Undergraduate Thesis Prospectus

Electrical Energy Battery Storage Improvement for a Sustainable Future

(technical research project in Engineering Science)

Opposition to Renewable Energy

(STS 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 can renewable energy be more widely implemented?

Despite rapid growth renewable energy still accounts for only a third of total installed electricity capacity worldwide (Dhabi, 2019). Reliance on fossil fuels dominates energy production worldwide (coal remains the largest source of electricity generation with a 38% market share), but finite global stores of oil and coal are being depleted and dependence on them generates by-products harmful to humans and the environment (IEA, 2019). Widespread implementation of renewable energy is essential to address global warming and exhaustion of fossil fuels. Fossil fuel interests are resisting renewables' development in the market. They lobby against clean energy legislation, sometimes by spreading disinformation. Technical and social challenges must be overcome before renewable energy sources can develop sufficiently.

Electrical Energy Battery Storage Improvement for a Sustainable Future

How can the efficiency, affordability, and sustainability of small-scale electrical energy battery storage technologies be improved?

My advisor is James Groves (STS department) and I'm taking his ENGR 4010 Design Thinking class for my Engineering Science Major capstone. My project team includes Jesse Boston, Mark Maguire, and Liz Stais.

Recognition of human and environmental impacts of greenhouse gas (GHG) emissions from combustion of fossil fuels is increasing emphasis on renewables; "in the U.S. a nine-fold growth of the energy storage market is expected over the next five years" (Bardajií, M. et al., 2017). Small-scale applications of renewable energy (individual homeowners and small communities) are sensitive to consistency, power levels, and affordability. Homeowners currently rely on consistent power from the grid, however, “the inherent intermittency and variability of renewable energy resources complicates microgrid operations” (Su, Wang, & Roh, 2014). Therefore, storing energy when supply is in excess and retrieving it when needed must become more efficient and affordable to meet the intermittency of power from renewables.

This project will develop affordable, reliable, and efficient residential and small-community battery energy storage technology that features cradle-to-grave sustainable human and environmental impacts. Such a battery must have hours-long storage capability, appropriate volume and mass energy densities, and a long shelf life. Also, the battery’s technical characteristics must improve affordability to achieve widespread use for residential and small-community energy storage.

Currently, the most common battery technologies for small-scale use are sodium-sulfur (Na-S), lead-acid, and lithium-ion (Li-ion). Each has advantages and disadvantages. Research and development with these technologies is improving efficiency and driving down cost.

Sodium-sulfur batteries have high operating temperature (300C-350C) which is inconvenient for residential applications, but they have potential for small community use. Their disposal is environmentally benign but some chemical reactivity safety concerns exist. Lifecycle analysis shows they are cost effective compared to other technologies, with a price point of $0.04-$0.75/kWh/cycle (Bardajií et al., 2017). They also have reasonable energy density (around 150-240 Wh/kg) and a fair cycle life (2500-4500 cycles) (Akinyele, Belikov, & Levron, 2017).

Lead-acid batteries are the most mature of all current battery technologies; they are also the most stable. They have relatively poor energy density (40-50 Wh/kg) and a low cycle life (2000-2500 cycles) but do have a wide operating temperature range (-40C to +60C) (Akinyele et al., 2017). They are generally the most cost effective due to their long-standing foothold in the battery market at $360/kWh (Akinyele et al., 2017). However, lead-acid batteries are extremely toxic to both humans and the environment due to lead contamination during disposal.

Lithium-ion batteries are currently the most popular type of rechargeable battery for stationary power. They have a good operating temperature range (-20C to +55C), a high energy density (274 Wh/kg), and a long cycle life (5000 cycles) (Esposito & Michael, 2017; Bardajií et al., 2017). Currently their price is around $690/kWh; more expensive than more mature technologies, but this cost is rapidly decreasing (Akinyele et al., 2017). However, the mining of cobalt (used in Li-ion batteries) is both environmentally unsustainable and the source of human rights atrocities in the third-world countries where the majority of cobalt is obtained (Cheyns et al., 2014).

To lower cost and reduce environmental impact, research is needed for new materials or manipulation of existing materials to decrease battery toxic content, increase efficiencies at room temperature, and extend battery lifetime.

My team will research state-of-the-art technologies applicable to the residential and small community battery energy storage market. Lab work will compare technologies and identify the most efficient, using established techniques to quantify energy and power density, charge/discharge rate, and estimated battery life. We will perform cost-benefit and lifecycle analyses to understand how “clean” and sustainable the technology will be for mass production and implementation. We will not build a new technology.

Our project’s product will identify and defend the best new technology for energy storage. Our product will influence manufacturers and policy makers to more aggressively pursue this new technology, making renewable energy implementation more attractive and cost competitive.

Opposition to Renewable Energy

How do opponents of renewable energy advance their agenda?

Renewable energy is proliferating through public support, “green” legislation, and technological advancements. A 2018 national survey found 72% of respondents favor renewable energy over oil for the future of U.S. energy needs (Hamilton, 2018). But to coal and oil companies, restrictions of fossil fuels and subsidies for renewable energy are threats (Krane, 2016). In response, these companies and their defenders are fighting back by generating and spreading disinformation and by lobbying against clean energy bills (EPI, 2014).

To overturn pro-clean energy legislation, fossil fuel organizations generate skewed reports claiming clean energy policies have undesirable effects, aiding front groups that use the data to spread disinformation through grassroots networks (EPI, 2014). These groups mask their intentions by labeling themselves as “think tanks” or “institutes,” often claiming to advocate for a “free-market.” The groups gain public support by targeting emotions, instilling fear of personal losses and economic repercussions to convince people to oppose renewables.

According to Bidwell (2016), public attitudes towards renewable energy are highly dependent on information exposure: "public opposition to technology is based on a lack of quality information." Public positions on clean energy are also affected by emotion. Renewable energy proposals can "disrupt or threaten place attachments and identities," and provoke questions about distributional fairness (Cass, 2009). Using these tactics, fossil fuel groups gain public support. Lobbyists are then in a stronger position to oppose clean energy bills. According to Pasqualetti (2011) a sustainable future requires renewable energy programs to shift from a technical to a social approach.

The Edison Electric Institute (EEI) is a utility trade association that represents all U.S. investor-owned electric companies (EEI, 2019). It seeks repeal of net metering laws that help make solar panels cost effective, contending they are unfair to non-solar households: "net-metered customers effectively avoid paying [grid infrastructure] costs" (EEI, 2016). EEI favors nuclear energy, claiming it is a "24/7 clean energy source," and contends that preservation of existing plants is essential to "ensuring electric reliability and affordability" (EEI, 2019).

Coal industry groups, such as the West Virginia Coal Association (WVCA), oppose renewables to protect coal companies' profits, employment, and competitiveness (Raney, 2017). These groups make renewables appear unnecessary by exaggerating coal's importance and by claiming carbon capture and storage can make coal clean (Bezdek, 2017). WVCA cites continued increase in carbon emissions as proof that renewables are failing: "putting thousands of coal miners out of work and jeopardizing affordable, reliable power has proven to be not much of a climate plan" (WVCA, 2019).

Americans for Prosperity (AFP) presents itself as a conservative advocacy but it is funded by fossil fuel interest groups (Mayer, 2010). AFP criticizes renewables, calling tax breaks unfair to taxpayers: “renewable energy received over 65% of the total tax-related support for the energy industry but provides only 12.8% of the energy Americans used” (AFP, 2019). The organization also contends that “a $25 per ton carbon tax would cost a family of four $1,900 per year, increase gas prices by 50 cents per gallon, and cost the economy more than 1 million jobs” (Rodriguez, 2018).

The Heartland Institute, an organization funded by fossil fuel companies but masked as a “free market” advocacy, opposes clean energy agendas. It characterizes CO2 as harmless, attacks global warming predictions, and warns that mass unemployment would follow a fossil fuel phase out (Ferrara, 2018). The organization seeks repeal of the Clean Power Plan, arguing that because it is based on “an erroneous interpretation of the Clean Air Act” it has no legal authority (Ferrara, 2018).

The Beacon Hill Institute (BHI) is a fossil fuel funded organization that conducts economic research and publishes false and misleading reports and analyses on various public policy issues. In a proposal to a prominent conservative foundation, BHI requested money to pursue biased economic research to support rollbacks of clean energy policies; “earned media and legislative efforts to repeal or diminish the Regional Greenhouse Gas Initiative will be determinants of success” (SPN, 2013).

The American Legislative Exchange Council (ALEC) connects conservative lawmakers with corporate lobbyists and generates model legislation to benefit its members. ALEC has approved language aimed at weakening and repealing Renewable Energy Standard laws, and eliminating solar net metering policies. In a 2013 annual meeting policy report, ALEC claimed that after the Electricity Freedom Act became its model policy, “approximately 15 states across the country introduced legislation to reform, freeze, or repeal their state’s renewable energy mandate” (ALEC, 2013).

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