1	2
Fukushima Consortium	Shinpuu	Semi-Sub	Japan	2015-	1	7
Fukushima Consortium	Hamakaze	Adv. Spar	Japan	2016-	1	5
Statoil	Hywind 2	Spar	Scotland	2017-	5	30
IDEOL	Floatgen 1	Barge	France	2018-	1	2
IDEOL	Hibiki	Barge	Japan	2019-	1	2
Principle Power	WindFloat	Semi-Sub	Portugal	2019 (est.) -	3	25
Stiesdal	TetraSpar	Spar	Norway	2020 (est.) -	1	3.6
Principle Power	Windfloat	Semi-Spar	Scotland	2020 (est.) -	6	50
Hexicon	Tri	Semi-Sub	Scotland	2020 (est.) -	1	10
IDEOL	Floatgen 2	Barge	France	2021 (est.) -	4	25
Eolfi	Naval Energies	Semi-Sub	France	2021 (est.) -	4	24
Principle Power	WindFloat	Semi-Sub	France	2021 (est.) -	3	24
SBM	SBM	TLP	France	2021 (est.) -	3	24
Equinor	Hywind 3	Spar	Norway	2022 (est.) -	8	88

Sources: *NREL Offshore Update* & offshore wind trade press reports

Progress on floating wind development has not been limited to prototype and pilot-scale projects. For example, offshore wind development companies and utilities have formed partnerships to build a series of 200 MW floating wind projects off South Korea.[11] This planning and investment, occurring at levels far beyond those depicted in the *Roadmap*

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[11] EvWind, *Equinor, KNOC And Korea East-West Power Have Agreed To Develop A 200 MW Floating Offshore Wind Farm* (July 8, 2019), available at https://www.evwind.es/2019/07/08/equinor-knoc-and-korea-east-west-power-have-agreed-to-develop-a-200-mw-floating-offshore-wind-farm/67931; D. Snieckus, Recharge News, *Floating Lidar Install Launches Giant Korea Offshore Wind Project* (June 10, 2019), available at https://www.rechargenews.com/wind/1803643/floating-lidar-install-launches-giant-korea-offshore-wind-project.

Presentation,[12] is driving rapid innovation in cabling and mooring for floating turbines, as well as in floating foundation design.

The relative immaturity of floating foundation technology increases the cost of power from prototype, and pilot-scale projects. But cost premiums for prototype and pilot-scale projects are typical of emerging technologies. Offshore wind experts have analyzed the long-term fundamentals and concluded that siting flexibility and ease of deployment will ultimately allow floating wind to become less expensive than bottom-fixed wind. According to the *National Offshore Wind Strategy*, prepared by NREL for DOE and the U.S. Department of the Interior,[13] floating wind's advantages include:

- Generating more power per unit of capacity by accessing sites with stronger, steadier winds
- Reducing development costs by avoiding areas with use conflicts
- Reducing deployment costs by assembling turbines quayside (using land-based cranes and taking advantage of the ability to work in a wider range of weather conditions) and installing with tugboats rather than expensive jack-up vessels
- Reducing the cost of major repairs by disconnecting turbines and towing them in for quayside repair, as opposed to mobilizing and demobilizing a specialized installation vessel

In light of these advantages, NREL concluded that "although floating technologies are more expensive than fixed-bottom technologies at this time, floating technologies have the potential to achieve costs that are equal to or even lower than fixed-bottom technologies by 2030." *Id.* Energy authorities in the UK, the undisputed world leading bottom-fixed offshore wind market, have reached similar conclusions. The UK authorities project that floating wind costs will "'catch[ ] up' rapidly with bottom-fixed wind," and reach grid parity by 2031 at 50GBP/MWh -- about 6.3 cents/kWh at current exchange rates.[14] Other projections from respected industry sources anticipate a similar cost declines. A Director and floating wind expert at the business consultancy

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[12] The *Roadmap Presentation* states that "[t]here is currently only a single offshore demonstration in operation globally (Hywind in Scotland) with another funded (WindFloat in Portugal)." *Roadmap Presentation* at 35. The *NREL Offshore Update* and other sources cited here that the floating offshore wind technology sector is far larger and more dynamic than the *Roadmap Presentation* indicates.

[13] U.S. Department of the Interior & U.S. Department of Energy, *National Offshore Wind Strategy: Facilitating the Development of the Offshore Wind Industry in the United States* 28-29 (Sept. 2016), available at http://www.boem.gov/National-Offshore-Wind-Strategy/.

[14] ORE-Catapult & Crowne Estate Scotland, *Macroeconomic Benefits of Floating Offshore Wind in the UK* at 20 (Oct. 2018), available at https://s3-eu-west-1.amazonaws.com/media.newore.catapult/app/uploads/2018/10/29105933/PN000244-FWMS-Report_FINAL.pdf.

BVG Associates projects that a rapid build out of floating offshore wind would drive prices below 5.6 cents/kWh by 2030.[15] Equinor has projected that the LCOE for projects based on its Hywind foundation can reach 4.5 to 6.7 cents/ kWh by 2030.[16]

In short, floating offshore wind in California is well-positioned to benefit from shared-system innovation driven by large-scale global development of bottom-fixed projects as well as rapid, early-stage innovation on floating-specific technology in the emerging floating wind sector. In assessing future floating wind costs for the final research roadmap, the CEC should begin with up-to-date information on bottom-fixed offshore wind costs. (Lazard and NREL figures from 2018, or any updates that become available, are far more relevant than the *DOE Budget Request* based on 2016 data.) Using these data to predict future floating wind costs presents challenges, due in large part to rapid innovation in the floating wind sector. However, expert assessments that floating costs will reach or fall below bottom-fixed costs, provide a reasonable approach at this time, subject to review and adjustment as floating foundation technology develops and expert analysis advances.

3. <u>The research roadmap should recognize the importance of factors other than price in the development of an efficient renewable energy portfolio for California</u>.

Finally, the final research roadmap should include further analysis of how the timing and location of power delivery affect the value of specific renewable resources. The *Draft Roadmap* focuses on unit costs of delivered power and prospects for research-driven cost reductions. It is clear, however, that the value of each renewable resource to the California grid depends critically on where and when power can be delivered. The *Draft Roadmap* acknowledges, for example, that adding more solar PV to California's generation mix will increase curtailment and grid integration costs, noting that a "lack of storage will limit the grid-value of increased solar PV installations." *Draft Roadmap* at 12.

The final research roadmap should extend this insight by explicitly recognizing that the timing and location of power deliveries significantly affect renewable resource value and therefore warrant consideration in CEC research funding decisions. With respect to offshore wind power, the timing of power generation tends to complement solar PV on both a daily and seasonal basis. Moreover, high capacity factors, in relation to both solar PV and land-based wind resources, can help to meet resource adequacy. Offshore wind in California also offers potential locational benefits, particularly with

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[15] D. Snieckus, Recharge Wind, *Next Wave of Floating Wind Begins to Build,*(April 23, 2019) (quoting statement of BVG expert Giles Hundleby that "[w]e will definitely see a sub-E50/MWh [LCOE] when we see the first 1GW project switched on.") (paid subscription required for full article, excerpted at https://bvgassociates.com/next-wave-of-floating-wind-begins-to-build/).

[16] Sebastian Bringsværd, Equinor, *Hywind – Riding the Next Wave of Renewables* at 14 (June 7, 2018) (conference presentation).

respect to interconnection points at retiring thermal plants on the central coast near load centers.

Issues relating to timing and locational value of renewable resources are central to the CPUC's integrated resource planning efforts. We do not propose that the CEC duplicate the CPUC's modeling work. It would be useful, however, for the final roadmap to include more discussion of system integration issues and to assign timing and locational value more weight in its research funding decisions.

Conclusion

We thank the CEC for providing this opportunity to comment on the *Draft Roadmap*. We look forward to working with the CEC and other parties on the completion and implementation of the final version.

Respectfully submitted,

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