NORTHERN KENTUCKY UNIVERSITY

Solar Based Smart Outdoor Lighting System

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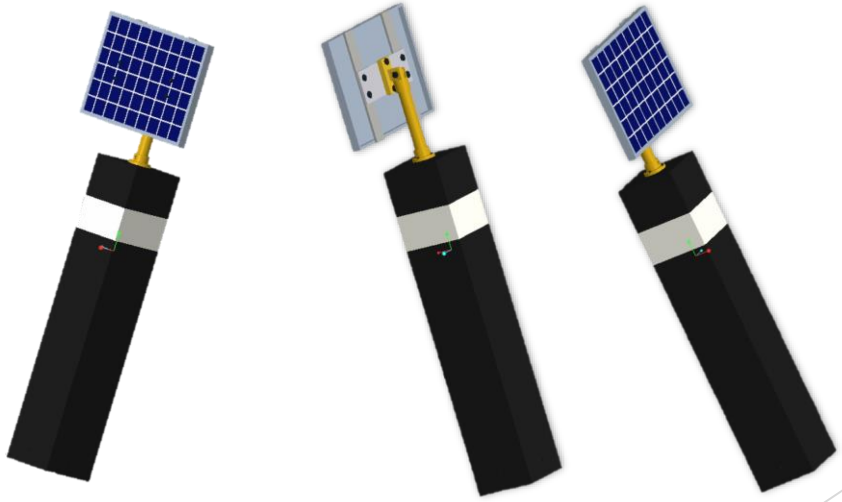


Introduction

- **Problem Statement:**

- **High CO_2 emissions**
- **Large amount of electrical power consumed by the outdoor lightings**

- **Solution:**

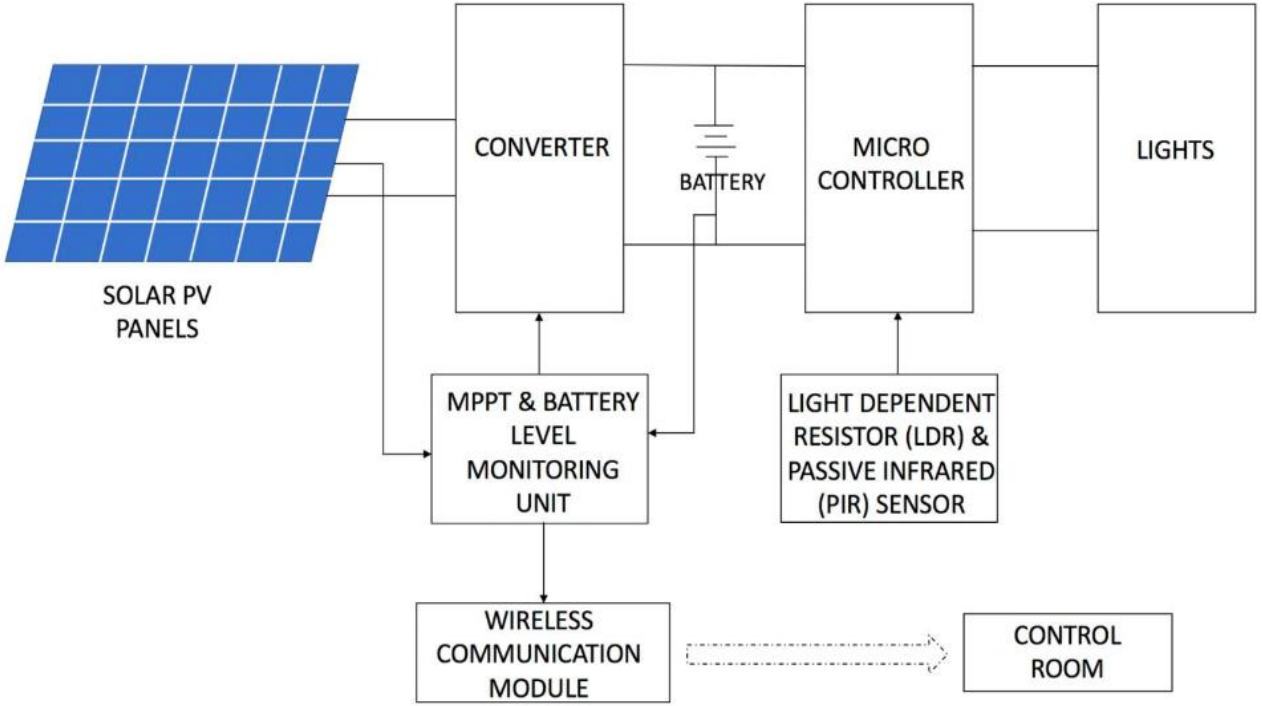
✓ **The installation of a solar based smart outdoor lighting system to provide renewable energy.**

Objectives

- **Design smart outdoor lighting model that includes solar panels, converters, battery, lights, microcontroller, sensors, transmitter modules.**
- **Convert four existing outdoor lights in the lake Loch Norse into solar based outdoor lights using solar panels**
- **Optimize the size of solar panels and battery**
- **Develop code for Arduino to control intensity of lights and monitor level of battery**
- **Develop wireless data collection method using wireless internet**
- **Set up test beds for solar based outdoor lighting system**
- **Collect real-time data from the test-beds using a Wi-Fi module**
- **Investigate the optimum mounting angle based on the season**

Methodology

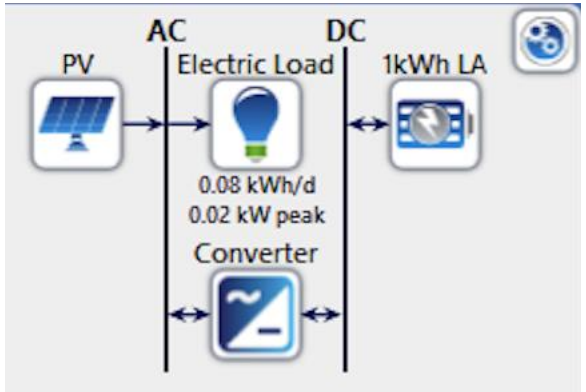
- **Optimization**
  - Homer Pro
- **Simulation**
  - MATLAB
  - Fritzing
- **Coding & Programming**
  - Arduino
- **Drawing**
  - PTC Creo



Homer Pro

- ❖ To find the lowest cost solution for our simulation model.
- ❖ Trusted database from NASA Surface Meteorology and Solar Energy
- ❖ Simulate different systems and allow comparing

- ○ System Configuration:

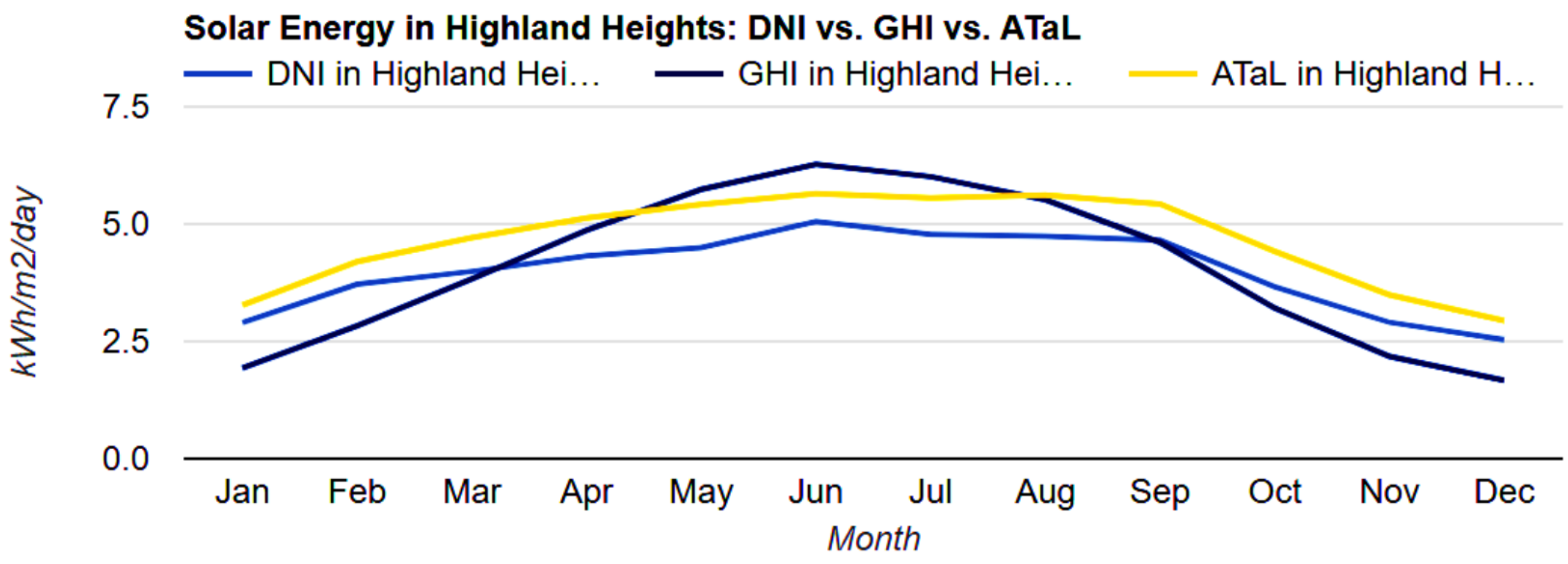


Area of Study

- The selected area is Northern Kentucky University, Highland Heights, KY. Figure below shows the location of the study on the map with coordinates of 39.0331° N Latitude, 84.4519° W Longitude

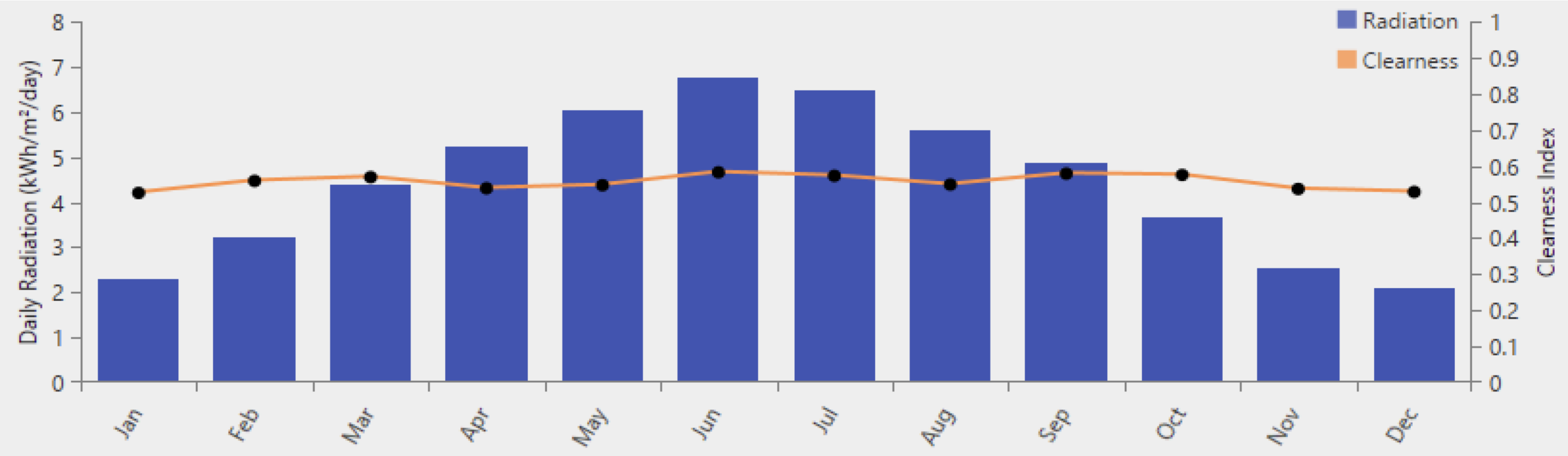
Irradiation Data

✓ Annually Average of irradiation data of 4.42 kWh/m^2/day

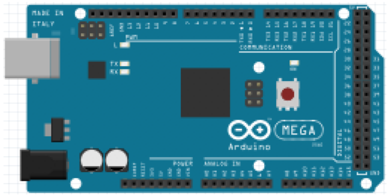


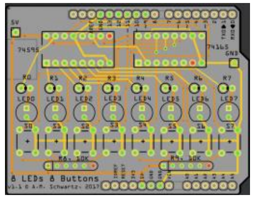
Sources of Study Area

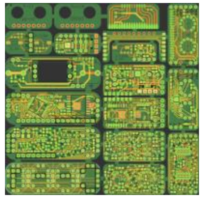
- The selected study area solar radiation data for this region is obtained from the NASA Surface Meteorology and Solar Energy database. The radiation data is monthly averaged values over a 22-year period (July 1983 – June 2005)

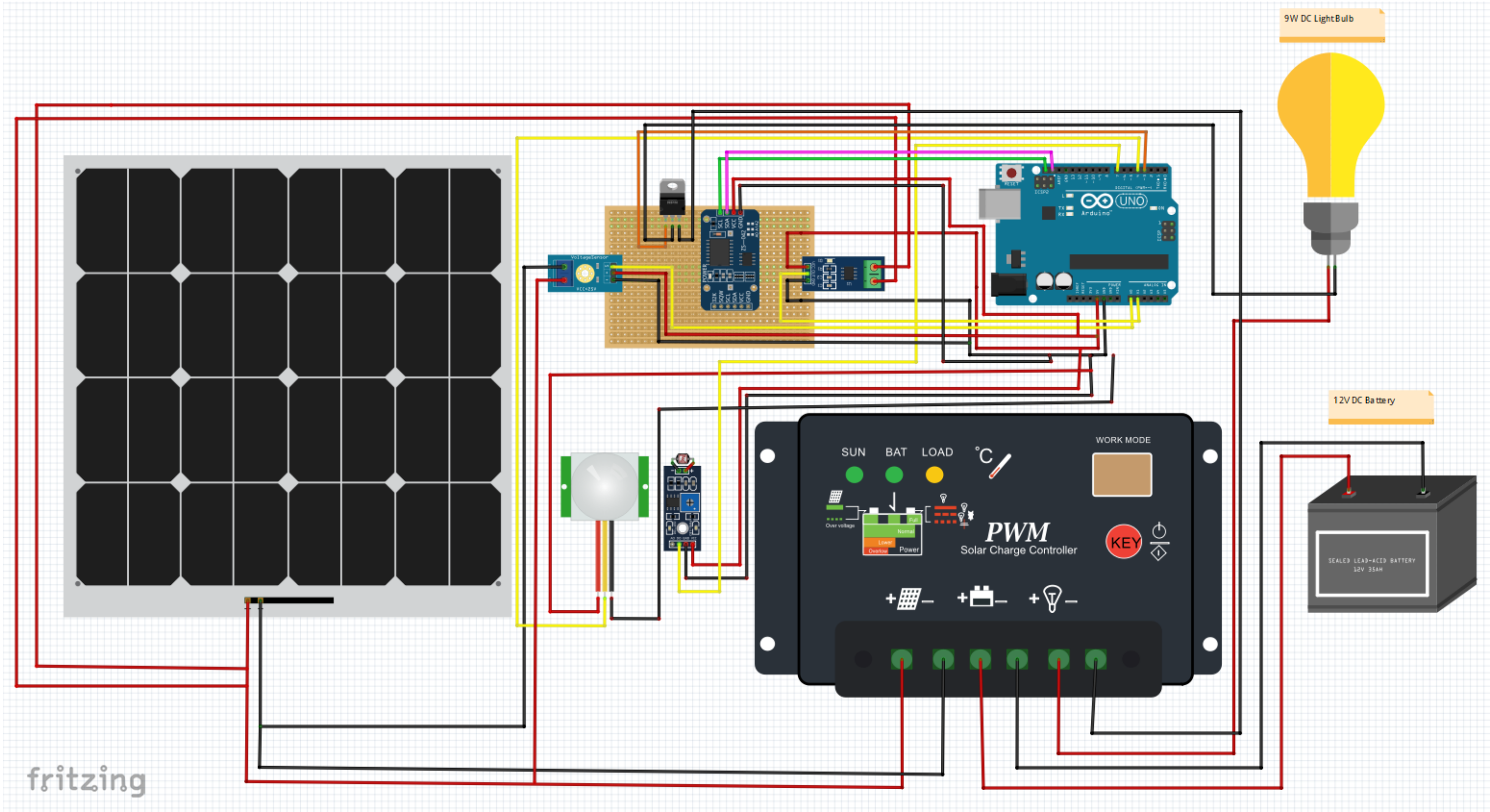


Fritzing Diagram

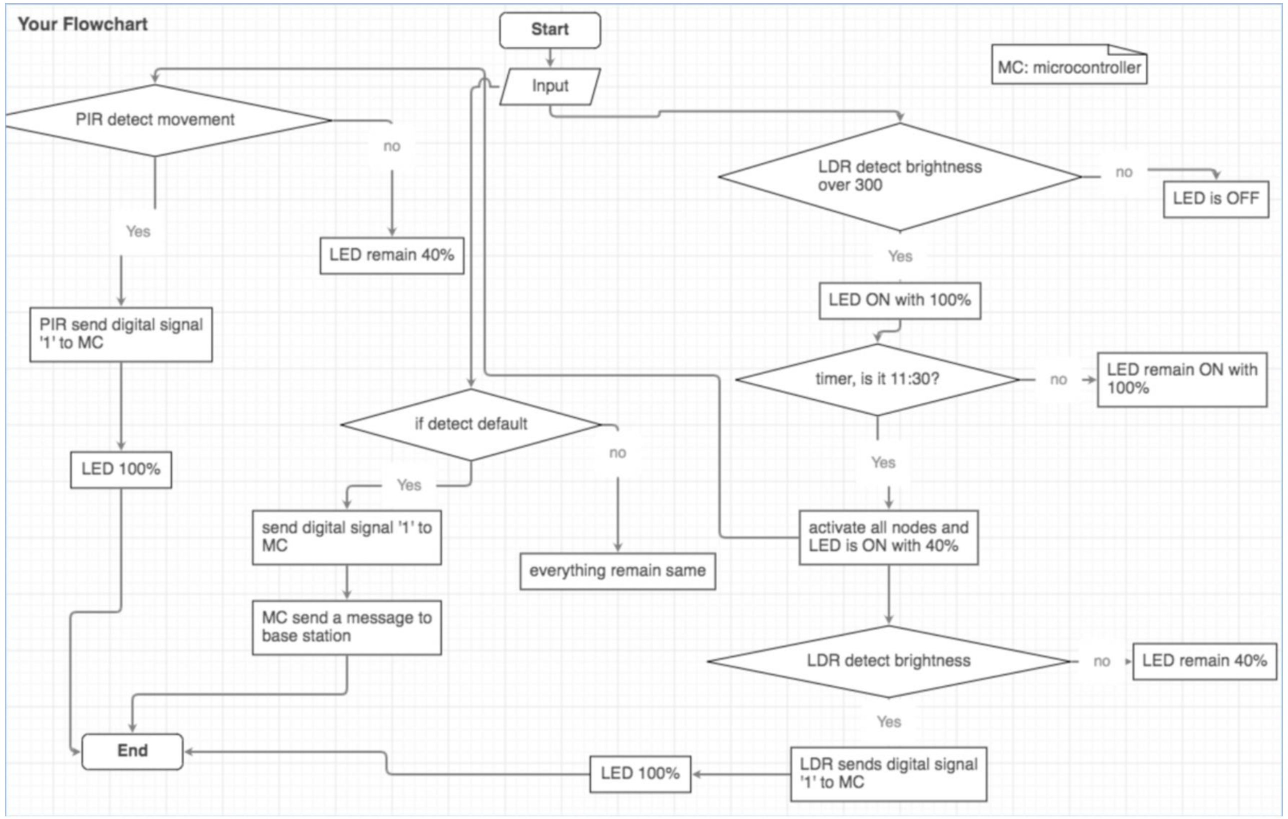






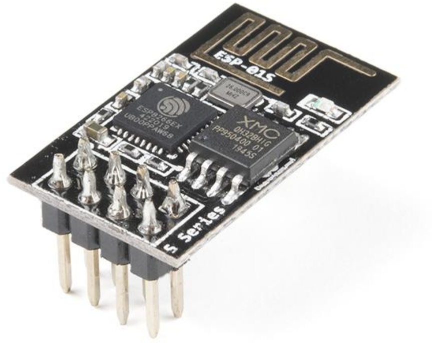


System Operation & Mechanism



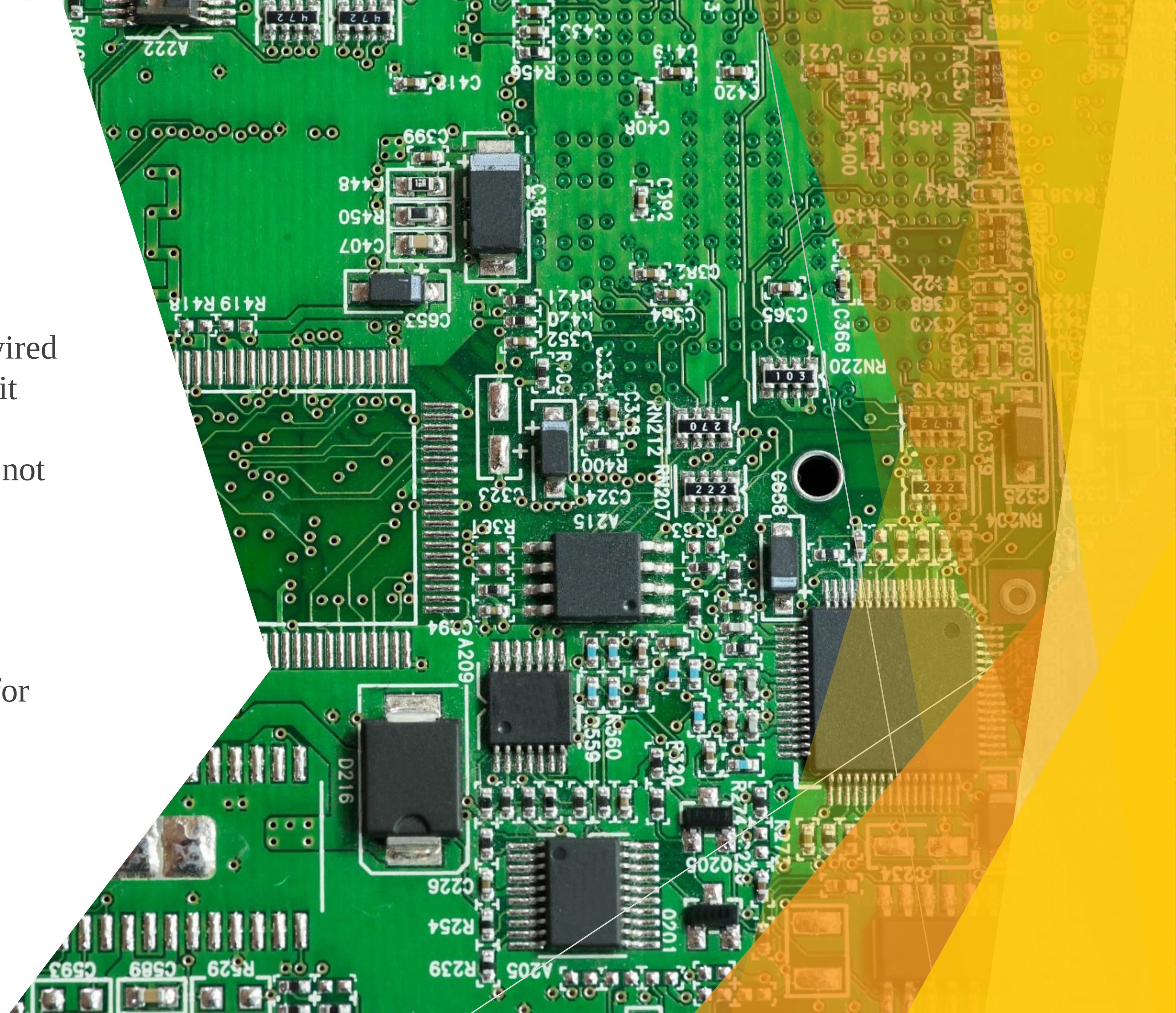
Adding Wi-Fi Capabilities

- In review of the final project, it was apparent how adding Wi-Fi into the system would create a more practical user and data collection experience over a long distance
- Using coded variables to tell when, why, and how much the lightbulb is on

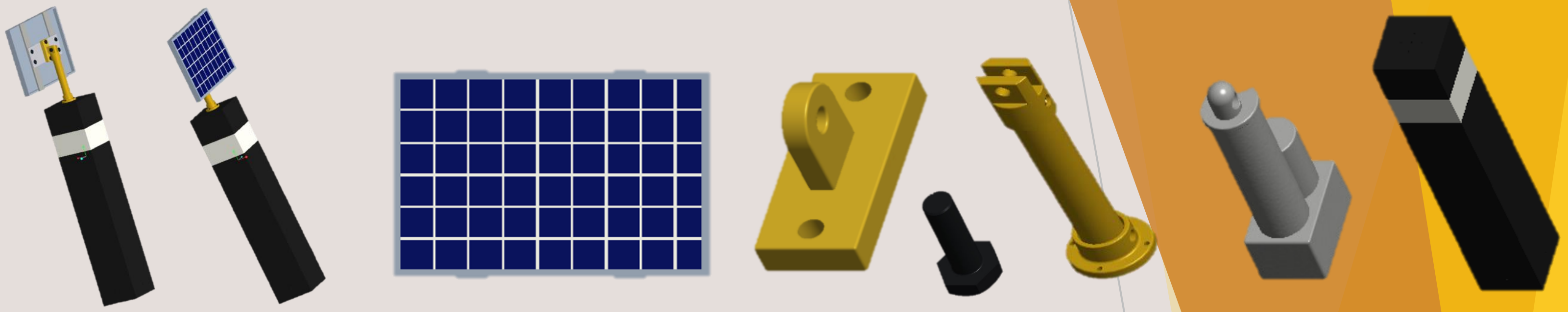


The Development of a PCB Board

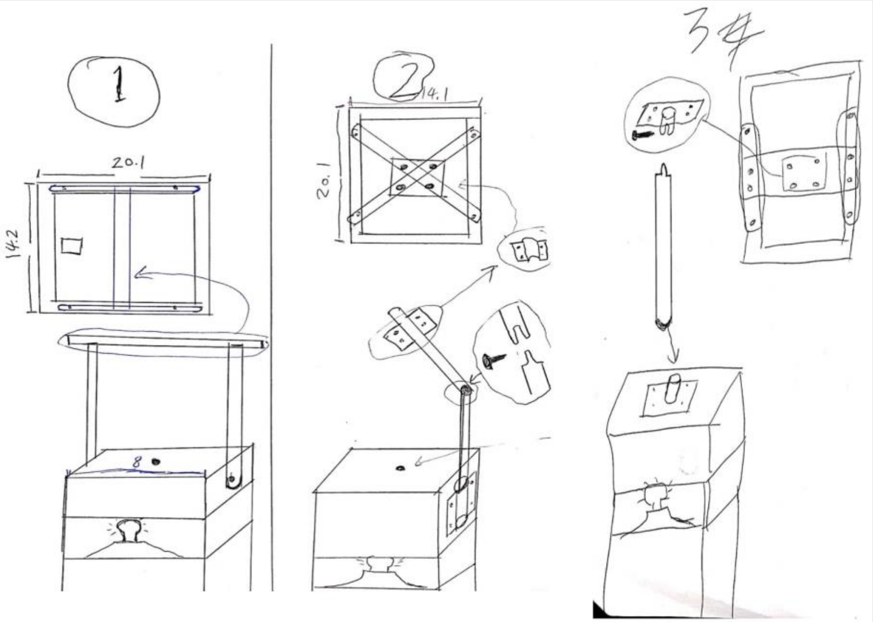
- When attempting to recreate the wired system using a soldering method, it became difficult to accurately replicate the system and often did not work
- The development of a PCB board would lead to easy replication of many lighting systems and would cause there to be a minimal need for extensive wiring

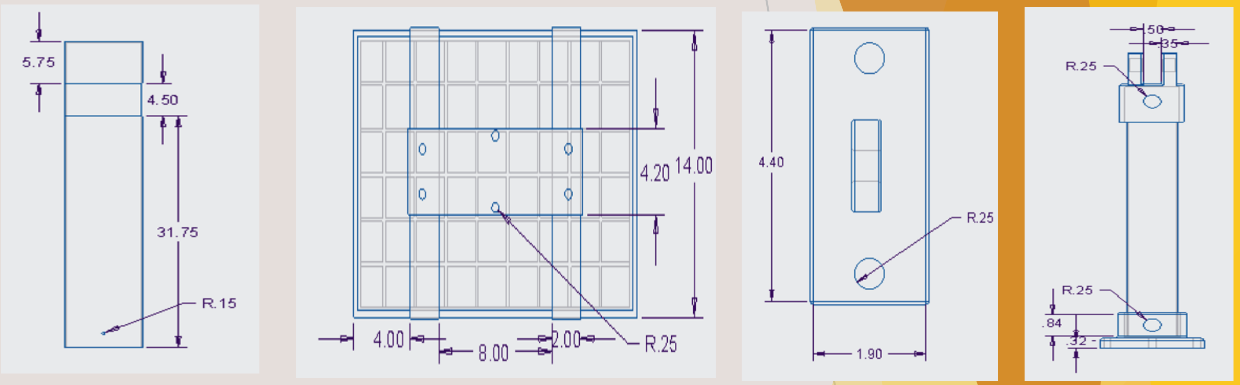


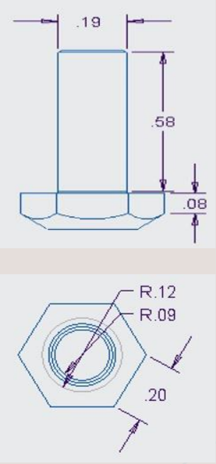
PTC Creo



- 3D modeling software that allows engineers to design technical drawing







Results

Installation cost

Components Name	Price	QTY
Arduino Uno	$18.00	1
Voltage Sensor -ST0430X5	$1.60	1
Current Sensor-DAOKI 30A	$2.04	1
Real Time Clock Mudule-DS3231	$2.02	1
3V Lithium Battery	$0.60	1
12V 35AH AGM Battery	$64.90	1
N-Channel Power Mosfet TO-220 ESD Rated for Arduino	$0.80	1
22awg Electric wires	$15.99	1
ELEGOO PCB Board Prototype Kit	$0.41	1
PCS Light Detection Sensor	$1.60	1
PIR Motion IR Sensor	$1.79	1
Renogy Wanderer 10 Amp MPPT	$13.07	1
¾ IN flange BLK	$5.78	1
¾ IN swivel base BLK	$11.68	1
¾ IN X 18-IN GALV PESCH30	$7.48	1
Tento LED 12V Bulbs 10W	$4.99	1
ACOPOWER0 25W Solar Panel	$46.8	1
Total cost	$199.55	

Replacement Cost For The Proposed Project

Component	QTY	Cost
12V 35AH AGM Battery	2	$64.9
Tento LED 12V Bulbs 10W	3	$4.99
3V Lithium Battery	7	$0.6
Total		$148.97
Total cost for 25 years		$348.52

Cost Comparison between current and proposed systems

Specification	CURRENT (GRID)	Proposed
Bulb used (Watts)	100 Watt	10 Watt
Operational Hours	12 hrs	12 hrs
Installation Cost ($)	$0	$199.55
Replacement Cost ($)	$233.75/25 years	$148.97 /25year
Operations Cost ($)	$1204.5 /25years	$0
Maintenance Cost ($)	$100	$200
Total cost	$1538.25/ 25 years	$548.52/ 25 years

Quantity	Current	Proposed
Single Bollard	$1,538.25	$548.52
Total Bollards= 462	$710,671.5	$253,416.24

Lifecycle Emissions

Lifecycle Emissions	Current	Proposed
Per Year	98 KG CO2	3.3 Kg CO2
For 25 Years	2450 KG CO2	82.5 KG CO2

- Single bollard will save $1000 & will reduce 94.7kg CO2 emissions
- All bollards will save $450,000 & will reduce 43.8 Tonnes of CO2 emissions

Concluding Remarks

- Reduction of CO_2 emissions and the implementation of renewable energy sources is not only important to Northern Kentucky University but the world as a whole and projects such as these will allow progression of these renewable energy sources in the coming years.
- The project allows us to provide light to the campus without using the power grid. Solar panels the energy is one hundred percent self sufficient and renewable
- Currently the project is moving to phase two which is implementing three other test beds that have three different mount angles.
- Due to COVID circumstances, only one test bed could be implemented. While the designs of the other three test beds are ready, it will be implemented when the university opens up. A comprehensive analysis on the best mounting angle will also be discussed in future.
- The addition of Wi-Fi into the project has caused for better communication between our test bed and data analysis area

Project Pictures