Project Proposal

US Army Tactical Microgrid System Civilian Application

ECE 445
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Team 49
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1 Introduction

1.2 Objective

The Tactical Microgrid System (TMS) of the US Army Corps of Engineers is a centralized power distribution system developed for seamless deployment in areas that have temporarily lost their means of producing electricity. It is currently deployed in multiple locations, however there exists no integration for this technology in a civilian environment. Our client, the US Army Corps of Engineers, wants us to adapt this project for civilian use.

The goal for our project will be to modify the current TMS deployed by the Army Corps of Engineers to allow for initial power generation with diesel engines and then seamlessly transition to using renewable sources of energy. During this semester we will be working with both Army Corps Engineers and 2 Seniors in the Agricultural Engineering Department. Due to the increased number of stakeholders and the compliance requirements of working with the military, we must follow the administrative guidelines of all involved parties. We will develop a functioning prototype of our design that will be demoed to stakeholders that include the US Army Corps of Engineers, the ECE Department, and the ABE Department.

1.2 Background

Across the globe there are still many places that do not have infrastructure in place to deliver sustainable energy to its citizens, or the power grids in place are destroyed by natural disasters. The current tactical microgrid utilized by the military is not practical for civilian use and it is not sustainable. The purpose of the diesel generators would be to provide immediate aid, and then over time the renewable energy sources would create a more permanent energy solution. An example of this is the recent earthquakes that have struck Puerto Rico have increased the need for humanitarian aid to be sent to the areas most affected. The prototype we design this semester will be sent to Puerto Rico with a group of students over the summer. A successful prototype will directly impact the community that our first prototype will be deployed to, and showcase how it can be used to aid other communities across the globe.

At the time of writing this document, we do not have concrete knowledge of our technical success criteria nor our responsibilities in the scope of the overall project. We are currently in the process of planning a visit to the CERL facility to be formally on-boarded, which is where the project is based and where we will do most of our work.

1.3 Physical Design

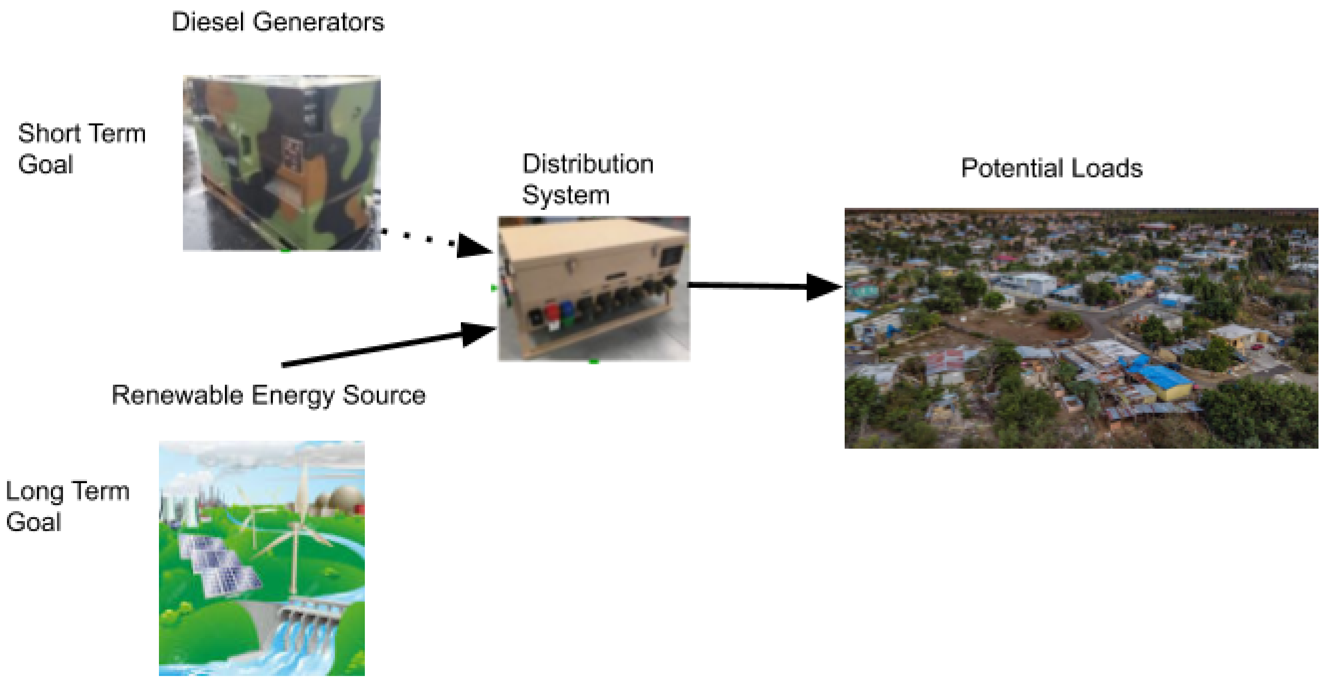

Figure 1: High Level Idea for the Physical Layout

1.4 High Level Requirements

- We must modify existing microcontroller code for diesel generators to work for other power sources, such as solar panels or hydroelectric power
- The operation of the microgrid should be simple enough to require minimal training to run and maintain; simple enough that a civilian with little to no education could setup and control the microgrid
- The microgrid must be capable of handling smart loads, while also maximizing power usage and storage, at a maximum input of 180 kW

2 Design

2.1 Block Diagram

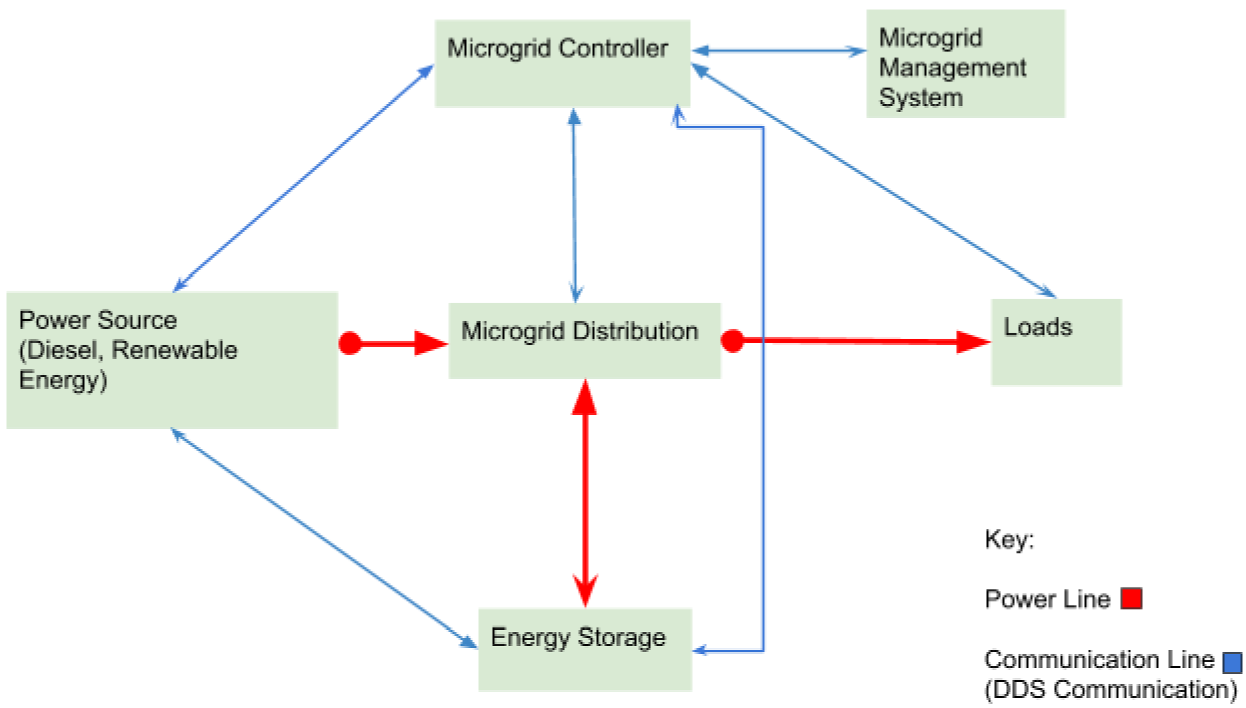

Figure 2: Block Diagram

2.2 Functional Overview

2.2.1: Power Source:

Responsible for delivering power to the microgrid. The types of power sources will be diesel generators for short term use to get electricity up and running in the area, and as an emergency backup. The long term, sustainable option will be to use a renewable energy source. The application would determine the best renewable energy source to use, for now we are looking at using either solar panels or hydroelectric power for use in Puerto Rico.

Requirements: The USACE has said that initially 3 60 kW diesel generators will be used. The USACE already has these generators, and they have modified them to fit current military applications. We will have to modify these in some way to fit civilian applications. At the time of writing this document, we have not received documentation on these generators, nor have we visited CERL to actually see these generators, so the requirements for these generators are vague. However, the few requirements that come to mind based on our initial meeting with the USACE is that these generators must be modified so that they can be easily re-integrated into the microgrid when necessary. The end goal is to use renewable energy as the source for the microgrid, and the two available sources chosen are solar and hydroelectric. This is because they are the most available and relatively cheaper than other renewable sources (wind) to install. We have to keep in mind that these microgrids will be deployed in affected areas where transportation of equipment can be difficult or even impossible by ground. This is why wind power has been excluded because the size of wind turbines make it difficult to transport.

2.2.2: Microgrid Distribution:

The distribution system converts the energy produced by the power sources so that the proper amount of power is transferred based on the loads connected to the microgrid. The distribution will also be able to add or take power from the energy storage unit depending on the energy requirements of the microgrid at a given point in time.

Requirements: The diesel generators are rated to deliver up to 800 Amps of power, so the distribution system has to be able to tolerate that level of current. Transformers will be required to bring the level of voltage down to civilian use, so 120-240 Volts. Converters will also be needed to convert the electricity from the source to DC in case civilian applications call for it. The distribution system will need to operate at all times, so a separate back-up power source will be needed in case the primary power source fails. This will most likely be a back-up battery that is charged by the primary power source. Since the microgrid will be placed in locations that are impacted by weather, this system must be robust and able to tolerate harsh weather conditions. The distribution system will need to communicate the state of the loads with the microgrid controller, so hardware will need to be installed as well with the ability to quickly let the controller know the state of the loads.

2.2.3: Microgrid Loads:

This block will be the devices that are connected and powered on by the microgrid. The types of devices connected would vary widely depending on the application of the grid and the location that the grid is being deployed to.

Requirements: The loads this microgrid will serve can wildy vary. We know the microgrid will serve civilian applications, so initially we can assume that the distribution system should be able to output 120-240 Volts to the loads.

2.2.4: Energy Storage:

One of the USACE's objectives is that the microgrid should be sustainable; this means that energy storage is needed when the primary renewable energy sources are not producing enough power to fulfil the loads' demands. Stationary batteries for renewable energy storage are not something new, but further research will be needed to figure what type of batteries are best suited for our design.

Requirements: Will need to communicate with the microgrid controller so that it knows when to turn on and start delivering power to the loads via the distribution system. Will need to be capable of being charged by the primary power sources.

2.2.5: Microgrid Controller:

The microgrid controller is in charge of communicating with all other subsystems so that the state of the microgrid can be monitored and adjustments can be made accordingly. At the time of writing this document, we know that the USACE already has a system in place, but we have yet to receive documentation on what type of hardware they are using as well as how the controller communicates with all other subsystems. The microgrid controller that we used must be compliant with IEEE standard 2030.7, which defines what the controller must be capable of managing. [3]

Requirements: The controller is the brain of the microgrid; it has to always be on and therefore will need a back-up power source in case primary power fails. This most likely could be coming from energy storage. Since the USACE would like this microgrid to be scalable, the controller needs to be able to be reprogrammed easily to account for new loads or changes in power generation (more/less diesel generators, integration of renewable energy sources). The testing of our microgrid controller must be compliant with IEEE standard 2030.8. IEEE 2030.8 has a set of testing procedures that microgrid controllers must pass for verification, quantification of performance, and how it compares to minimum requirements. [4]

2.2.6: Microgrid Management System:

The management system for the microgrid controller will be to give us a way to analyze the performance of the microgrid remotely. Also, the system is used by the US Army Corps of Engineers currently to implement cybersecurity measures to protect the microgrid systems from being hacked.

Requirements: Since cybersecurity is one of the USACE's concerns, this system will need to be robust enough so that it can withstand cyber attacks from threats since it will be hosted on a remote network, separate from the microgrid network. This system is for monitoring purposes only, so there should be no communication back to the grid from this system. On the flip side, the connection between this network and the microgrid network must be robust enough to tolerate physical harm.

2.3 Risk Analysis

The block that will prove to be the the most difficult to get correct will be the microgrid controller. Being able to control how energy is being stored, distributed, and drawn from the energy source will be the key to the successful operation of the microgrid. The controller will have the greatest responsibility, as it will be constantly monitoring the loads that are connected to the grid, which will determine how power will be distributed to each of the loads efficiently. The controller will also be responsible for determining how much energy the microgrid is capable of storing depending on what power sources are being used at the time, whether it is the diesel generators or a clean energy source, and how much power is required to power all connected loads. The efficiency and safe operation of the microgrid will hinge on the success of the controller being able to actively read in the data that it is fed and respond accordingly to ensure power is being utilized properly.

3 Ethics and Safety

The high power levels of our microgrid can lead to serious safety concerns if care is not taken. Each individual diesel generator that we will be utilizing will output power as high as 60kW, with a current limit of 800A. Extreme caution will have to be taken to ensure that the generators, and the grid as a well, is operated in as safe of conditions as possible. Another safety concern that must be taken into account is that the end user of this product will be someone who receives minimal training to run and maintain the microgrid after the initial setup. This means that we must provide clear instructions on how to operate the microgrid, and also place safety measures to block any extreme hazards that should not be approached during operation.

Using diesel generators also leads to another safety risk for the individuals around them during operation. The diesel generators will give off toxic fumes, mostly in the form of carbon monoxide, so it will be essential to make sure that the area that has these generators are sufficiently ventilated to lessen the risk of breathing in the toxic gas. Also the diesel fuel is highly flammable, which will be that this fire hazard must be monitored to ensure the fuel is not unintentionally ignited.

The renewable energy source that is used to take over for diesel generators to make the microgrid more sustainable will also bring up safety hazards as well. The type of renewable energy source used will be based on the environment that the microgrid will be deployed in, but all of the renewable energy sources will be capable of high and extremely dangerous levels of voltage and current that can electrocute an operator.

An ethical issue that our project will face is the pollution caused by running diesel generators. We have an understanding that diesel engines in this capacity are not sustainable in areas with minimal power grid infrastructure in place, which is why renewables energy sources must be capable for our microgrid so that the diesel energy source will serve the purpose of being a back-up power supply in case of emergency. This is in accordance to the IEEE code of ethics, #1, "...to disclose factors that might endanger the public or the environment." [2].

Another ethical issue that our project will face will be that we must have detailed documentation for safe operation of the microgrid. The assumption that we are under is that the individuals using the microgrid long term will not be an experienced technician. According to the IEEE code of ethics, #5, we are responsible "to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies…" [2]. This means that we must have clear instructions on how to initially train and operate the microgrid once the system has been deployed, as well as make sure the end user is clear about the purpose of each component and how to safely operate the equipment.

References:

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[2] ieee.org, "IEEE Code of Ethics", 2016. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 13- Feb- 2020].

[3] IEEE Standard for the Specification of Microgrid Controllers," in IEEE Std 2030.7-2017 , vol., no., pp.1-43, 23 April 2018

[4] IEEE Standard for the Testing of Microgrid Controllers," in IEEE Std 2030.8-2018 , vol., no., pp.1-42, 24 Aug. 2018