Initial Project and Group Identification Document

Senior Design I

EEL 4914

Off-Grid Clean Energy Power Generation

Group

Pablo Pozo (Electrical Engineer)

Patrick O'Connor (Electrical Engineer)

Cory Bianchi (Computer Engineer)

Steban Ossa (Electrical Engineer)

Sponsor:

Dr. Alvin Wang

Project Narrative Description:

The motivation for the clean energy power generation project comes from having the desire to help others, set new standards and the excitement to solve a real world problem for our senior design project. We believe that our group is the perfect candidate to carry out this project. Our team is composed of individuals that are leaders and understand the concept of working as a team. As good leaders we have stepped forward to deliver this project to the best of our ability. The reason we have selected this project is because we know that we can put our skills, work and get the reward to help others. There are South African villages that have no food, education, or electricity. The purpose of this project is to be able to provide clean energy at low cost by ensuring high efficiency, low maintenance, safe to operate, user friendly and inexpensive to repair. This project will open new frontiers for the South African people to have a better life style and be able to start an education through a recreation center. The goal of the project is to generate, store and distribute energyit to the recreation center.

In order to meet our goal we will need two power generation sources. The first source is a solar panel that will capture light energy (photons) from the sun to create electricity through the photovoltaic effect. This panel will be placed strategically on a structure so it can absorb direct sun light at its maximum. The limiting factor for a solar panel is the amount of sun light that it can collect during the day. In order to counter this issue we will use a wind turbine to compensate when the sun is not present to ensure energy is still being produced. Wind turbine converts kinetic energy from the wind into mechanical energy to produce electricity. An additional feature of adding a backup generator can be added based on funding. The backup generator will help if there is a situation where there are prolonged cloudy days with limited winds. The diesel DC backup generator will have a dual purpose for when the system won't produce enough energy and in case of system failure. Before storing the power into the battery bank, a controller to regulate the amount of power that goes into the batteries is needed. Also, the controller will be responsible for stopping the charging of the batteries when they are fully charged; diverting the energy directly to the inverter. This will maximize the energy produced while at the same time maximizing the life time of the battery bank. The way it maximizes the life of the battery bank is by reducing the number of charges and discharges. Also, the battery bank will stay fully charge for when the sources are not producing sufficient energy. The size of the battery bank will depend on the amount of energy required to be stored. The type of battery required for the battery bank is a deep cycle battery. This type of battery is designed to be regularly discharged for most of its storage capacity. Golf cart batteries are designed in this manner and they are low cost, light weight, and very efficient.

In order to maximize the voltage and amps from the batteries we will connect the batteries using a series-parallel combination. Connecting batteries in series will help us achieve the desired voltage and connecting the batteries in parallel will give us higher amperage. Since safety is a critical of our project we will use catastrophic battery DC safety fuses on all the positive battery terminals to prevent serious damage if the system is shorted. Additionally, the battery bank needs to be sheltered to protect it from extreme weather conditions, but at the same time it needs to be well ventilated. After we have stored the energy we can split the system and have the ability to supply DC and AC. DC power can be drawn directly from this stage as needed for DC components. To provide AC power we need to convert DC power into AC. In order to conversion into AC we will need an inverter. The inverter is an important component in the system because it will ensure the stable AC output voltage going to the house. A battery powered inverter is necessary since it will be powering itself from the battery bank. Other features to consider are the maximum load that will be used, maximum surge required, AC output voltage required, input battery voltage, and maximum continuous output in watts. Once obtained the desired AC output the power will be fed to a distribution panel. The distribution panel will contain AC circuit breakers since the input is now AC. This is important because it protects the power generation system in case there is a malfunction in any of the circuits of the building. In order to distribute the AC power to the house it is critical to select the correct wire gauge to prevent overloads and avoid fire hazards. Once the distribution stage has been completed, an evaluation of the devices being used as loads is necessary to ensure the most energy efficient products are being used. For example, incandescent bulbs consume use as much as 4 times more energy than compact florescent bulbs. Since the amount of energy that we can produce is limited it is a smart decision use energy efficient products.

Specifications and Requirements:

As previously discussed, the average power consumed by a house in the United States will be used as reference to determine the required components. Adjustments will be made once we will receive more specifications from the customer to provide an accurate figure. Based on internet resources, the average power consumed by a household in the United States is about 600 watts-hours. If we multiply this figure 600 x 24 = 14,400 Watts-hour per day. Rounding down this figure we will need to produce 14KW per day to achieve continuous power.

Calculating total panel size

On average a solar panel can generate their maximum power for 5 hours. The amount of power it can generate per sq-inch is 70mW. To obtain the total amount of maximum power that we can produce each day we multiply 70mW x 5h = 350 mW-h. To calculate the size of the panel in sq-inches we need to divide $\frac{14{,}000W}{0.35W}$per sq-inch = 40,000sq-inch. Converting that into sq-ft gives us a total of 278sq-ft which is the area.

Calculate the number of panels needed

To calculate the amount of panels that we need to know the solar radiation energy. In Southern Africa peak sunlight hours ranges from 4.5 to 6 depending on a specific location. The minimum value will be used to cover every region of the country. Also, the amount produced by the panel is required. A CHSM 6610P module 240-watt module will be used for calculation purposes.. Since we need to produce 14KWh per day we will divide $\frac{14{,}000W}{4.5\ hours}$ = 3,111 W. It is necessary to take into account 20% for inefficiencies so 3,111*0.2 = 622W. Now, adding both figures

3,111+622= 3733W we get the total power required daily. To obtain the number of panels we divide $\frac{3{,}733W}{240W}$ = 15.55 or 15 panels.

Wind turbine

In order to decide the kind of wind turbine we need it is necessary to know the wind conditions of the location. South Africa wind speeds range from 12 to 13 mph. Wind turbines that can support the solar panel generate power when the sun is down is an Air breeze 48VDC land turbine. The Air Breeze Land produces 48 VDC and it starts producing power at a wind speed of 6 mph. It can produce up to 38KWh per month at 12 mph.

Wind and solar charge controller board

A wind and solar charge controller board is essential to limit the rate at which electric current is added to electric batteries. It prevents overcharging, against overvoltage, and may pose a safety risk. It also prevents the batteries from completely discharging, to protect the battery life. It is important that batteries do not get discharge below 50% otherwise it will greatly reduce battery life. As mentioned before one of the additional features was the controller having the capability to disconnect the batteries once fully charge and divert directly to the inverter to consume excess energy. This feature will increase the price of the project but at the same time it will make the system much more efficient.

Battery bank

The battery bank will be built using L16 size deep discharge battery with 6V at a capacity of 350Ah. In order to figure out the number of batteries needed the following calculation is required. First we need to know the amperage the panel produces. The solar panel used as an example in the calculating the number of panels produces 8.13A. Now, multiply the number of panels times the current 15 x 8.13A = 121A the result obtain is the total output amperage. Next, we multiply the total amperage times the number of hours 121A x 4.5h = 548Ah which is the total of amp hours produced in a day. From previous discussion it is known the batteries should not drop below 50% charge to preserve their lifetime. Taking the 50% into the calculation will ensure that we protect the life of the battery. The next step is to multiply battery amperage by 50% because that is all we are going to use in order to protect the battery 350Ah x 0.5 = 175Ah. Now we take the total amp hours and divide it by 50% of the battery amperage $\frac{548Ah}{175Ah}$ = 4 which is the total battery sets. Multiplying the number of batteries by the amperage capacity 4 x 350Ah = 1400Ah which is the total amperage we need to produce. In other words, a set of 4 batteries in series will produce 24V and four sets of these in parallel will give us a total of 1400Ah. See figure 1 to have a better visual of battery configuration.

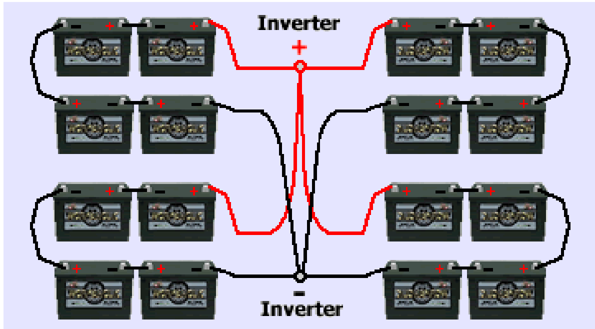


Figure 1. Battery Bank Configuration

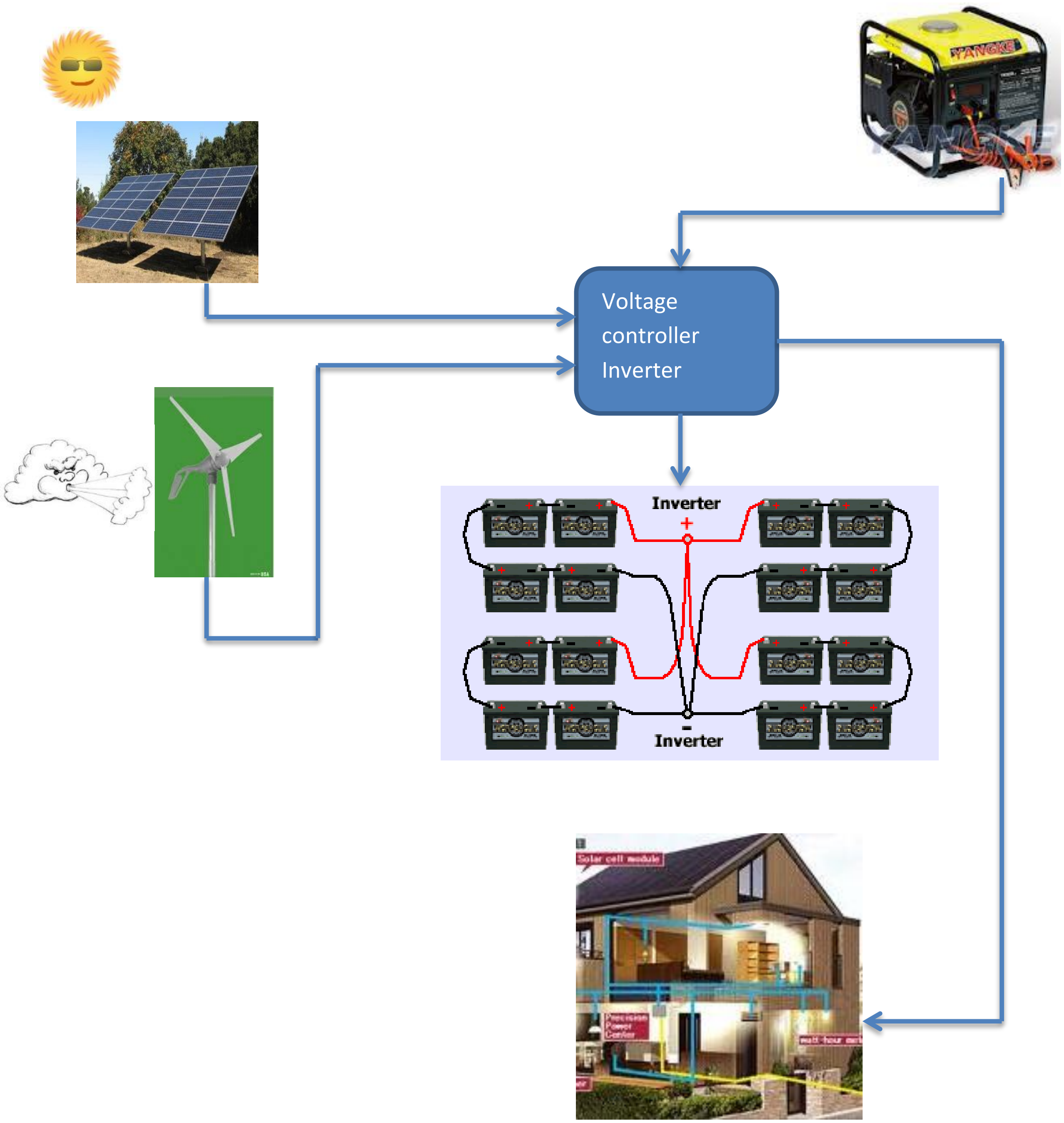
Inverter

The inverter is the heart of the wind-solar system because it converts the low voltage DC to the 120V AC that most appliances run on. There are two types of inverter that are recommended a modified sine wave and a true sine wave. A modified sine wave is probably the most popular inverter in the market for the price and reliability. The modified sine wave works great with most demanding applications with the exception of appliances that use motor speed controls or timers. The alternative is a True Sine Wave power inverter that is compatible with practically any type of AC equipment. Many True Sine Wave power inverter are computer controlled and will automatically turn on and off as AC loads demand power. When no AC components are running the inverter shuts itself of to preserve energy from the batteries.

Wire Sizes

Estimating the distance will be 30 ft. from the panel to the battery bank we will require a 12-guagevwire. The power inverter and the batteries require the largest wires in the system. The length of this wire should not exceed 6ft to reach the battery. Largest possible size wire will be need for this section due to the amount of amperage drawn by the inverter from the batteries.

Block Diagram



Budget and Financing

The figures on the budget sheet are based on average power consumption on a house in the United State. Once we get more details on the project will be able to make the necessary adjustments to have a more realistic price.

Wind Solar Hybrid System

Item	Quantity	Unit Price	Total Price
Solar Panel	15	275	4125
Wind Turbine	1	320	320
Voltage Controller/ Inverter	1	700	700
Battery	16	290	4640