DOCKETED	
Docket Number:	20-EPIC-01
Project Title:	Development of the California Energy Commission Electric Program Investment Charge Investment Plans 2021-2025
TN #:	238653
Document Title:	Andrew Popell Comments - Vertical Gravity Storage Research Concept Proposal
Description:	N/A
Filer:	System
Organization:	Andrew Popell
Submitter Role:	Public
Submission Date:	7/2/2021 11:30:03 AM
Docketed Date:	7/2/2021

Comment Received From: Andrew Popell
Submitted On: 7/2/2021
Docket Number: 20-EPIC-01

Vertical Gravity Storage Research Concept Proposal

Additional submitted attachment is included below.

ELECTRIC PROGRAM INVESTMENT CHARGE 2021-2025 (EPIC 4)
RESEARCH CONCEPT PROPOSAL FORM

The CEC is currently soliciting research concept ideas and other stakeholder input for the EPIC 4 Investment Plan. For those who would like to submit an idea for consideration, we ask that you complete this form and submit it to the CEC by 5:00 p.m. on **July 2, 2021**.

To submit the form, please visit the e-commenting link, https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=20-EPIC-01, enter your contact information, and then use the "choose file" button at the bottom of the page to upload and submit the completed form. Thank you for your input.

1. Please provide the name, email, and phone number of the best person to contact should the CEC have additional questions regarding the research concept:

   Andrew Popell
   andy@stratosolar.com
   415-457-4987

2. Please provide the name of the contact person's organization or affiliation:

   Stratosolar, Inc.

3. Please provide a brief description of the proposed concept you would like the CEC to consider as part of the EPIC 4 Investment Plan. What is the purpose of the concept, and what would it seek to do?

   We propose doing research on the increased efficiency and cost advantage of vertical gravity energy storage at high altitudes.

   Our purpose is to prove that high altitude vertical gravity storage is viable, can return over 95% of the energy it stores with a response time measured in seconds, and can provide environmentally clean storage at a capital cost of under $1/Watt ($100/kWh).

   We seek to design and build vertical gravity storage systems using weights suspended from buoyant platforms at 65,000 feet.

4. In accordance with Senate Bill 96, please describe how the proposed concept will **"lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory energy goals."** For example, what

technical and/or market barriers or customer pain points would the proposed concept address that would lead to increased adoption of clean energy technologies? Where possible, please provide specific cost and performance targets that need to be met for increased industry and consumer acceptance. For scientific analysis and tools, what data and information gaps would the proposed concept help fill, what specific stakeholders will use the results, and for what purpose(s)?

According to the CEC, to meet California's 2045 retail electricity zero-carbon targets, 50 GW of new electricity storage need to come online. The CEC has identified scalability (battery build rates would need to increase 8X to achieve these goals). In addition, there are significant environmental and ethical issues with batteries. California also uses pumped hydroelectric storage. However, this is severely limited by geography, is adversely affected by hot weather, and is extremely expensive to build.

Vertical gravity storage systems are more efficient than pumped hydroelectric storage, and much more geographically flexible, scalable and responsive. Vertical gravity storage also avoids the problems associated with mining the massive amount of lithium and cobalt needed for 50GW of traditional battery storage and has a much longer 30 plus year useful life.

5. Please describe the anticipated outcomes if this research concept is successful, either fully or partially. For example, to what extent would the research reduce technology costs and/or increase performance to improve the overall value proposition of the technology? What is the potential of the technology at scale?

We anticipate that vertical gravity storage will be 15 to 20% more efficient than water-based gravity storage and batteries and that capital cost will be under $1/Watt. Vertical gravity storage systems could scale from 25MWh (2.5MW) to 50GWh (5GW) in 25MWh (2.5MW) modular increments.

6. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed research concept.

Percent of energy returned vs stored. Capital cost per Watt.

7. Please provide references to any information provided in the form that support the research concept's merits. This can include references to cost targets, technical potential, market barriers, etc.

Limitations of battery storage:
https://www.technologyreview.com/2018/07/27/141282/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/
https://kleinmanenergy.upenn.edu/wp-content/uploads/2020/10/KCEP-Opportunities-and-Limitations-P10.pdf
"Battery storage, meanwhile, continues to be costly, and can only be used over relatively short time periods. Leaving a lithium-ion battery empty for weeks or longer can allow copper dendrites to form and degrade the internal infrastructure, thereby permanently reducing the cell's capacity and causing the cell to become unstable."

"Pumped hydrological storage systems have a similar challenge with evaporation during hot, dry weather. If left for a considerable length of time for the purposes of long-duration storage, these pumped hydro systems could also be limited by "self-discharge."

Ethical issues with batteries:
https://sancroft.com/2018/08/06/the-surge-for-power-the-ethics-behind-batteries/
https://www.wired.co.uk/article/lithium-batteries-environment-impact

Storage efficiency:
https://www.eia.gov/todayinenergy/detail.php?id=46756