4 Design

4.1 Design Context

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address?

Our design would potentially have a broader impact on communities in disaster relief situations, and other portable power applications. If the setup of the microgrids is more accessible, the deployment should be quicker and thus further reaching in terms of scale of the networks. With larger networks/more deployments, more people in need would be able to get the help they need. With our automation of microgrid setup and coordination, they will be able to be used by people with a variety of backgrounds and serve higher-power requirement applications.

List relevant considerations related to your project in each of the following areas:

Area	**Description**	**Our Project**
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	Increasing availability/ease of use of emergency deployment equipment by providing portable power. Increasing availability/ease of use of renewable energy deployment equipment by providing portable power.
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	The microgrids are much more environmentally friendly compared to generators as they are rechargeable and do not emit harmful gasses. The batteries used are also recycled. These microgrid pallets can act as distributed storage devices on an energy grid. When they are fully developed it may encourage moving to a distributed grid model rather than the centralized utility grid in use today. The Tactical Microgrid Standard (TMS) used as a framework for this project is in the draft stages right now, however our successful implementation may improve its development.

Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	The microgrids are designed for use with renewable power sources such as wind and solar, so they may increase the use of renewable energy in military operations. They use reclaimed batteries for energy storage which reduces electronic waste.
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	The product itself is quite expensive, our work shouldn't affect cost much compared to the cost of existing hardware.

4.1.2 Prior Work/Solutions

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

There are various products on the market that provide similar solutions in terms of generating and storing energy from renewable sources. Very few of these products are compliant to the TMS standard, which is a goal for our project.

– If you are following previous work, cite that and discuss the **advantages/shortcomings**

Pallets like this exist and the specific pallets we are working on, do function. The problem is that those pallets are not TMS compliant and they have complex interfaces that require previous experience with electricity in order to operate them. The goal of our project is to automate a lot of the pallet setup and create a simple, user friendly interface to allow anyone to use the pallets if they wanted to.

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available. Thus, provide a list of pros and cons of your target solution compared to all other related products/systems.

What our project aims to achieve is building upon these existing solutions by making them easier to configure. The interconnectivity, portability, and thus scalability of these packs/microgrids is what sets our project apart. Many solutions out there either do not support this connectivity or it is difficult to achieve.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

4.1.3 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–

The existing system contains an inverter/charger and energy storage unit with a user interface that is networked with a proprietary communications protocol developed by Outback Power.. Our design will require connection to this network and to a typical TCP/IP ethernet network, and coordination between the two.

The software we are creating must handle many different tasks, and we have divided it into several modules. One to handle user input and a graphical display, several to handle communications over the TMS network, and one to translate between user input, TMS communications, and communications over the Outback proprietary network.

2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

Communication with proprietary hardware and software protocols is difficult in and of itself. We don't have access to proprietary information for troubleshooting and/or expanding upon device functionality.

In order to implement anything, we need a strong understanding of the system and standards that are required. It takes a lot of time to sift through and digest the documentation before we can begin making informed design decisions.

4.2 Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

1. Network topology
    a. Multiple networks and protocols
        i. Raspberry Pi communication
            1. TCP/IP
            2. Tactical Microgrid Standard
        ii. Raspberry Pi to AXS Port
            1. SunSpec communication
        iii. Existing hardware communication
2. Graphic interface hardware
    a. Physical controls
    b. Display
3. Master/Slave arbitration between microgrids

The Network topology is a very important aspect of our project because it dictates how each of the microgrids will communicate with each other. All of the data that we are going to be looking at and

modifying will come from this aspect of the project so it is vital that we get it right. Graphic interface hardware will also be very important because it is how the general user will interact with the device.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.

Most of our work on the project has been looking into how the existing project hardware works. We have not made any design decisions but plan to in the coming weeks.

4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish to include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

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