Concept of Operation – Outline

1. Executive Summary
   * Generating clean energy is an important goal to many in this day and age. The purpose of this project is to create a functionally independent power grid capable of generating power from a solar cell system. This grid will be able to power both AC and DC consumer devices such as computers and smartphones while simultaneously charging a battery integrated in the system. A key component of this system will be the ability to switch to battery power in cases where the solar cells are not generating enough.

2. Introduction

2.1. Background

* The Earth’s temperature will steadily increase and eventually be too warm to grow crops and increase the risk of more frequent and heavier rainfall, snowfall, and other types of precipitation. A recent example of severe precipitation was the snowstorm on February 13th in Texas which caused 4.5 million homes to be without power and caused the worst energy infrastructure failure in its history.
* As a result, a need to switch from relying on fossil fuels to relying on renewable energy has emerged due to global warming and its effects. There are many types of renewable energy sources that are being used today to make the switch from fossil fuels with a United States goal of producing 100% clean energy by 2050. Of these is solar power, or energy that is harnessed from the sun which is our team's main focus. Solar energy is one of the top three most popular renewable energy sources today since they are easy to install, predictable, require little maintenance, and don't use power to operate.
* Our team’s solar powered independent grid aims to showcase these advantages through solar energy’s reliability, effectiveness, and wide range of applications . This system will be able to monitor the sun for optimal power harnessing during peak sunlight hours and switch to battery power when interferences occur. With this architecture, the user will be able to charge their devices even when the sun is not out, providing cost effective alternatives to their current power sources.

2.2. Overview

* Our system will use a Maximum Power Point Tracking (MPPT) algorithm to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel under varying conditions. This will optimize the power output of the solar panel so the battery can be charging while the user is charging their devices. If the PV panel is under varying conditions or there is no sunlight, the system will switch to battery power so the user’s devices will still receive power. Additionally, the algorithm will constantly send data to the backend database so that it can be stored and monitored using a website. The purpose of the website is to funnel and display the data received from the solar panel such as a graph of the peak harnessing times throughout the day, the current power storage of the battery, maintenance of the solar panel, whether the system is in charging or in discharging mode, and if there is devices connected to the system.

2.3. Referenced Documents and Standards

* (need research to fill this in - Description : link )

3. Operating Concept

3.1. Scope

* The solar/battery power system aims to provide a source of renewable energy, using solar energy to charge common electronic devices such as cell phones and laptops. The DC electricity generated by the solar panel flows through a DC-DC converter which acts to convert the input voltage (12 Vdc) to the desired output voltage (120 Vdc), while also charging a battery that will be used when not enough power is being generated by the solar panels. A maximum power point tracking system will be used to monitor the output of the solar panels and switch to battery when necessary. A DC-AC inverter is used to convert the DC electricity (120 Vdc) to AC electricity (120 Vac), allowing the use of the electrical grid. (need to add more) (something about website/database)

3.2. Operational Description and Constraints

* This power grid system is intended for use by consumers to store and generate consumer usable power and present this data to the user via website with the ability to use the stored power in situations in which adequate power is not generated from the solar panel. Listed below are the constraints for this system.
  + The budget for the project is $400
  + The system must be able to tolerate outdoor temperatures from -15 degC to 50 degC
  + Must be placed in light to generate power, stored power will only last so long.
  + The grid can only handle so many loads?

3.3. System Description (pls write in what your subsystem does when you have a chance!)

This solar power system will consist of four distinct subsystems; a max power point tracking system, a DC-DC converter, a DC-AC inverter, and a website/database. Detailed below is each subsystem and a short description of what they do and how they work.

* Mppt system - This subsystem regulates the power and voltage (PV) output between the solar panel and the battery. Specifically, it will consist of a microcontroller and sensors to monitor the output of the solar panel. If the solar panel is not producing enough power the output will be switched to the battery.
* DC-DC converter - This subsystem is dedicated to converting the input voltage to a desired output voltage. More specifically, the subsystem will draw altered voltage and current from the solar cells and boost the voltage to 110V while reducing the current using a boost converter and a feedback loop to ensure the proper gain is met and output voltage is stable.
* DC-AC inverter - The inverter acts to regulate the flow of electrical power. It switches the direction of direct current (DC) electricity, which the solar panel generates, back and forth very rapidly, hence converting it to alternating current (AC) electricity, which the electrical grid uses.
* Website application - This subsystem is going to be created using Angular. Angular is an IDE for website design, allowing for the user to combine the necessary languages (HTML, CSS, TYPESCRIPT) all into one folder. This website will show the user the data from the solar panel harnessing algorithm, sensor for the current power in the battery, if the system is in discharge or charging mode, and the devices that are connected to certain ports. To gather this data a free or cheap backend database such as Firebase or AWS will be used.
* Switch control - This subsystem will control when the system will draw power from the solar cell or the battery. If the solar cell is not delivering sufficient power, this controller will switch the system such that power will be directly drawn from the battery.

3.4. Modes of Operations

* This power grid system will have two main modes of operation. The first of which is when the solar panel itself is generating enough energy to power the consumer devices connected to it. In this case, the max power point system (mppt) will regulate the voltage and current to charge the battery with max efficiency. This altered voltage and current will go to the DC-DC converter which boosts the voltage to 110V which can either be stepped back down to provide 12V DC power or converted to 110V 60Hz AC power using the inverter. Throughout this process, relevant voltage, current, and power data will be collected and sent to a database/website where it can be viewed by consumers.
* The second mode of operation will be in the case in which the solar panel does not provide enough energy to power the loads, typically at night. In this case, power is taken directly from the battery storage and converted to either 110V 60 Hz AC or 12V DC for use in consumer electronics. The same current, voltage, and power data collection occurs in this mode of operation as well, funneling into a database/website viewable by consumers.

3.5. Users

* Our product will be marketed primarily towards consumers that have a need to generate their own power independently. Consumers that want to generate their own electricity for their devices can simply buy the system as is, able to power most if not all consumer products such as a phone or laptop.

3.6. Support

* A detailed user manual will be included with the system, providing information on how the system works, instructions for installation and usage, tips for maintenance, tolerances, and relevant information regarding the product. The manual will also provide a website in which users can track the voltage, current, and power generated by the system.

4. Scenario(s)

4.1. Charging Devices in Remote Locations

* Our primary use of a Solar Power Battery is to have access to electricity when there is none or limited access to electricity. Specifically, due to the large size of this device it can be used in remote locations where someone is stationary for a large amount of time. Someone can use this device and track the amount of power and voltage available to them, and track when the solar panels reach maximum capability. Fully functioning the device will allow someone to charge their phone and laptop at the same time day and night.

4.2. Easier Access to Renewable Energy

* The solar power battery is useful in any location given enough room for the solar panels to fit. This will allow a common person to make their own energy inside their home to connect any device whether a fan, a lamp, and other common household devices (within the specified range). The solar panels allow the battery to charge during the day, thus the device can be used at night to use or charge devices.

4.3 Determining optimal solar panel positions

* The solar power battery can be used to determine the best location for solar panels. Homes and Businesses, who may not be familiar with the sun's positioning, can measure the maximum track how much power the solar panels produce everyday. This data will be easily accessible through a website to make the most efficient use of their solar panels.

5. Analysis

5.1. Summary of Proposed Improvements

* The battery will be solar powered. Therefore, it will be a self sustaining system.
* Our device will supply both an AC and DC source, allowing for the charge of small electronics including laptops, phones, etc.
* The output will change depending on the amount of light received by the solar panels.
* The battery will be charged when light is received by the solar panel and supply power when light is no longer detected.
* The website will display the voltage output of the solar panel throughout the day for the user to track the efficiency.

5.2. Disadvantages and Limitations

There are some limitations in the design of the solar / battery system. These are listed below

* Due to the price range that we are working with, the overall power output of the solar panel will be the main priority. This directly decreases the ability to purchase a more efficient solar panel that can produce the same output while being smaller in design.
* System can only charge with sufficient light levels.
* Power generated during sufficient light level hours will depend on how big the solar cell is.
* Battery power will only be able to run for a couple of hours due to budget constraints
* The output terminals will only have so many outlets.

5.3. Alternatives

The solar power battery system has some alternatives solutions, some are listed below

* The solar / battery system could instead switch to battery when there is no light instead of sufficient light. The trade off being that the system could absorb more power than it is producing under low light levels.
* The solar panel can be switched out for any type of generator as long as you reconfigure the voltage and current.
* A smartphone application is an alternative to the website/ database.

5.4. Impact

* Economic Impact: The solar power battery system uses solar power, therefore it would lessen the cost of electrical bills.
* Environmental and Sustainability: The system uses renewable energy source therefore lessens the use of oil/gas methods.
* Social: Easier access to using renewable energy because of the lower cost of only supplying power to small devices. It will provide a good starting point for communities who may not be able to afford a solar panel array to power a house.
* Health and safety: Producing power using the solar power battery system is clean unlike most traditional generators. Owning and operating one of these systems will help battle pollution, a major health concern in this day and age.