Energy Management System

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PROBLEM STATEMENT

All sources of energy production have an impact on our air, water, and land, but the magnitude of that impact varies. Electricity consumes around 40% of total energy consumed in the United States, making electricity usage a substantial component of each individual's environmental footprint. Energy efficiency reduces the amount of fuel consumed to generate power, as well as the amount of greenhouse gases and other air pollutants produced. Renewable energy sources such as solar, geothermal, and wind, contribute significantly less to climate change or local air pollution since no fuels are consumed. Energy storage is an essential component of decarbonization. Climate change has already had serious impacts on the world and environment around us. Studies have attributed a 1.1 C increase in temperature globally to climate change, with estimates as high as 5.7 degrees by the end of the century. To adapt to this change humanity needs to decarbonize its energy generation by transitioning to renewable energy sources. Although California leads the nation in renewable energy production, the majority of power consumed is still from non-renewable sources. In order to address this issue, as well as the challenges associated with adapting renewable energy to utility-based power distribution, we have created an energy management system which integrates solar power generation and battery storage with local power.

BACKGROUND

Solar panels convert sunlight into energy using photovoltaic cells utilizing the electrical charges that are moved as a reaction to the electric field generated in the cell. The battery storage system we have created uses lithium iron phosphate (LiFePO4) cells, which are notably different from the more common lithium-ion as being more stable, especially at higher temperatures, and a longer lifespan. In order to create a cost-effective system which reflects energy-use requirements of our local community, the system we have created is scaled at 1:20 of the average energy use of a single-family home in the Sacramento area.

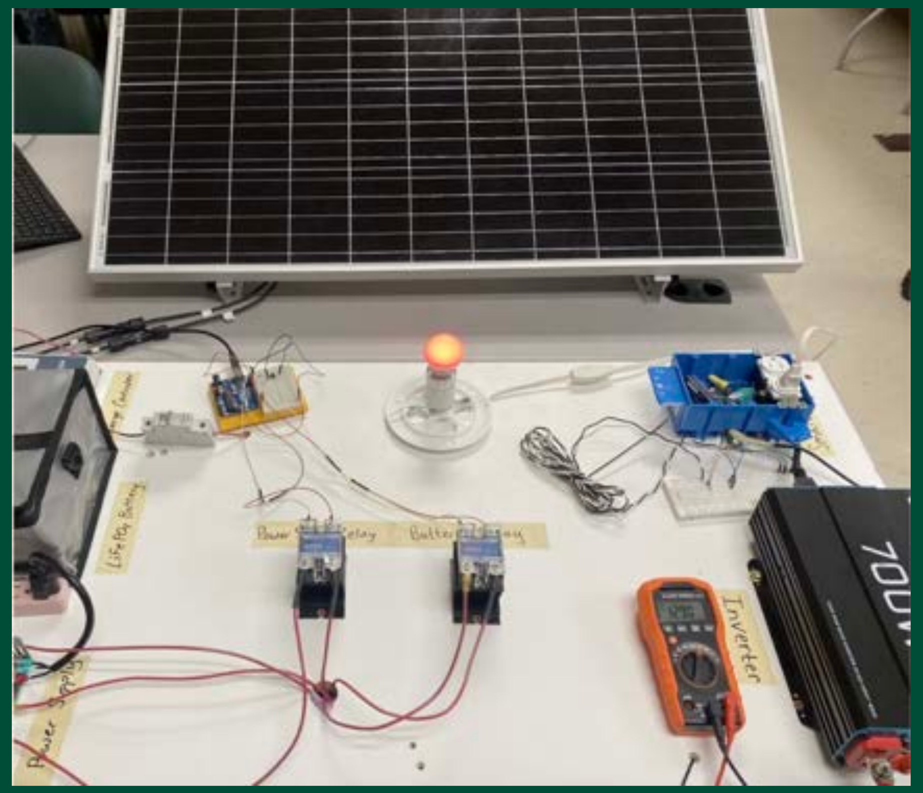


Figure 1: Energy management system built by Team 4

SUMMARY OF WORK

Energy Management System

- Raspberry Pi MCU calculates solar production, controls electrical relays to switch between power sources
- Power adapter converts 120V AC utility power to 12V DC
- Solar Charge Controller (MPPT) automatically adjusts impedance to allow for maximum current flow to battery at any given time.

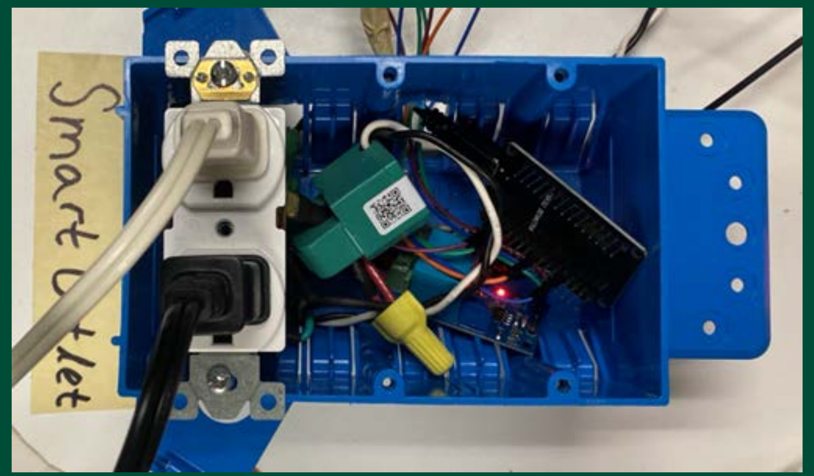


Figure 1: (above) Smart Outlet. Includes a voltage sensor, current sensor, and microcontroller to calculate power draw from the load which is transmitted to the primary microcontroller, which records data and controls the switching between utility and battery power

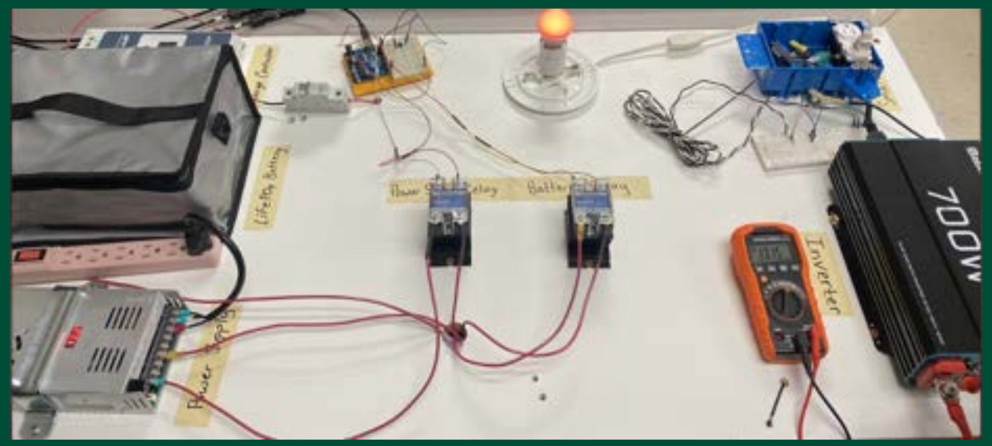


Figure 2: (above) From left to right: Solar charge controller, LiFePO4 Battery, Power Adapter, Relays, Smart Outlet, Inverter

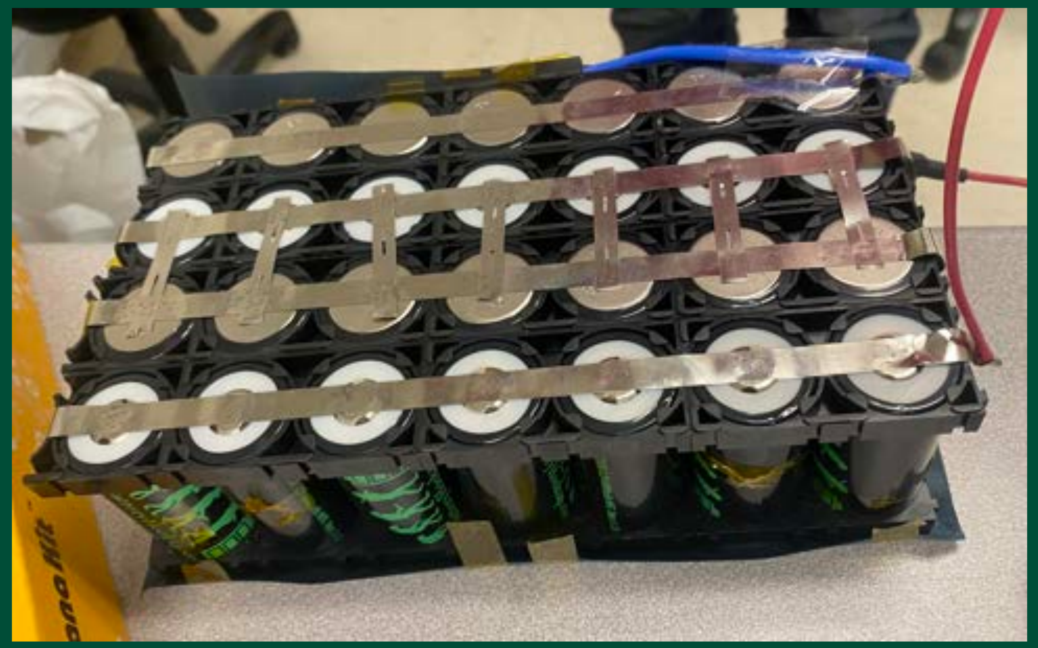
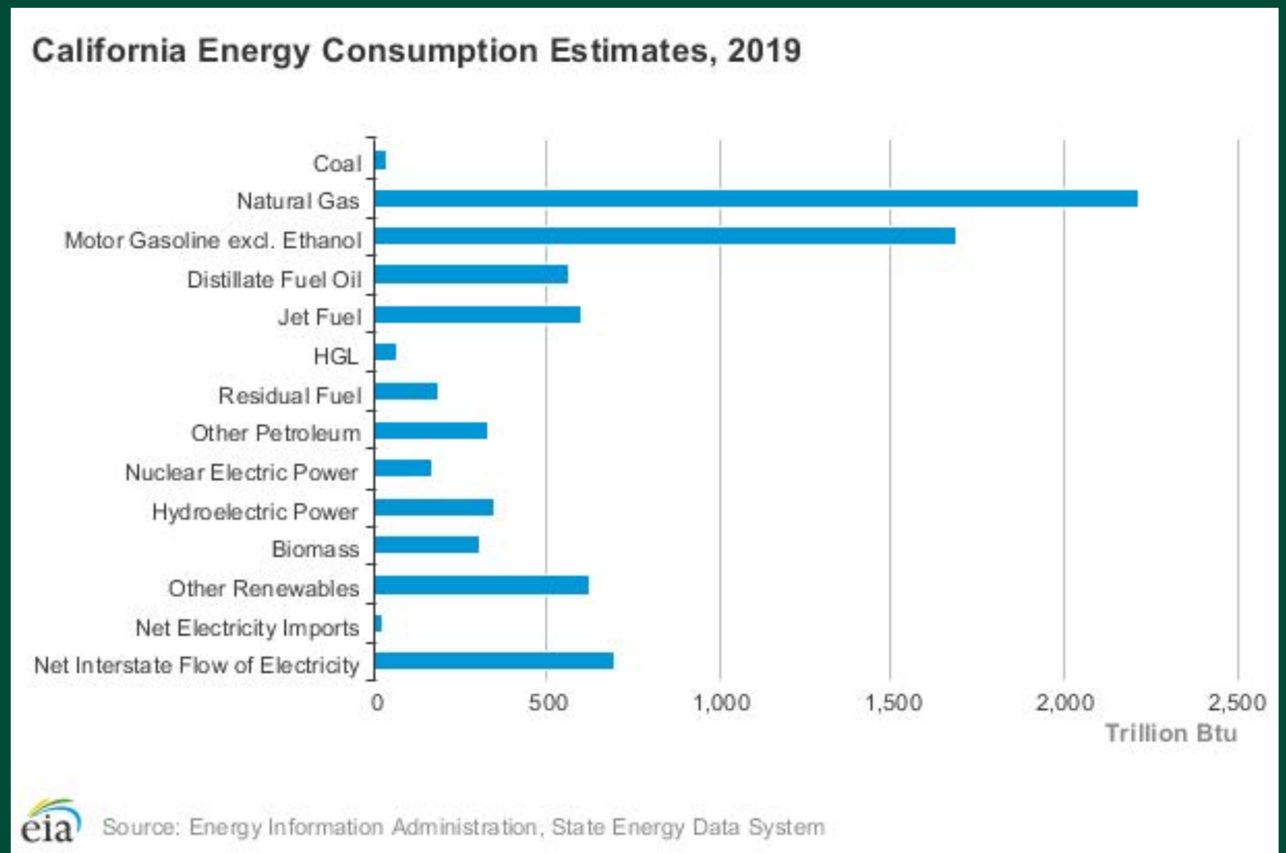


Figure 3: LiFePO4 Battery. Above is the battery that was built with 28 Cells arranged 4 in series and 7 in parallel.

IMPACT ON COMMUNITY



The intent of this project is to create a system that:

- Is scalable to different power consumption needs and uses
- Regionally specific to customers of different utility providers
- Allows for a hands-off approach for users, not requiring them to adjust individual settings to improve their carbon footprint and reduce dependency on fossil fuels
- Is robust enough to be cost-effective for consumers In lower income areas