SOLAR LIGHT SYSTEM

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**Midterm Report**

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**Concept of Operations**

REVISION – Draft

29 August 2023

Concept of Operations

for

Solar Lighting System

Team 60

Approved by:

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T/A Date

**Change Record**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rev.** | **Date** | **Originator** | **Approvals** | **Description** |
| **-** | 08/29/2023 | Team 60 |  | Draft Release |

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# Executive Summary

The purpose of this project is to offer a simple and reproducible solution to address growing environmental concerns by utilizing renewable energy and sensors to reduce power consumption. Our aim is to develop a solar lighting system for two places in a house: the foyer (indoor) and the porch (outdoor). The panel gets energy from the sun and stores it in a battery for the lights. Sensors are used to determine when to turn on lights in both places. Outdoor lights can use motion sensors along with location data to turn on only at night. Indoor lights can use motion sensors to avoid unnecessary triggers by pets. For remote operation, a mobile application is provided for displaying system status and input from the users for their preferences.

# Introduction

This document is an introduction to a Solar Lighting System (SLS), a system which makes use of renewable energy and sensors to provide a light source to several areas of the house with minimal waste of energy. The outdoor light will turn on when motion activated and only during the night, illuminating people or small animals moving around in a dedicated space. The indoor lighting system will be motion activated as well, operating throughout all hours of the day. The entire system will be environmentally clean, limiting excess damage to our atmosphere from the usage of nonrenewable sources. An app will be implemented with the system, supplying the user with preferential control over the lights. Additionally, implementation of solar energy will provide homeowners with potential tax credits.

## Background

The world relies primarily on nonrenewable sources of energy such as coal, oil, and natural gas to run countless systems. It is no secret that these sources can have harmful effects on our environment. In 2010, coal alone contributed to 35% of the United States’ emissions of carbon dioxide into the atmosphere. In addition to this, burning petroleum releases an abundance of harmful emissions and chemicals into the air and contaminates nearby ecosystems. The need for clean, renewable sources of energy is more apparent than ever, and yet many hesitate to make the change due to concerns about potential declines in efficiency or the difficulty in implementing such a system.

The Solar Lighting System (SLS) intends to provide environmentally clean, economically efficient, and easy-to-use indoor and outdoor lighting systems to potential homeowners. This system aims to replace active systems relying on city or state-wide power grids with a much more localized, environmentally friendly option. Although the positive environmental benefits of solar energy are well known, some consumers may be concerned about the budgetary risks or long-term performance of these panels. Solar panels typically last between 25 to 30 years before degrading in efficiency; in that time, homeowners may expect savings of up to $1,500 a year after switching from their existing power provider. Additionally, the Federal Tax Credit (2022) offers a 26% rebate on the installation of solar panels.

## Overview

The SLS will integrate solar panels and a battery to provide light to a variety of areas in a house. The panels will absorb light from the sun during the day and provide energy to the battery in an efficient manner.

## Referenced Documents and Standards

<https://www.sunwize.com/tech-notes/solar-sizing-ieee-1562/#:~:text=The%20IEEE%20standard%201562%3A2007,produced%20by%20the%20solar%20panels>.

<http://www.solarabcs.org/codes-standards/IEEE/index.html>

<https://www.sciencedirect.com/science/article/pii/S0196890409004968>

<https://pressbooks.umn.edu/environmentalbiology/chapter/non-renewable-energy-sources/#:~:text=Burning%20of%20coal%20emits%20higher,combustion%20contributes%20to%20water%20contamination.>

<https://www.forbes.com/home-improvement/solar/how-much-solar-panels-save/>

# Operating Concept

## Scope

The Solar Lighting System (SLS) is intended to allow commercial consumers of electricity to easily use renewable energy to power a lighting system in their homes. Two sets of lighting fixtures, along with corresponding sensors for those lights, will be installed in the patio and the foyer of a home. For ease of use, sensors are provided so that the system is powered at opportune times, without the need for manual interaction. They’ll primarily be motion sensors, with programs designed to recognize people rather than animals, or moving objects. The sensors will be connected to an app through Bluetooth for the purpose of manual and remote control of light switches. All systems within the house will be in turn powered by a solar panel that is set to charge the battery as needed when solar power is available. The system is intended primarily for commercial use in houses; however, it could be upscaled to industrial use.

## Operational Description and Constraints

This solar lighting system is intended to be used by the average homeowner in an area with ample sunlight. Solar panels will be installed on a high, unobscured surface outdoors. Motion sensors will be installed indoors and outdoors to activate lights. An app will control light preferences and provide data for battery and lights.

The following constraints are needed for this system:

* Direct sunlight will be needed in the installation spot for the solar panel.
* A direct line of sight will be needed for the motion sensors. Indoor motion sensors will need to be established to avoid accidental triggering by pets.
* A separate device will be necessary for app implementation. This device will need to be near the system to connect.

## System Description

* **Solar Panel:** This subsystem will send power to the battery charge controller, and power the whole system. The solar panel will charge the battery during the day until it reaches a full charge. A singular solar panel will be used, and placed preferably in a location that will get a large amount of sunlight, such as on a roof.
* **Battery Network:** The battery network system is comprised of a battery charge controller and the battery itself. The battery charge controller will ensure that the battery will not get overcharged or fed too quickly, and the battery will power the entire system during operational hours.
* **Microcontroller:** The microcontroller subsystem will interface with each individual component within the system other than the solar panel and battery. It will manage the sensor inputs and mobile app instructions, and in turn control the Load Control switches for the lights.
* **Sensors:** While the system is in automatic mode, it will be triggered by motion sensors, both in the foyer and the patio. The motion sensors will be programmed to recognize only movements made by people, rather than pets or a random moving object. Both the foyer and the patio will be using the same sensors and programmed to behave the same.
* **Lights:** The lights used will differ based on the location they are in and for what purpose they are being used. In the foyer, 3 LED lights will be set up to be activated by the motion sensors in that area and have a manual switch in the foyer. A flood light will be set up in the patio, though this one will only be activated by a manual switch and by the motion sensors for a limited time. An additional smaller LED light will be set up above the door of the patio, to be kept on whenever the app receives a signal that it has become appropriately dark.
* **Mobile Application:** The mobile app will be designed on Android Studio and will be able to connect to the SLS using Bluetooth. Data regarding panel irradiation and battery levels will be provided to the user through the app. The user will also be able to set their lighting preferences and modes with the app. The app will track sunlight and weather data in the user’s location to determine when the lights and certain sensors should be active.

A diagram of solar panel and battery

Description automatically generated

Figure 1. Subsystem Diagram

## Modes of Operations

The Solar Lighting System will have two modes of operation that it functions from: ‘Automatic’ and ‘Manual’. The mode of operation can be controlled by a manual switch attached to the MCU, as well as by the app.

* **Automatic:** The SLS will function without need for constant interaction and will work until fault. Both the inside foyer lights as well as the outside patio lights will be triggered by any motion picked up from their respective motion sensors.
* **Manual:** The SLS can also be operated manually, triggering lights and sensors with a switch. The inside and outside lights can be operated either with a physical switch or a switch within the app.

## Users

This Solar Lighting System is intended for the everyday homeowner wishing to reduce their impact on the environment regarding carbon footprints, as well as diminish the cost of their utility bills. It will be designed such that the average person should have no issues with installation or use.

## Support

Support for the Solar Lighting System will be provided through a user manual and online support through the developed app. The user manuals will come with easy-to-understand installation instructions, with additional documentation for each subsystem to help with troubleshooting. Online support through the app will come with frequently asked questions and their answers, and another copy of the user manual in PDF format.

# Scenarios

## Porch

Whenever the light sensor detects that it is dark, a small light will illuminate the entrance from the porch to the house. If some unidentified object triggers the motion sensor, a flood light will turn on illuminating the porch. The user will be able to customize when these lights turn on using the app.

## Foyer

Whenever the user enters or exits the foyer, the motion sensor will turn on or turn off the light. The app can also be used to control this light according to the users' preferences.

# Analysis

## Summary of Proposed Improvements

The Solar Lighting System promises a variety of benefits, including:

* The system will be solar powered, providing environmentally clean and self-sustaining energy.
* The outdoor lights will only be active at night, limiting resource consumption during the day.
* Motion sensors will be implemented for indoor and outdoor lighting systems, limiting resource consumption when there is no one around. The outdoor motion sensor will be implemented with a floodlight, illuminating moving objects when it is dark.
* Homeowners will save money over time from smaller energy bills and tax credits.
* The solar panels will last 25 to 30 years before degrading in efficiency.
* The app will provide an easy-to-use interface for consumers to interact with the system. The interface will display light and battery data and will also allow users to set preferences and modes.

## Disadvantages and Limitations

The Solar Lighting System has a few limitations, including:

* The sunlight received by the solar panel can vary based on location and weather patterns. This causes the energy source to be intermittent.
* The initial cost of the system will be substantial.
* Once the old panels degrade, new ones will have to be installed.
* The app will require a device with Bluetooth capabilities.

## Alternatives

Some alternatives to the Solar Lighting System are:

* Staying with the existing system provided by a power grid. This requires no extra installation costs or difficulties but will not save money over time and will not necessarily be clean.
* Switching to another form of renewable energy to power the lights. Solar power is currently the most commercially available form of renewable energy. Any other installations will be difficult to engineer and incredibly expensive.

## Impact

Three key impacts of this system are reduced greenhouse gas emissions, renewable energy sourcing, and economic relief. There are few environmental or ethical concerns about solar panels, only concerns regarding their efficiency and cost. The global impact of the SLS increases as the number of consumers increases.