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Water-Cooled Data Centers

Additional submitted attachment is included below.

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The Energy Commission is currently soliciting ideas and stakeholder input for the 2018 – 2020 EPIC Triennial Investment Plan. For those that would like to submit an idea for consideration in the 2018-2020 EPIC Triennial Plan, we ask that you complete the form below. Submittals are due by **5:00 p.m. on February 10, 2017.**

Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Nautilus Data Technologies is pioneering a new benchmark for data center efficiency, environmental sustainability, and scalability. Data centers are the backbone of the modern economy. They provide the necessary infrastructure to meet growing needs for telecommunications, internet, transportation, energy, security systems, and entertainment. With more users coming online and more businesses and industries moving to a digital platform, there is a need to pilot test and scale an operation scale, advanced data center water cooling technology that can reduce energy consumption, associated carbon emissions, and other harmful emissions by more than 30%, and eliminate nearly all water consumption, water treatment chemicals, and potent greenhouse gas/ozone-depleting refrigerants. This initiative will deploy, test, and validate water-borne and landside data centers with an advanced water cooling system that removes heat produced by server racks using an internal closed loop system in combination with an open loop heat transfer system, utilizing the natural water surrounding the ship. Unlike the systems deployed in

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Conventional data centers consume large amounts of energy and water, with significant greenhouse gas emissions and other harmful air pollutants. A single medium size data center consumes more than 10MW of electricity and more than 80,000,000 gallons of water per year to operate large, complex, and noisy evaporative cooling and refrigerated air handling systems , which impose an immense burden on public energy and water supplies. Energy performance in a data center is typically measured by Power Use Effectiveness (•PUEŽ),which is defined as total power consumed at a data center divided by the total power consumed by information technology (IT) equipment. The lower PUE the better, with 1.0 being a perfect score. According to the U.S. Department of Energy Lawrence Berkeley National Laboratory, while significant energy efficiency improvements have been introduced into the servers and other computer equipment housed in data centers over the last ten years, the energy efficiency of data center cooling and operations has barely budged essentially , stuck between a PUE rating of 1.7 - 1.9 As demand for

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

If successful, the initiative will significantly improve data center efficiency and could provide up to 30% reductions of carbon emissions and other harmful air pollution from associated electricity generation at data centers, significantly reduce water consumption, and eliminate the use of water treatment chemicals and potent greenhouse gas/ozone depleting refrigerants widely used by conventional data centers. Currently, California•s more than 800 data centers together consume roughly 2% of the State•s energy (4.0GW) and 0.7% of the State•s water (104 billion gallons), figures that could double by 2020, meaning there is an opportunity to have a significant impact on the data center industry's overall water and energy consumption. The initiative will also provide multiple direct qualitative and quantitative benefits to California•s IOU ratepayers. The initiative•s energy and water efficiency will provide electricity ratepayers direct cost savings, improved grid reliability, and added value from use of existing, underutilized electricity infrastructure. It will also significantly reduce water use – helping water managers meet the State•s

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The key metrics to evaluate the performance of data center efficiency are PUE, GHG emissions, and water consumption. Industry standards for the key metrics are well documented (i.e. PUE 1.7 …1.9, GHG 0.73lbs/kWh, 8-million gallons of water consumed per megawatt). Improvements in these these metrics for future California's data centers will indicate and illustrate the impacts of the initiative. As stated above, state-of-the-art water-colled data centers can reduce the PUE and associated GHG emissions significnatly. Specifically, the current market average for conventional Data Center's is 1.7-1.9, with the lower value being better, and a 1.0 being perfect. The initial proof of concept for this initiative showed the potential for a PUE of 1.05, representing an 87% improvement in efficiency compared to current benchmark technologies. This improved metric is due to the innovative cooling and piping system and data center design.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

As called out in Pacific Gas & Electric's •Data Center Best Practices.Ž Data Center Design Guidelines (2012), "A cooling system using water as the heat transport medium can conduct about 3,500 times more heat on a volume basis than a system using air.• All other major industries outside of data centers that are challenged with thermal discharge use water for cooling, including power generation, industrial, manufacturing and maritime industries for the very reason called out by Pacific Gas & Electric, which is that water is exponentially more effective in heat dissipation than air. A water-cooled data center leverages the cooling benefits of water without consuming the 8-million gallons per megawatt air-cooled data centers consume; the once through cooling design of water-cooled data centers result in virtually no water utilization (<10,000 gallons) and a very modest increase in water temperature (<4-degrees).
As reported by Lawrence Berkeley National Laboratory•s Rod Mahdavi, PE, LEED AP in a 2014 paper describing the efficiency characteristics of a water cooled information

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Current conventional, air-cooled data centers rely on decades-old technology consisting of massive evaporative cooling and refrigerated air handling systems, including chillers, industrial air-conditioner and fan systems, water evaporators, and water treatment chemical storage. These systems are needed to reduce the heat generated by the banks of computer server racks in a data center in order to ensure equipment performance, safety, and comfort. As a result, these systems consume large amounts of energy and water, emit carbon emissions and other harmful air pollutants, require toxic water treatment chemicals and potent greenhouse gas/ozone depleting refrigerants, and necessitates sizable, impermeable land development. Energy performance in a data center is typically measured by Power Use Effectiveness (•PUEŽ),which is defined as total power consumed at a data center divided by the total power consumed by information technology (IT) equipment. The current market average for conventional Data Center's is between 1.7-1.9, with the lower value being better, and a 1.0 being perfect. The proof of

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

If Other, Please Specify

• Advance Technology Solutions for Deep Energy Savings in Building and Facilities