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Additional submitted attachment is included below.

Response to Kevin Wolf's Submission to the CEC Draft Research Concept on Advance to Next-Generation Offshore Wind Energy Technology

Research Idea Exchange, Docket Number 19-ERDD-01
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RCAM Technologies, Inc (RCAM) offers the following public comments regarding Kevin Wolf's November 10, 2020 submission to the CEC Research Idea Exchange, Docket Number 19-ERDD-01 titled *Methodologies and Tools Related to Assessing Benefits of Research and Development Investments*. RCAM appreciates Mr. Wolf's participation and comments regarding the benefits of research and development agreements. Both RCAM and Mr. Wolf appear to agree on the broader benefits of wind energy and the importance of quantifying benefits. However RCAM and Mr. Wolf seem to have different perspectives on the value of support structure technologies for large turbines. Mr. Wolf appears to reference a prior CEC award to RCAM as an example to illustrate his differing perspective in his statement: "For a past EPIC grant funded ultra-tall wind tower R&D. Those tall towers aren't likely going to be installed in CA for all kinds of reasons. They are important for the south east states where wind turbines have to be super tall to be effective."

In this response, RCAM offers the Commission a different perspective and supporting materials as to why large turbines on tall towers can and will play an important role in achieving California's clean energy targets. Tall towers, or more precisely large turbines with big rotors on tall towers, offer numerous benefits to California's IOU ratepayers, providing motivation for California IOUs, developers, and stakeholders to install more onshore wind energy.

RCAM projects 3D concrete printed towers will benefit California IOU ratepayers across the state by 1) Increasing new on-shore and repowered wind capacity deployment potential 10-fold to 60 GW, 2) Reducing land-based LCOE up to 11%, 3) Increasing energy captured by land based wind turbines up to 21% compared to 80-m towers , and 4) Increasing onshore wind capacity factors by enabling access to wind resources at higher heights and enabling turbines with larger rotors with high capacity factors. Recent peer reviewed survey results by Berkeley Lab provide additional evidence of these benefits[1]. According to the 163 wind experts surveyed in a Nature Energy article, still-larger turbines offer promise, and will be regularly used by 2030. For land-based applications in North America, these experts anticipate evolutionary growth in AVERAGE turbine generator size (2 MW in 2015 to 3.25 MW in 2030) and AVERAGE hub heights (82 meters in 2015 to 115 meters in 2030). Many wind turbines will be significantly larger and taller than these average values. For example, the three largest US wind turbine OEM manufacturers (GE, Vestas, and Siemens Gamesa) all have 6-MW turbine models today. RCAM is designing a scalable tower technology that can be used to support a range of large Next Generation turbines from 3MW to 10MW in rating on tower heights from 120-m to 160-m.

The trend toward larger turbines is also global phenomena that will benefit California (Figure 1). According the International Renewable Energy Agency (IRENA) Wind power cost reductions are driven mainly by advancements in wind turbine technology. **The key parameters that denote the improvements in wind turbine technologies are the rotor diameter and the hub height to access more power from wind turbines.** Ongoing innovations and technology enhancements towards larger-capacity turbines, increased hub heights and rotor diameters would improve energy yields and reduce capital and operation costs per unit of installed

[1] https://emp.lbl.gov/news/future-wind-energy-part-3-reducing-wind#:~:text=For%20land%2Dbased%20applications%20in,to%20115%20meters%20in%202030).

capacity. Bigger turbines will inevitably become available that will benefit California with lower cost and other benefits; however, low cost tall tower technologies are needed to support these larger turbines. RCAM's large turbine tower manufacturing technology will also bring numerous non-energy benefits including improved aesthetics, cleaner air, and economic development opportunities to California's diverse communities including:

a. **Job creation and local revenues from new California wind deployments and on-site manufacturing:** The high cost of deploying conventional wind technologies in California has led to plans to import wind generated electricity approximately 800 miles from New Mexico and Wyoming, or natural gas electricity from Utah. The increased on-shore wind deployments in California made possible with RCAM's cost-reducing on-site manufacturing technologies will retain the jobs and economic benefits in California.

b. **Improved turbine aesthetics** by using larger turbines that reduce the number of turbines on land: Larger turbines are increasingly important for reducing the ground disturbances and visual impacts of smaller legacy turbines such as in Palm Springs and Altamont Pass. For example, Fred Noble's company, Wintec Energy, replaced 212 original smaller capacity turbines with five modern, large machines.[2] Those five machines could be potentially be further consolidated with one or two next-generation turbines on RCAM's towers and foundations. Larger turbines also benefit greenfield wind deployments such as the Strauss wind plant in Santa Barbra County that was very recently approved after 10 years with the help of larger and fewer wind tower generators compared to prior project proposals during which such large turbines were not available.[3]

c. **Substantial reductions in GHG emissions compared to fossil sources and potential conventional turbines:** Onshore wind is in most cases less expensive and has the lowest carbon footprint of any new form of electrical generation capacity including solar energy or offshore wind energy (Figure 2). Wind deployments avoid substantial emissions of greenhouse gases compared to fossil fuel generated electricity. Wind generated electricity emits up to 120 times less carbon dioxide (CO2e) than natural gas generated electricity and nearly 200 times less than coal on a lifecycle basis (5 g/kwh, 607 g/kWh, and 975 g/kWh respectively)[4]. RCAM's preliminary analysis of a 3DCP tower indicates that a conventional concrete wind turbine tower results in about 40% more CO2e (7 g/kwh) than a 140-m conventional steel tower. However, this CO2 is inconsequential compared to the CO2 emitted from electricity sources such as coal and natural gas generated electricity. An RCAM 140-m tower is projected to result in 85 times less CO2 compared to natural gas and 138 times less than coal fired generation.[5, 6] Moreover these increases can potentially be reduced below that of a steel tower when considering RCAM's low-mass 3DCP foundation concept, and the additional energy capture and generation possible with lower cost tall 3DCP towers and bigger turbines.

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2 Roth, Sammy. n.d. "Palm Springs Is Famous for Its Wind Farms. They May Look a Lot Different in the Future." Desert Sun. Accessed December 5, 2019. https://www.desertsun.com/story/tech/science/energy/2018/10/24/palm-springs-iconic-wind-farms-could-change-dramatically/1578515002/.

3 Scully, Janene, and 2019 | 9:27 P.m. n.d. "Wind-Energy Project Near Lompoc Approved by County Planning Commission." Accessed December 5, 2019. https://www.noozhawk.com/article/wind_energy_project_planned_near_lompoc_gets_ok.

4 Wang, Yuxuan, and Tianye Sun. 2012. "Life Cycle Assessment of CO2 Emissions from Wind Power Plants: Methodology and Case Studies." *Renewable Energy* 43 (July): 30–36. doi:10.1016/j.renene.2011.12.017.

5 Concrete is reported to emit 1 kg of CO2 per kg of concrete, and steel 1.9 kg of CO2 emitted per kg of steel.

6 "CO2 Emissions in the Steel Industry." 2017. ResearchGate. Accessed May 20. https://www.researchgate.net/publication/242151978_CO2_Emissions_in_the_Steel_Industry.

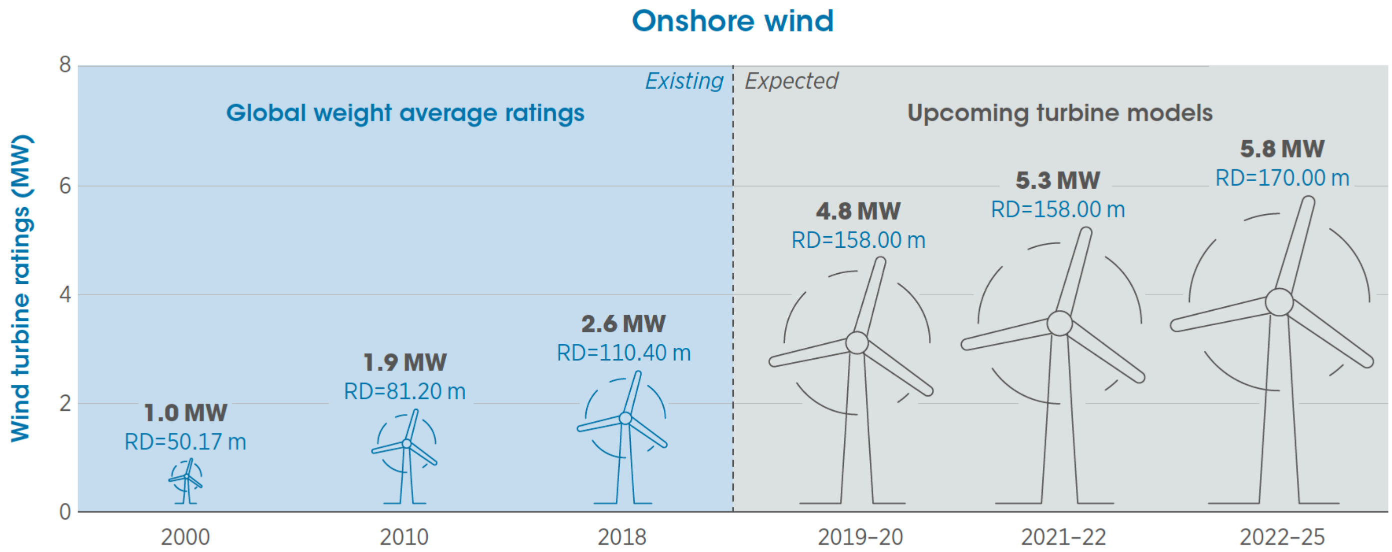

Figure 1: The global trend to larger onshore wind turbines with bigger rotors and taller towers is also present in California. Source: Future of Wind. IRENA 2019. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Oct/IRENA_Future_of_wind_2019.pdf

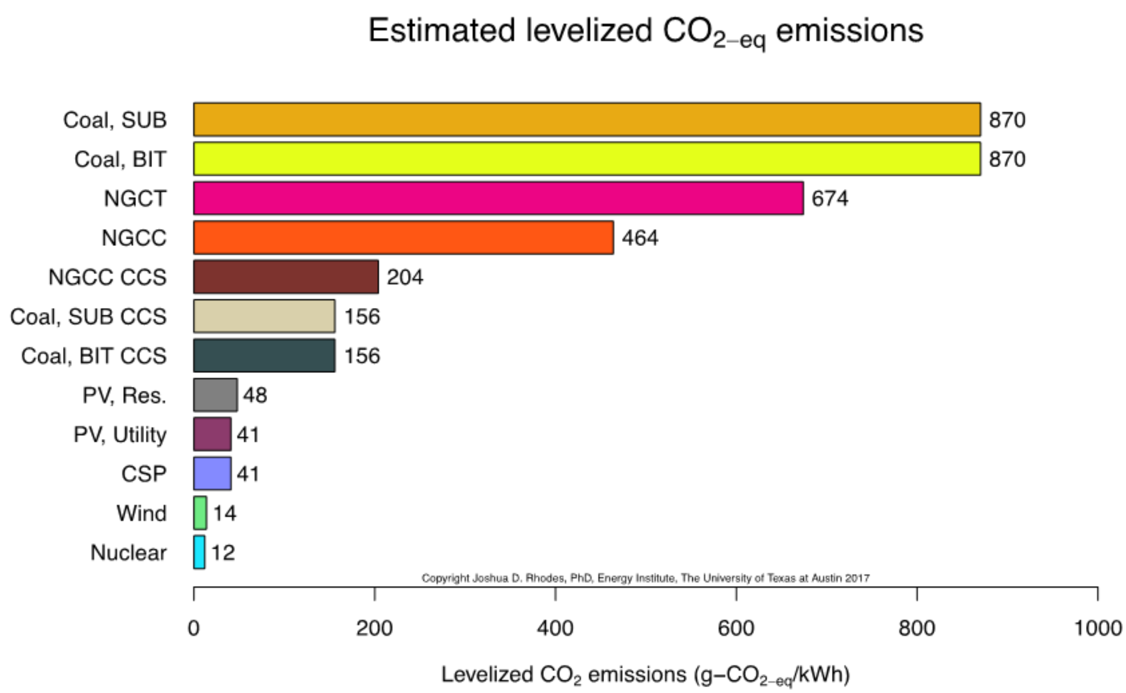

Figure 2: UT Austin's estimated levelized carbon intensities of 12 different power plants showing nuclear and onshore wind power having the lowest levelized CO2 emissions over their operating lifetime. Source: UT Austin Energy Institute, 2017. https://energy.utexas.edu/news/nuclear-and-wind-power-estimated-have-lowest-levelized-co2-emissions