**Emergency Power Station**

**Senior Design Project Proposal**

**James Benner**

**Chen Chen**

**Andrew Dolan**

**Ryan Loos**

**Everistus Obiakor**

**INTRODUCTION**

As a part of the electrical engineering curriculum at the University of Notre Dame, senior electrical engineers are required to take a year-long Senior Design course. The main focus of this course is to act as a capstone course encompassing all of the knowledge one has acquired while studying electrical engineering. To do this, teams of 4-5 students select a design project to work on that solves a real world problem and that allows them to use both creative and in depth engineering skills. For our project, we have decided to design an emergency portable power station. This document will detail the problems we will attempt to solve with this project and propose an engineering solution.

**Problem Description**

We seek to solve the problems of relatively limited battery life of today's smartphones, limited availability of AC electricity from a typical wall charger, weak signal strength, and other problems that arise in emergency situations. Cell phones are especially important in situations such as emergencies, road trips, hiking, blackouts, etc., and access to a renewable and sustainable charging source in these situations would prove to be very valuable. In addition to the problem of limited battery life, we plan on addressing other problems that could arise in emergency situations such as knowing the date, time, your location via GPS, and access to an AM/FM radio.

**Problem Solution**

The emergency unit we plan to design and build will be a compact, affordable and durable solution to the aforementioned problems. We plan to use solar panels and a mechanical crank as our two power sources. The unit would have rechargeable batteries for storage, and a USB port as charging interface. The unit would have a small screen to display the time and the location as well as an AM/FM radio with the possibility of access to weather alerts.

# Demonstrated Features

* Battery – The rechargeable battery is the heart of our device. It will allow energy input from a wall, from our solar panel and from our mechanical crank. The battery will power the native features of our device, and will be able to charge other devices through a USB cable. We have not decided what type of battery to use yet as we must test the cost efficiency of each type, but considerations include nickel cadmium, nickel metal hydride, lithium ion, and lithium ion polymer.
* Solar panel – One of the alternative energy sources of our device. The solar panel will charge our battery whenever light is present. Diodes will prevent energy from being drained from the battery in darkness.
* Crank – Our other alternative energy source will be a crank that allows for the transformation of mechanical energy to electrical energy. This will have different adaptors which will allow for different methods of generating energy. Two possible such adaptors will be a handle for hand charging and a set of pedals to charge the battery with one’s feet.
* USB charger – USB cables and ports are ubiquitous in today’s technology. Most all portable devices can be charged in a USB outlet. By putting a USB outlet in our device, it will be able to charge most anything from cell phones to iPods. This will require internal logic to detect the amount of charge a device currently holds so as not to overcharge the device. The USB port will be powered by our battery.
* Clock – A simple clock will be powered by our battery. The clock will be a seven segment LED display capable of displaying the time of day, and whether it is currently AM or PM.
* Radio – an AM/FM radio for determining weather and other conditions. Includes a speaker as well as controls for frequency and volume.
* GPS – A microcontroller device with an LCD readout which displays latitude and longitude coordinates to the user. This will allow for the determination of location in case of an emergency situation in which the user is in contact with a rescue team.
* Light – A simple LED flashlight driven by the battery.

# AVAILABLE TECHNOLOGIES

Battery:

In order to create our device, we need to use a battery that:

* Is rechargeable.
* Can be charged and discharged multiple times without damage to battery life.
* Is affordable.
* Is lightweight.

We were able to find data on a number of different battery technologies. The leading technologies for our purposes are Nickel-Cadmium, Metal-Nickel-Hydride, and Lithium-Ion. In addition, there are a number of variants of Lithium-Ion. The following statistics were taken from the Cadex website, a company specializing in battery charging and analyzing equipment.

|  | NiCd | NiMH | Li-ion cobalt | Li-ion Manganese | Li-ion Phosphate |
| --- | --- | --- | --- | --- | --- |
| Specific energy density (Wh/kg) | 45-80 | 60-120 | 150-190 | 100-135 | 90-120 |
| Internal resistance (mΩ) | 100-200 in a 6V pack | 200-300 in a 6V pack | 150-300 7.2V | 25-75 per cell | 25-50 per cell |
| Cycle life (80% discharge) | 1000 | 300-500 | 500-1000 | 500-1000 | 1000-2000 |
| Fast-charge time | 1h | 2-4h | 2-4h | <1h | <1h |
| Cell Voltage (V) | 1.2 | 1.2 | 3.6 | 3.8 | 3.3 |

Because our users will be constantly charging and discharging our battery, we must prioritize cycle life, or how many times the battery can be charged and discharged. At this point, Li-ion Phosphate seems to be the best choice of battery because of its long cycle life. There are drawbacks to this as this battery does not hold the greatest amount of energy per kilogram. While this will be our initial choice for a battery, we will continue to explore possibilities for batteries as we discover which technologies are commercially available and at what cost.

Solar Cell:

We chose to incorporate a solar cell into our design to allow users to have a way to charge their emergency station if they are taking it with them. If users are going camping or just taking it on a trip, they will not have to worry about the device running out of power.

When looking at different solar cells, the most important specification is the output power. Depending on what size voltage battery we decide for a power source, we will want a solar cell that is capable of charging up the battery in a reasonable amount of time. In order to determine how long it will take a solar panel to charge up the rechargeable battery, take the output power of the solar cell and divide it by the voltage of the battery to determine the current being provided to the battery. Next, take the capacity rating of the battery and divide it by the current going to the battery to determine the time in hours that the battery will take to charge completely provided the solar cell is outputting at its maximum power.

The table below is a comparison of different battery types to different wattage solar cells as well as a comparison of their price. Since we want out product to be small, light, and portable, we would like to have a solar cell that is also not too large but can provide enough power to charge the battery in a reasonable time.

|  | NiCd | NiMH | Li-ion  Cobalt | Li-ion  Manganese | Li-ion  Phosphate |
| --- | --- | --- | --- | --- | --- |
| Voltage (V) | 1.20 | 1.20 | 3.70 | 3.70 | 3.20 |
| Capacity (Ah) | 0.60 | 2.65 | 2.55 | 1.40 | 0.60 |
| Current from 1W SC to Bat (A) | 0.83 | 0.83 | 0.27 | 0.27 | 0.31 |
| Current from 3W SC to Bat (A) | 2.50 | 2.50 | 0.81 | 0.81 | 0.94 |
| Current from 5W SC to Bat (A) | 4.17 | 4.17 | 1.35 | 1.35 | 1.56 |
| Time for Recharge w/ 1W SC (h) | 0.72 | 3.19 | 9.44 | 5.19 | 1.94 |
| Time for Recharge w/ 3W SC (h) | 0.24 | 1.06 | 3.15 | 1.73 | 0.64 |
| Time for Recharge w/ 5W SC (h) | 0.14 | 0.64 | 1.89 | 1.04 | 0.38 |

The main cost of the solar cell will depend on the wattage we choose and the size of the cell. The system should not need that massive of an amount of power so we can probably get by with a solar cell no bigger than 5W since the longest charge time of any of the batteries at a 5W its about 2 hours which is reasonable but ideally we would like to have it closer to an hour or under an hour if possible. A 5W solar cell should cost us no more than $30.

Crank:

The crank will consist of a hand/foot crank that is connected to a generator that converts the mechanical energy into electrical energy which is then in turn used to charge the battery. We can find a DC hand crank/generator that goes for $19.99.

USB Charger:

The USB charger would be used to charge any device that charges via USB so the user could charge their cellphone while on the go. To make a USB charger, we would need a solder ($1), a rectifier diode ($0.15), a Zener diode ($1.59), a USB A/A extension cable ($6.99) and some heat-shrink tubing ($1.17).

Clock:

The clock would let the user know what time it is and possibly include an alarm/timer function. We can use the clock built into the microcontroller and use that to create the logic to display the clock on a small LCD screen which should only cost no more than $5.

Radio:

The radio will be an AM/FM radio that may also include a weather radio setting to get weather updates. In order to build a radio, we will need miscellaneous transistors, resistors, capacitors, and an amplifier all of which should not be all that expensive and probably cost less than $5 total.

GPS:

A GPS locator would be nice to include in our project provided we have the time to include it. This would allow emergency responders to locate the device and hopefully the user if ever needed. GPS receivers generally consist of an antenna ($6), receiver-processors ($0.5), and a highly stable clock such as a [crystal oscillator](http://en.wikipedia.org/wiki/Crystal_oscillator) ($1). They may also include a display ($3) to provide information to a user.

Light:

An LED flashlight will allow users to see in the dark if they need to use the device when they power is out or they are outside in woods at night. The only parts needed are white LEDs, a resistor and a switch which together should cost about $5-$10 depending on how many LEDs we want to use and how bright we want the flashlight to be.

# Engineering Content

The major engineering content of our project will be to integrate all the above mentioned devices to create one working product that satisfies all the needs of the user. In addition to designing each of the systems for the clock, radio, USB charger, solar power, crank power generator, and possibly GPS locator, we will also need to design an easy to use and appealing user interface. We want try to design the device to be small and portable so people can take it with them on the go so since you never know when you may need it for an emergency. Another main engineering concern is the dissipation of power through the device. We need to design the way the charging system works and how power is delivered from the battery to the different systems by using the microcontroller and interfacing it with the user interface buttons and LCD screen.

**CONCLUSIONS**

Our Senior Design project incorporates a lot of the knowledge we have learned over the years in our EE classes. It also allows us to take a handful of different systems that we may have either dealt with in the past or have a basic understanding of how they work and allow us to interface them together into one product. This project will serve two main purposes: a satisfying apex to our EE undergraduate studies and the creation of a consumer product that can be a solution to real world problem. Although this may be the end to our undergrad studies, it is only just the beginning of our lives as engineers and solving real world problems, which in the end is the most satisfying part of being an engineer.