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RCAM Technologies' Long Duration Energy Storage Comments for docket #20-EPIC-01, EPIC 4 Investment Plan

Additional submitted attachment is included below.

Comments on
Electric Program Investment Charge 2021-2025 Investment Plan Scoping
Technology Advancements for Energy Storage
EPIC 4 Investment Plan

Research Idea Exchange, Docket Log (20-EPIC-01)
7/30/2021

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General Comments

RCAM Technologies, Inc. (RCAM) is a growing wind energy and long duration energy storage technology company with offices in California, Colorado, and Scotland. We offer the following public comments regarding the workshop panel topic for (1) RCAM's new long duration energy storage technology called Marine Pumped HydroElectric Storage (M-PHES), and (2) synergistic integration of M-PHES with offshore wind energy as part of a California hybrid energy wind/storage energy system.

M-PHES has potential to provide ALL of the long duration energy storage needed by California to reach its 100% clean energy goals by 2045 while providing economic benefits and good jobs resulting from localized manufacturing and using abundant regionally-available construction materials.

RCAM strongly supports the Electric Program Investment Charge (EPIC's) plan for research, development, and acceleration of Floating Offshore Wind deployment in California and the Investment Plan themes of Decarbonization, Resilience and Reliability, Entrepreneurship, Affordability, and Equity. The Investment Plan and themes are appropriate priorities for maximizing the benefits of clean energy R&D in California.

RCAM believes that the CEC's proposed energy storage investment plans are critical to:

1) Providing grant funding to advance the technology readiness level of RCAM's M-PHES technology in California and bridge the valley of death.

2) Realizing the potential synergistic growth of M-PHES and floating offshore wind energy systems.

3) Ensuring economic benefits and manufacturing of energy storage components benefit California EPIC ratepayers and disadvantaged residents.

4) Creating and sustaining an ecosystem of California small entrepreneurial businesses, educational institutions, supply chain members, and investors required to innovate, develop, and manufacture energy storage in California.

In order to achieve these benefits, it is essential that CEC consider and allow for technologies such as RCAM's innovative Marine Pumped Hydroelectric Storage Technology in future CEC EPIC grant opportunities.

Responses to Panel Discussion Questions

Topic 1: RCAM's promising long duration energy storage technology

California has a unique and timely opportunity California to combine Floating Offshore Wind (FOSW) and ocean based long duration energy storage such as Marine Pumped HydroElectric Storage (M-PHES). California has vast deep water ocean resources extending more than 800 miles along its coastlines that are ideal for both FOSW and M-PHES. The (optional) integration of these two technologies into a hybrid wind/storage energy system would have synergistic benefits for both FOSW and M-PHES that could accelerate deployment, reduce the cost, and increase the value and benefits of both technologies. RCAM suggests the CEC consider two new technical reports by NREL and London Imperial College that describe the benefits of hybrid energy systems such as wind energy with long duration mechanical energy storage. [1,2]

A 1st generation M-PHES has been proven independently by MIT and the Fraunhofer Institute[3]. RCAM's next generation M-PHES design is a lower cost, longer duration energy storage technology that can be used with renewable energy technologies along America's coastlines and in lakes to provide up to 100% clean electricity and strengthen grid resiliency for over 127 million people in the US alone. M-PHES has all the benefits of conventional (onshore) Pumped HydroElectric Storage (PHES) but solves the problems PHES has with long development timelines, water availability, financing, capital costs, and limited geographic availability. RCAM's M-PHES technology will cut project development time by 75%, capital costs by 50%, and increases the available storage technical resource capacity 200X compared to PHES.

RCAM is developing a patent pending M-PHES configuration that improves the cost effectiveness and storage capacity that can be manufactured using low cost 3D concrete printing (3DCP) methods. The 3DCP additive manufacturing approach facilitates fast production of M-PHES systems of various sizes and capacities in California ports using regionally available concrete materials and concrete supply chains, providing quality jobs and localized economic benefits.

M-PHES uses the static pressure of the water column in lakes, seas, and oceans to store and release electrical energy when needed in a process similar to conventional (onshore) pumped hydro power plants. To use this potential energy, a large hollow concrete sphere is installed under water in oceans and lakes in depths between 100 m and 2000 m. A motor/pump connected to the hollow spheres stores electrical energy by pumping water out of the sphere against the surrounding hydrostatic pressure. The process is reversed to generate electricity using a turbine/generator (Figure 1).

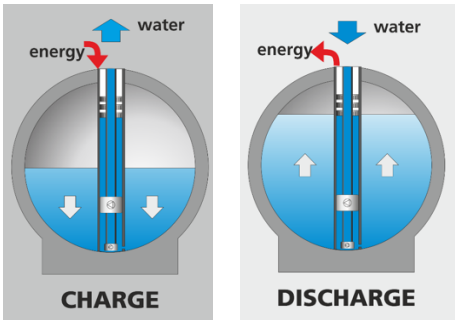

Figure 1: M-PHES charges by pumping water out of a sphere (left) and is discharged by allowing the water to return through a turbine (right). Image source is the Fraunhofer Institute.

The amount of M-PHES energy storage depends primarily on the water depth and volume of water stored. RCAM's higher capacity design increases the storage volume and capacity in all water depths, which is especially important in shallower waters with less pressure head. 3DCP cuts manufacturing costs in half and enables RCAM to vary the number of spheres, depth, and diameters without fabricating new formwork. Nominally, a grid-scale M-PHES with three

[1] "Whole-System Value of Long-Duration Energy Storage in a Net-Zero Emission Energy System for Great Britain," *Imperial College London*. http://www.imperial.ac.uk/energy-futures-lab/reports/whole-system-value-of-long-duration-energy-storage-in-a-net-zero-emission-energy-system-for-great-britain/ (accessed Jul. 24, 2021)

[2] "Are Hybrid Systems Truly the Future of the Grid? NREL's Magic 8-Ball Says: 'Concentrate and Ask Again.'" https://www.nrel.gov/news/features/2021/are-hybrid-systems-truly-the-future-of-the-grid.html (accessed Jul. 24, 2021).

[3] M. Puchta et al., "Development and testing of a novel offshore pumped storage concept for storing energy at sea – Stensea," J. Energy Storage, vol. 14, pp. 271–275, Dec. 2017, doi: 10.1016/j.est.2017.06.004.

30-m diameter spheres installed in 700-m water and a 5-MW pump/turbine module has a storage capacity of 60 MWh providing 12 hours of energy storage at rated power. Increasing the spheres to 8 per pump/turbine provides 32 hours (1.3 days) or 160 MWh of energy storage. The modularity of M-PHES allows deployment of additional systems to meet growing capacity needs.

The daily and seasonal mismatch of variable renewable energy sources (such as wind and solar) and load demand requires long duration storage from hours to days to achieve very high levels of renewable energy in the power sector. The National Renewable Energy Laboratory (NREL) projects the U.S. needs to install approximately 350 GW of long duration energy (4 - 12 hours) and multiday seasonal storage to reach 80% to 90% penetrations of renewable energy.[4] Conventional pumped hydroelectric energy storage has been the preferred long duration storage technology due to its high efficiency (80%), low cost, vast storage capacities, quick response time, ultra-long plant life (100 years with refurbishment), and technological maturity. In 2019 PHES contributed 93% of U.S. grid storage power capacity (22 GW) and 99% of electrical energy storage (553 GWh). **However no new pumped hydropower plants have started operations in the U.S. in over 25 years due primarily to long regulatory and construction timelines for development of new projects (up to 10 years), financing challenges, and limited availability of suitable terrain and water**. Environmental concerns with competing land and water uses, and financing challenges result from high capital cost and long development timelines have hindered successful development of new PHES projects. As a very recent example, the ½ GW San Vicente Energy Storage Facility pumped energy storage project proposed by the City of San Diego and the San Diego County Water Authority won't enter service until 2030 if built[5] and is many times too small to meet California's growing energy needs alone.

RCAM's innovative M-PHES system solves the geographic limitations of conventional pumped hydro by increasing the deployable technical resource capacity by 200X, cuts capital costs, increases drought resistance, and reduces development time by avoiding fresh-water use-conflicts and land-use permitting challenges. M-PHES has potential to reduce regulatory and development time from 10 years to 3 years by avoiding contentious land and water use conflicts and adapting marine permitting processes in or soon-to-be in-development for California offshore wind and wave energy deployments. M-PHES is deployed out-of-sight on the seafloor without obstructing marine traffic above. M-PHES can be planned, permitted, and installed with future U.S. fixed and floating offshore wind, wave, and solar plants or be installed independently ensuring that California has long duration energy storage it needs for deployment of renewable energy sources such as FOSW.

RCAM has recently performed preliminary estimates of the ability of M-PHES to meet all of the LDES needed to meet the LA100 vision[6]. A seafloor area circle with a diameter of 3 miles could provide approximately 16 hours and 10 GW of M-PHES storage to LA via an underwater power cable providing approximately enough energy storage for all of LA's LDES needs (Figure 2).

RCAM's portable 3d concrete printing technology can be used to manufacture the M-PHES in nearby ports, such as the Port Of Los Angeles, providing localized economic benefits to nearby residents in nearby disadvantaged zones. RCAM has performed similar analyses for the 10 largest metropolitan areas in the US (Chicago, Houston, New York,…), as well as the UK. The preliminary analysis show M-PHES also has potential to provide all of the energy storage needed for these metropolitan areas and countries helping to solve climate challenges that are also affecting California. This incredible potential of M-PHES is possible due to the vast water resources surrounding the US (figure 2) and major metropolitan areas globally.

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[4] P. Denholm, *et al.*, "Storage Futures Study: The Four Phases of Storage Deployment: A Framework for the Expanding Role of Storage in the U.S. Power System," NREL, Jan. 2021.

[5] "Proposed 500 MW pumped storage project secures California state funding," *pv magazine International*. https://www.pv-magazine.com/2021/07/22/proposed-500-mw-pumped-storage-project-secures-california-state-funding/ (accessed Jul. 30, 2021).

[6] "LA100: The Los Angeles 100% Renewable Energy Study." https://www.nrel.gov/analysis/los-angeles-100-percent-renewable-study.html (accessed Jul. 30, 2021).

Figure 2: M-PHES can be located out of sight in deep water near coastal California cities to provide all the long duration energy storage the it needs to meet renewable targets.

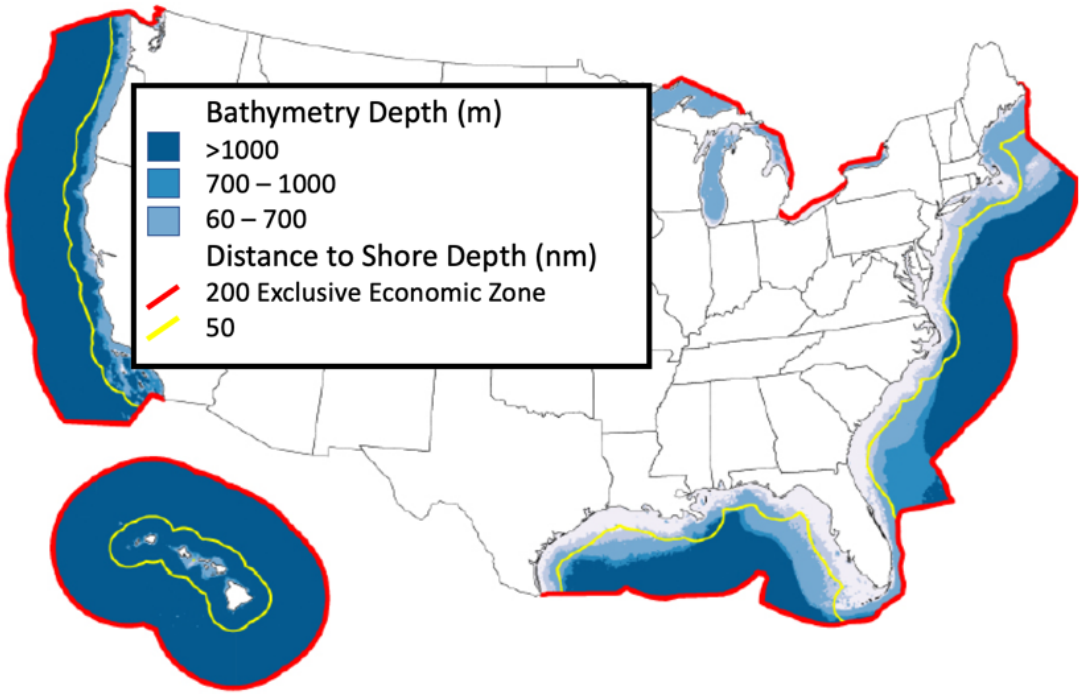

Figure 3: M-PHES can be deployed in oceans and lakes near the largest metro areas with onshore and offshore renewables to provide up to 100% renewable energy for over 127 million Americans (map source: NREL).

EPIC programs that encourage or support technology integration such as RCAM's Marine Pumped HydroElectric Storage systems will be critical to developing this new timely California opportunity.

Thank you for your consideration of these comments.

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