Undergraduate Thesis Prospectus

Spotlight on Solar: Harnessing the Power of the Sun for a Sustainable Future

(technical research project in Civil Engineering)

The Pursuit of Battery-Free Energy Storage in the United States

(sociotechnical research project)

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How may the transition to low-carbon energy best be pursued?

The harmful impacts of fossil fuels make the transition to low carbon energy crucial. Installing solar panels onto a community building is one way to spark this transition. The advocacy of non-battery energy storage is vital in this transition. These two components of energy transition have gained traction recently because of their economic and environmental viability. Non-battery energy storage advocates advance their agendas through policy, influence, research and innovations. Solar provides an economic opportunity for building owners, while simultaneously reducing carbon emissions. A deeper exploration can provide further information on the clean energy transition and the tools to accomplish it.

Spotlight on Solar: Harnessing the Power of the Sun for a Sustainable Future

How can the Brooks Family YMCA benefit from installing solar panels on its building?

This is a capstone project within civil and systems engineering with Reid Bailey as the advisor. I am collaborating with Julia Lombardi, Hannah Billing, Liam Shields, Laurens Beachy, and Jack Dreesen-Higginbotham.

A company approached the Brooks Family YMCA about installing solar panels on their building through a Power Purchase Agreement (PPA), but the board felt rushed to make a decision, ultimately deciding against it. A PPA is when a company agrees to buy electricity, typically at a reduced price, from a solar provider who installs and maintains the panels on their building. This provides renewable energy consumption without the upfront costs. This proposal exposed the economic, environmental, and social benefits that solar offers the YMCA. Over a

twenty year period in Charlottesville, VA, around $20,000 in savings can be expected from solar (EnergySage, 2023). Solar panels allow the consumption of renewable energy, which emits 88% less carbon dioxide throughout its lifecycle than natural gas and 94% less than coal (Union of Concerned Scientists, 2013). The visibility of the panels informs and promotes renewable energy and its benefits to the community. The YMCA wants our team to assess the viability of solar and advise them on their future action. With no notable constraints besides the size and strength of their roof, it is up to us to analyze the different options and to present our findings clearly and efficiently so the YMCA is able to make an informed decision.

Virginia ranks 11th nationally in solar, it currently produces around 2,500 MW of solar energy, which is roughly 2% of the state's electricity (NEM Group, 2023). Virginia is projected to rise to 5th place nationally, meaning a production of roughly 5,300 MW and 4% (Chester, 2023). The current resources allow us to gather information, request and analyze proposals from solar companies, construct a matrix that weights categories and can rate each proposal by how well it meets each one, and develop a recommendation to deliver to the board of the YMCA. This recommendation will have actionable steps to pursue each proposal analyzed, should the board choose to move forward.

The Pursuit of Battery-Free Energy Storage in the United States

In the United States, how do advocacies, companies and policymakers compete to promote various battery-free energy storage techniques?

The growth of renewable energy has brought the issue of energy storage, as renewable resources cannot provide an uninterrupted stream of power. Energy storage enables a stable and

resistant power supply while limiting the dependence on fossil fuels. Batteries are a viable choice, but cannot meet all energy storage needs. In 2017, the US generated 4 billion MWh of electricity, with only 431 MWh of electricity storage available (Zablocki, 2019). Non-battery storage helps to close this gap. Researchers and advocates must use tools and methods to promote alternate non battery options.

Researchers have evaluated non-battery energy storage technologies. In a life-cycle assessment on gravity energy storage (GES) for large-scale applications, Berrada et al. (2021) found that GES is cost-competitive with two other non-battery techniques: Pumped Hydro Energy Storage (PHES) and Compressed Air Energy Storage (CAES). A study of PHES has shown that its flexibility and storage capacity improve grid stability (Rehman et al., 2015). Nzotcha et al. (2019) accentuates the sustainability of PHES, how it could produce zero greenhouse gasses, while maintaining low prices of electricity. CAES is an energy storage solution for areas with limited reliable energy. Adib et al. (2023) explains that a CAES system is a cost effective and reliable storage solution for these areas. Publishing research, such as the above, promotes non-battery energy storage.

Companies like HOLCIM and Energyy5 promote sustainable energy. HOLCIM has partnered with other companies, INSA Lyon and ENGIE, to develop non-battery storage technology. They, along with their partners, promote this technology on their website to promote the technology, green energy, and themselves (Bermejo, 2022). Energy5 offers services in sustainability, while posting articles about the benefits of non-battery storage options. This approach is more educational rather than promotional, intending to inform readers about the technology, not sell it to them (Energy5, 2023). Federal agencies like the Office of Energy

Efficiency and Renewable Energy (EERE) advance the research and development of technologies to help America reach net-zero greenhouse gas emissions (WPTO, 2023). Nonprofits like the National Hydropower Association (NHA) release reports, articles, and supporting projects surrounding non-battery energy storage (Fitzgerald, 2022). NHA advocates for policies at the federal and state level. At the federal level, NHA lobbies for legislation to streamline pumped hydro storage, seen in the Community and Hydropower Improvement act. This act removes many of the obstacles in obtaining a permit for hydropower. The state level supports the meeting of targets for pumped hydro storage (Fitzgerald, 2023). NHA has many committees and councils to help them further their agenda. Their Pumped Storage Development Council focuses on the regulatory and legislative issues surrounding PHES development (National Hydropower Association, 2023). Crossley (2013) describes how the lack of legal definition for energy storage poses a challenge for policy makers. This is seen in the Community and Hydropower Improvement Act, which relates to pumped hydro, not any other systems. The Clean Energy States Alliance (CESA) is a trade association for clean energy technologies. They fund research on non-battery storage technologies. The Energy Storage Technology Advancement Partnership (ESTAP) is a federal-state initiative, funded by the U.S. Department of Energy and administered by CESA. It fosters partnerships between states and the government to deploy energy storage technologies. Their main methods include: project deployment, policy development, analysis, and information dissemination (Clean Energy States Alliance, 2023). Participants in this topic find success when working together. This is made difficult through the lack of legal definition of energy storage, which isolates each different system. Existing technologies will continue to improve, which further increases competition in the sector. A

further investigation into the methods and competition of the advocacies, companies and policymakers promoting various battery-free energy storage technologies would provide a response to this challenge.

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