Energy Optimization of Supercapacitors and Solar Battery Energy Storage

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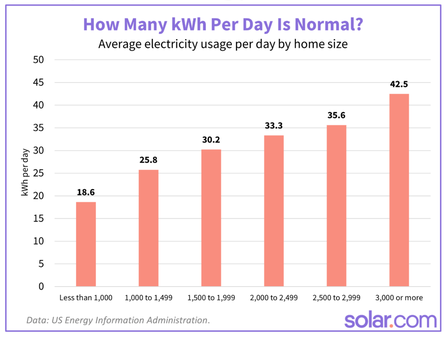
Abstract

- Solar batteries have limited lifespan, need for maintenance, and negative environmental impacts when disposed
- A potential alternative storage option is supercapacitors
- Pros: Longer lifespans, recyclability, and high charging rates
- Cons: High discharging rates that do not allow for a lot of storage capability
- Two main types: Electrochemical double layer capacitors (EDLCs), or graphene-based, and pseudocapacitors, or non-graphene-based

Background

- A 2000 square foot house in the United States takes ~33kWh per day.
- Supercapacitors are the middle ground between capacitors and batteries
- Supercapacitors have high capacitance (up to 12000F) and low voltage rating (<5V)
- Supercapacitors can charge and discharge for many cycles as they store energy electrostatically



[1] Energy usage for USA household based on size

[2] Supercapacitors!

Goal

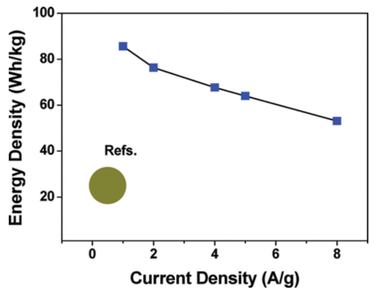
Determine from the three options - solar batteries, graphene-based supercapacitors, or non-graphene-based supercapacitors - what is the most efficient method to store solar energy.

Method

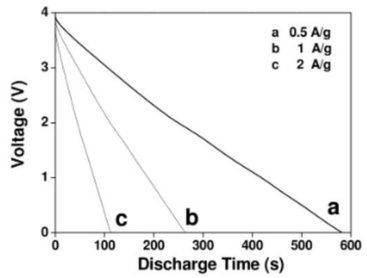
The methods used in this project were online research to complete the Research Learning Outcomes.

EDLCs

- At 1 A/g -> 85.6Wh/kg -> 385.5kg for one day
- Graphene can be made from any organic material
- Charge time: ~270 seconds



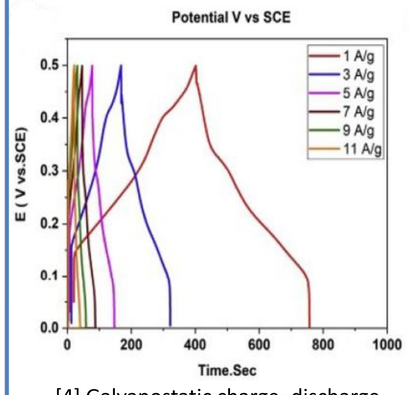
[3] Energy density vs Current Density for graphene-based supercapacitor



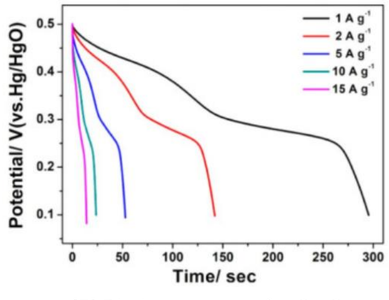
[3] Voltage vs Discharge Time for different A/g

Pseudocapacitors

- At 1 A/g -> 74.75 Wh/kg -> 441.5 kg for one day
- Transition metal oxides: RuO_2, cobalt oxide, nickel oxide, etc.
- Charge time: 300 - 400 seconds



[4] Galvanostatic charge–discharge diagram for $NiCoFeO_4$



[5] Discharge curves for Co_3O_4

Solar Batteries

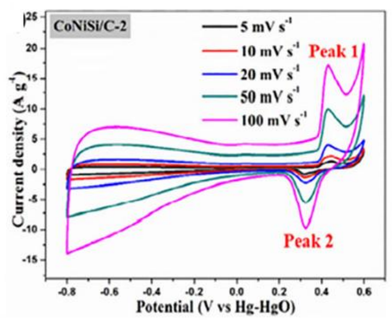
- 10 kWh/battery -> 3 to 4 batteries for one day
- Stores energy electrochemically which wears away at the battery over time
- Materials: Lithium iron phosphate, graphite, liquid electrolyte
- Charge time: ~6 hours

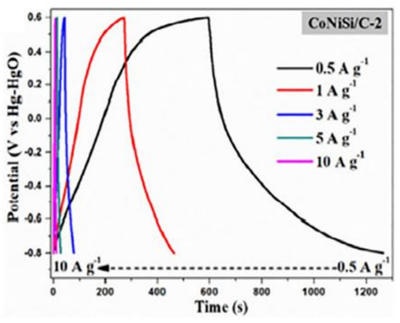
Findings

- Supercapacitors are not a viable option to charge a house on their own
- There are strides being made in increasing energy density of supercapacitors
- Of the three, solar batteries are the most efficient method
- An emerging method is utilizing a combination of supercapacitors and solar batteries

Supercapattery

- Supercapacitors have high power density and batteries have high energy densities
- Combining them allows us to “pick and choose” the desirable features of each
- Both EDLCs and pseudocapacitors are possible options





[6] Cycle voltammogram and Galvanostatic charge–discharge curves of CoNiSi used supercapattery device

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References

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