Senior Design Project Proposal

1 Introduction

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General Goals:
The general goals of this project are:
- To understand the functioning and simulate a smart microgrid system.
- To understand and design an efficiency energy generation model that takes into account
- To understand the functioning and use of wireless, notably Wifi communication with a microcontroller.
- To understand the principles of power taken into consideration to charge a battery bank and simulate a charge controller.

2 Problem Description

In many places, large grids have been unreliable or non-existent which calls for the use of microgrids. These are smaller scale grids that offer more modularity, reliability, savings (in terms of costs) and control to the user. Given the fact that microgrids are generally not powered by a utility company, in order to ensure access to energy, the system is usually accompanied by a battery bank. To ensure the longevity of the said battery banks, the individual batteries must not be overly charged or overly discharged as specified by its manufacturer.

Because of the efficiency and savings character of a microgrid, there are generally several sources to supply power to the system. Depending on the conditions at hand, it is more efficient or economic to generate power from different sources. These may include (but are not limited to) a solar array, wind turbines, and a gas-oil powered generator.

3 Proposed Solution

The proposed solution for this project is to emulate a smart system by reproducing a charge controller to which a load, a battery bank and some charging sources are connected. The charge controller prevents the battery from being overly charged or discharged by frequently checking its voltage. The charging sources will include a solar module, a small wind turbine and a small generator. We will have different sensors to check insolation and wind intensity, in addition to a program embedded into our microcontroller that performs efficiency calculations, to determine which charging source is the best one at a given time.

4 Demonstrated Features

The features we plan to be able to demonstrate is to have:

1) a variety of renewable sources and conventional sources powering a battery bank: solar, wind, and generator. With this, we will take measurements of environmental patterns, such as the amount of sunlight and wind speed, and by performing an efficiency analysis with a program, we will determine which power source will best charge the battery bank at that time period.

2) In addition to this intelligent system, we want to gauge the voltage level of our battery bank to determine when charging should commence and when it should halt.

3) Furthermore, the communication between the measurement tools and the central smart-grid computer system will be wireless. In this way, the measurement tools can be remotely placed and close to the generation sources while the computer system that gauges how much charge the battery bank has (through voltage measurements) and tells which generation sources should power the battery can be placed in an environmentally-protected, interior location.

5 Available Technologies

- Multimeter **($0)**
- IRF3205 mosfet -switch to vary duty cycle **($6.88 for 5)**
- SainSmart 4-Channel Relay Module (for connections and disconnections of sources) **($9)**
- Galileo2.p microcontroller **($45)**
- Wifi transmitters and receivers. **($75)**
- Anemometer equipped with a transmitter (to measure wind speed). La Crosse Technology TX-23U **($44.95)**
- 6 V UPG UB645 Sealed Lead Acid Battery **($12)**
- Solar radiation sensor for VantagePro2 (wireless) **($150)** (to measure sun radiation).
- Small DC power supply accompanied by a DC-AC inverter to convert the current from DC to AC. (We can use a DC power supply and an inverter from Dr. Ken Sauer's Village Project- see **Figure 1** below). **($0)**
- Variac Variable Transformer. (to simulate AC wind power). PHC Enterprise- SC-3M **($65)**
- Generator (from Dr. Sauer's Village Project- see **Figure 2** below). **($0)**
- Small system to represent the loads (to this end, we can use the campus electrical maquette in Dr. Sauer's Village Project- see **Figure 3** below). **($0)**
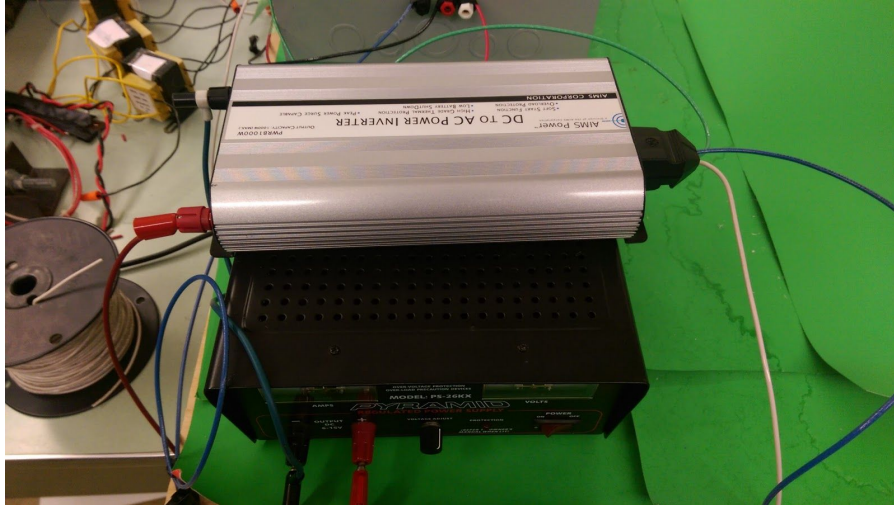
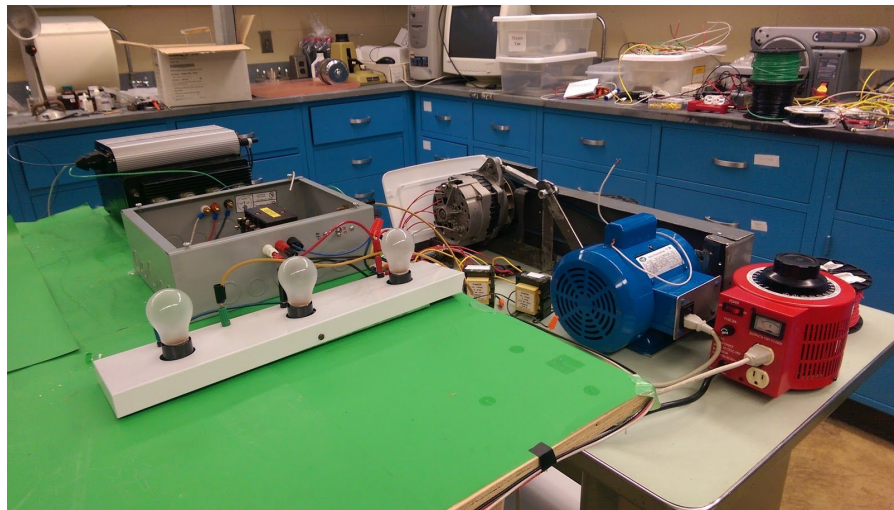**Figure 1-** DC Power Supply and Inverter to simulate solar power.

Figure 2- Generator at our disposition for our Senior Design Project.
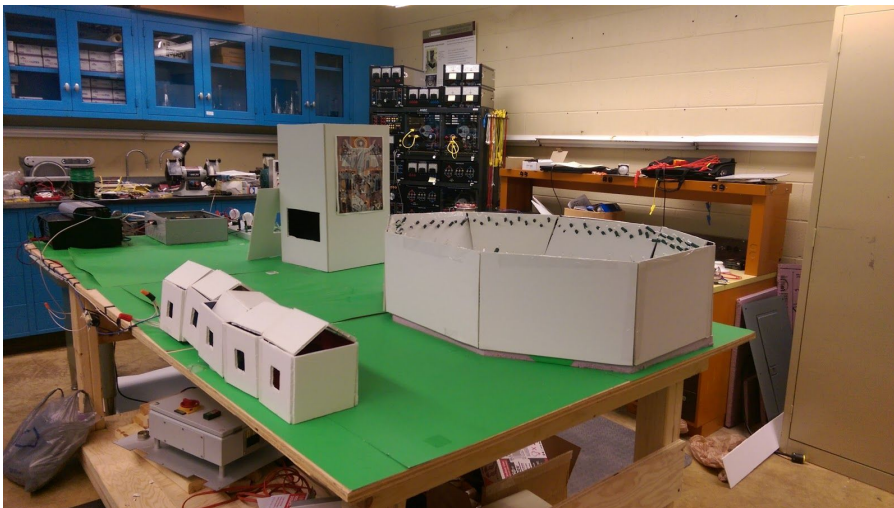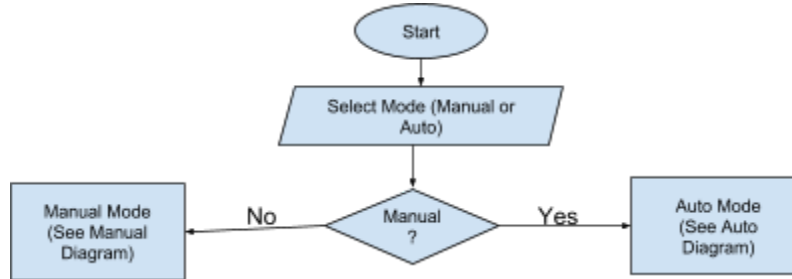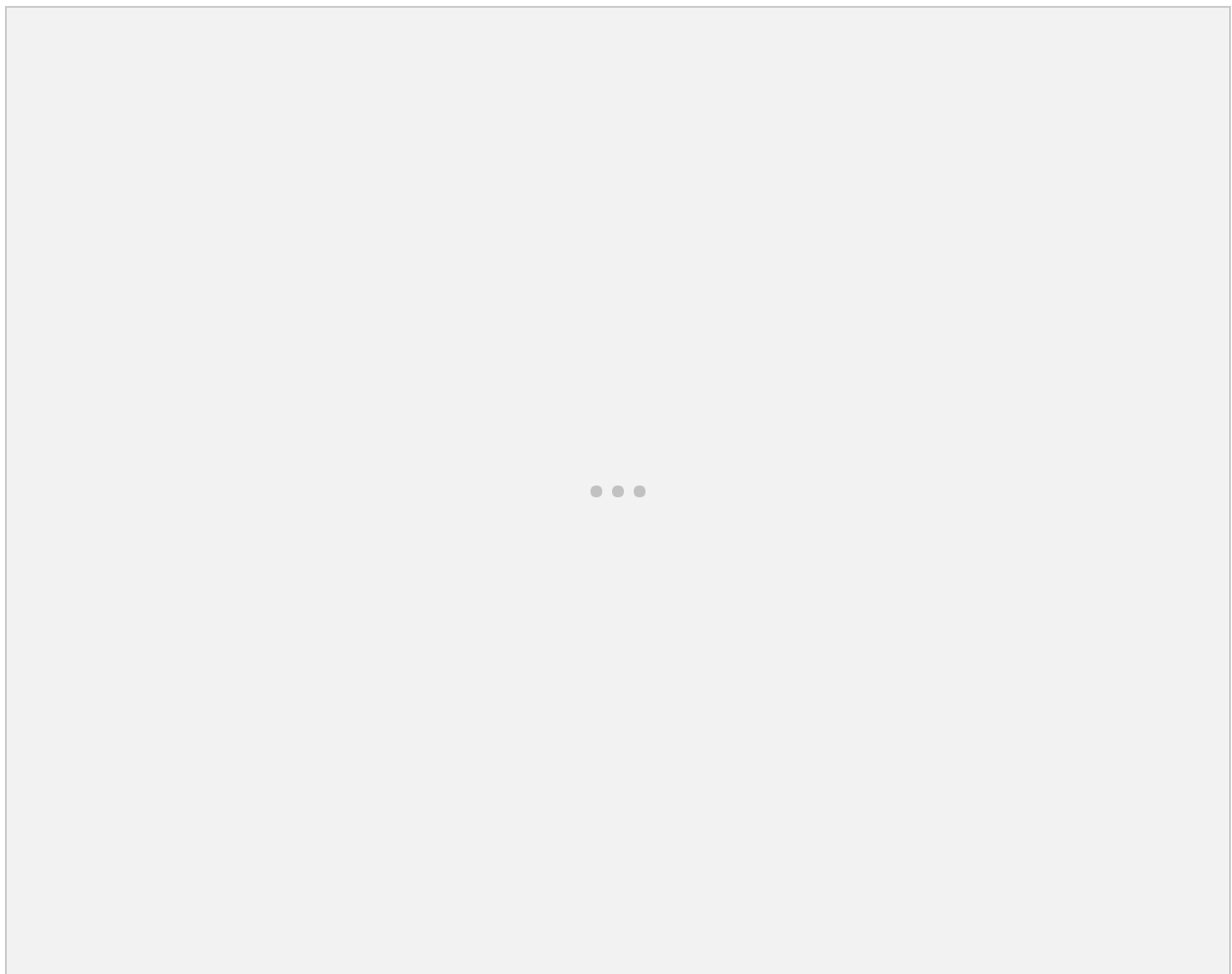

Figure 3- Campus Electrical Maquette will serve as our load.

Software High Level Diagram

Below is the high level diagram of the program that will be embedded into the microcontroller

Start of Program

Automatic Diagram

* Note that once the load becomes disconnected because the battery is undercharged (low voltage level), even if the battery becomes charged again, the load has to be

turned on manually, as is done in most real applications.

6 Engineering Content

- Control of charging current
- Limiting the voltage and ending the charge cycle at the appropriate time
- Design of thermal shutdown to avoid potential catastrophic events
- Lots and lots of work with spec sheet and controller schematic
- Wireless communication between sensors and charge controller
  - Possibly also between voltmeter and computer to perform power consumption calculations at the load.

7 Conclusions

The idea is to keep the power generation in Dr. Ken Sauer and Dr. Bernstein's lab in Fitzpatrick and be able to move around with our sensors that will communicate with our hub remotely (through wifi).

This project will combine our knowledge from microgrid performance (implementation of energy generation efficiency, modularity and control), wireless communication and power (to control the charge controller) into a final synchronous product.

The main modules are:
- Design of a program that performs energy efficiency calculations and determines when a particular power source should be connected or disconnected to the battery bank. This program will also determine when the load should be disconnected from the battery bank.
- Wireless communication from the different sensors to the hub.

Potential additional modules:
- Voltage and current measurements at different nodes to display on a computer screen.
- These measurements can in turn be used to calculated power consumption at the load.
- PWM charge performance
- Measure battery temperature & shut down at given level.