

Project Proposal - Ruben Bhatia

- 2104693

by Ruben Bhatia

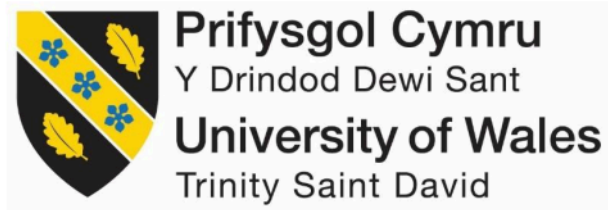
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A Study on the effects of heliostats in solar energy production within the UK– Project Proposal

by
Ruben Bhatia

Preferred Supervisor: Gareth Jones

Project submitted as part of the requirements for the
award of
BEng (Hons) Electrical and Electronics Engineering

October 2024

DECLARATION

I, Ruben Bhatia, declare that I am the sole author of this Project; that all references cited have been consulted; that I have conducted all work of which this is a record, and that the finished work lies within the prescribed word limits.

This work has not previously been accepted as part of any other degree submission.

Date : 20th October 2024

FORM OF CONSENT

I Ruben Bhatia hereby consent that my Project, submitted in candidature for the *BEng(Hons) Electrical & Electronic Engineering* degree, if successful, may be made available for inter-library loan or photocopying (subject to the law of copyright), and that the title and abstract may be made available to outside organisations.

Date : 20th October 2024

Introduction	3
Background Research/Literature Review	3
Project Design.....	5
Project Overview	5
Risks	5
Ethical Implications	6
Data Analysis	6
Resources and Planning	6
Resources	6
Planning	7

Introduction

Renewable energy is the generation of energy using natural resources that replenish, sunlight, geothermal heat and wind being a few examples [1]. It's implementation into infrastructure and devices used in society is vital as carbon dioxide emissions have led to a global temperature increase of 0.7°C over the past century [2]. Global warming is destroying the planet and lives as a result. Renewable energy removes humanity's over-reliance on fossil fuels and instead provides a stable alternative to electricity generation, ultimately preventing further damage to the environment from occurring.

Background Research/Literature Review

The UK generated 4.9% of its total electricity output by using solar power in 2023; and has been increasing from the start of the millennia up to this point. [3] Using solar power as an energy source has many advantages, with its main advantage being that solar panels can be used almost anywhere on a multitude of scales. This includes uses in industrial settings such as powering machinery within a factory, residential settings using roof mounted solar photo voltaic (PV) panels which provide energy to homes and in personal settings, being installed on a portable charging device to allow for small scale electronic device charging. When solar energy is generated in an industrial, commercial or residential setting, any excess energy generated by the property can be sold back to the grid, ultimately lowering energy costs when it is sourced from the supplier instead of the sun. In addition, when solar power is used in a personal setting, such as device charging, single use batteries and other E-waste is lessened.

However, the cost of PV panels increases proportionally with their size. Examining this further, the power generated by PV panels differs based upon the materials they contain. This is

because the power output efficiency of a PV cell (what a PV panel consists of) changes from their material and its structure. An example of this being that Gallium-Arsenic multicrystalline PV cells have an efficiency of 18.4% (± 0.5) whereas a Silicon multicrystalline PV cells have an efficiency of 20.4% (± 0.5) [4]. There are a multitude of other materials and structures used in PV cells that are used throughout the UK which alter the amount of energy the country's PV panels can generate. Although trivial for personal use, PV panels increase in cost as they become more efficient [4]. This has set a precedent where the space utilized by PV panels is not optimized for maximum efficiency of electricity generation and instead optimized for cost effectiveness. An alternative method of generating electricity using the sun is a heliostat. A heliostat is a mirror that tracks and reflects the sun's rays along two axes. This device reflects onto a receiver which heats up its contained fluid [5] to either be stored or used to generate steam in a Rankine cycle engine which generates electricity.

There are no large known heliostat plants within the UK. When a heliostat is used within the country however, it is used for commercial or research purposes which do not serve to generate electricity on any scale. In the case of Westfield shopping center in London, a heliostat is used for lighting purposes where it provides indoor lighting throughout the day [6]. Contrasting with this is the large variety of solar farms which generated over 15 GWp in 2017 [7]. These farms take up a large area of land.

Area is an important factor as the UK is a coastal country meaning there is only a finite space to work with. Optimizing the area used by solar energy production has the potential to allow either further scaling of solar energy production plants or for more production plants to be built. This will ultimately increase energy production, lower carbon emissions and reduce costs over time.

There have also been studies including both PV panels and heliostats although they are based upon hybrid concentrated solar power (CSP) and PV panels, where these two systems work synergistically to provide electricity on a large scale. Starke et al state that hybridizing both systems increases the energy output of the plant as the thermal energy of the CSP can be stored [8]. However, an answer to which system produces more energy utilizing their given space from this example cannot be derived as said systems are interlinked. There are no studies incorporating both systems and contrasting them as separate operations. This leads to the problem question being:

"Is a heliostat or a PV panel better suited for power generation over a given area?"

From this question, the overarching aim of the project will be to find whether a heliostat or a static PV panel generates more power relative to their systems area. Four sub-objectives can be attained from this aim:

1. To develop two comparative systems
2. To tabulate and analyse said systems performance using gathered data
3. To repeat experiments and scrutinize outlying data
4. To arrange a given timeframe and organize the project correspondingly

Therefore, by the end of the project, it is expected that both systems are produced, controlled experiments are conducted using these systems and data will be compiled from these experiments to be analyzed, along with the level of effectiveness of the built systems. All work should and will be completed within a given timeframe.

Project Design

Project Overview

The project will consist of two separate systems. The first system will be a PV panel mounted on a breadboard along with various other required components such as a PIC. In addition to this, a measuring device, such as a multimeter, may also be connected into the closed-loop system to measure the power produced. The second system will consist of a mirror which is also attached to a breadboard via a dual-axis/gyro mount and sensors (thermistor and axial sensor) and a PIC. The sun and an artificial source will be used to provide light to the systems and will provide accompanying sets of data during experiments. Regardless of light source, both systems will be equidistant to it as a form of control. The solar PV system will also be used alongside the heliostat system to focus light onto the PV panel, in which the energy it generates will be measured within its own system.

Data Collection

Various data collection methods will be used throughout the project's lifespan:

- The author will use their own knowledge of the subject matter as well as referral to journals and books to create the systems.
- A quantitative approach will be taken when data is produced, leading to tabulated data and graphical representation for further analysis
- A logbook will be used to note time spent working on the project and specify achieved criteria

Risks

A table has been made to represent risks, their proposed solutions as well as their likelihood to occur (see Figure 1):

Issue	Risk Type	Proposed Solution	Likelihood
Time constraints	Limitation	Plan project according to objectives and accounting for time away and spare time using gantt chart	Moderate
Cost	Limitation	Research alternative components which	Low

		are more cost effective	
External Hazards	Risk	Work on project in a controlled environment and store work safely	Low
Data loss	Risk	Backup all data and digital work	Low
Changes in scope	Risk	Only adjust project out of necessity – can be caused by variety of factors	High
Bug fixing	Risk	Spend spare time working them out	High

[Figure 1]

Ethical Implications

There are few ethical implications with the project. These are as follows:

- Are materials used produced using fair labour?
- How sustainable are the materials the project uses?
- Where are the project materials sourced?
- How will waste material be disposed of?

In terms of the project's impact on the environment and society, its purpose is to benefit both. Although production waste of the project materials may harm the environment, the project innately serves to reduce the consumption of fossil fuels which cause global warming.

Data Analysis

The results will be displayed and analysed in Joules (or Watts) per metre squared (j/m^2), where Joules will be the total energy generated by the PV panel and the area being how much space the system takes up on a surface, including but not limited to the face of the panel. In the scenario where the PV system is used in conjunction with the heliostat system for energy measurements taken, the area of both systems along with any 'dead space' (space between the two systems) will be accounted for and measured. The dead space will be determined by the mirror's capacity to encompass the PV panel's face with light from its source and so their distance will change accordingly. This is done to simulate larger scale applications. The data gathered will be tabulated, along with any conversions made. Additionally, this tabulated data will then be graphed for further analysis. Anomalies will also be scrutinized.

Resources and Planning

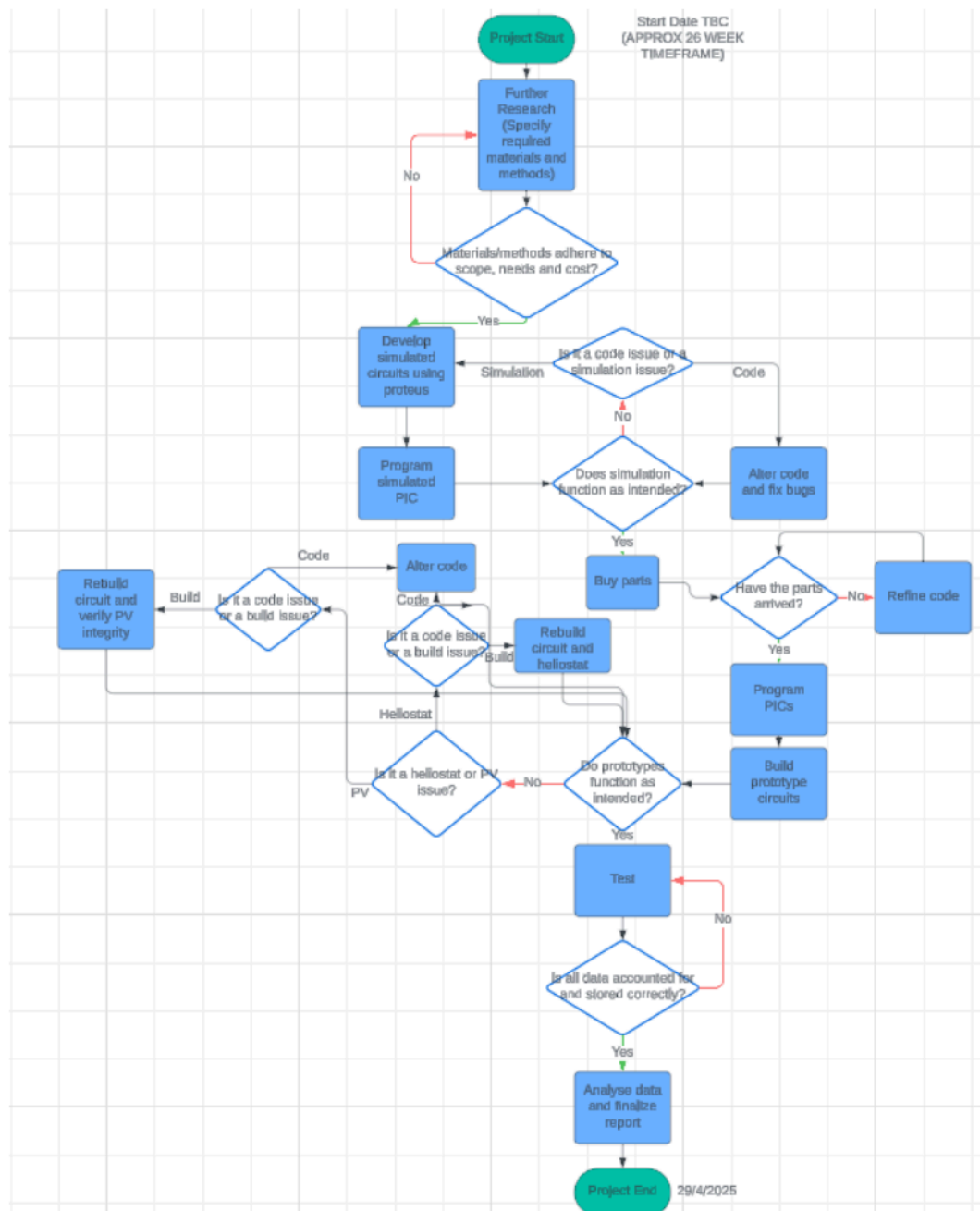
Resources

Various resources required for project completion have been identified. This includes:

- A laptop or desktop computer
- Computer applications (Proteus, MikroC)
- Embedded C
- I2C or RS232 compatible hardware and software
- Internet access
- Access to scientific journals, articles and books
- USB Storage
- Cloud data storage
- Physical container (large enough to house both prototype systems)
- Breadboards
- PV panel
- Planar mirror
- Dual-axis or gyro mount
- Torch
- PIC Microcontrollers
- Miscellaneous electronic components (zener diodes, resistors etc)
- Multimeter
- PICkit 3

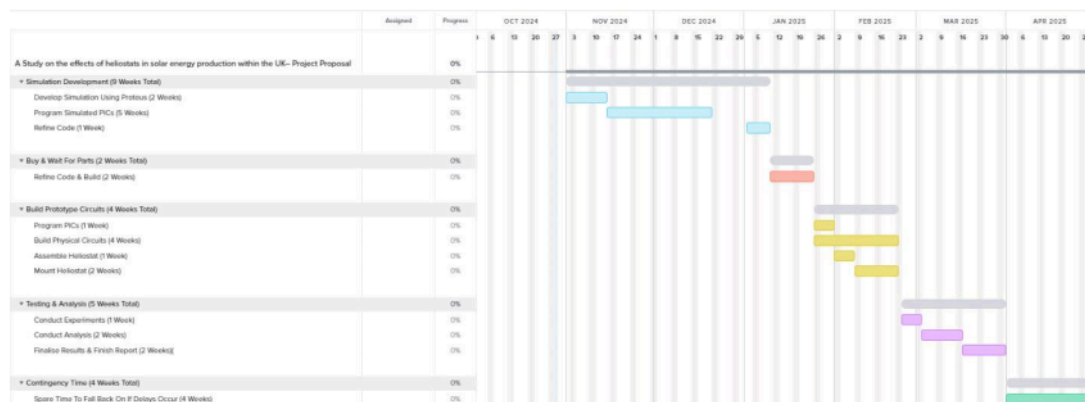
Planning

A project plan has been made in the form of a flow chart. This will enable the project to have a distinguished plan of work and displays dependencies throughout the project. See Figure 2 below:



[Figure 2]

In addition to this flow chart, a Gantt chart has also been made to optimize time management (see Figure 3 below):



[Figure 3]

References

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

68/100

Intro / A&O (400 words)		
An excellent general introduction to the problem.	20	70
Background to the Project / Literature Review (400 words)		
General comment overall: well presented report, with a good overall idea.	20	62
The proposal is also meant to be a feasibility study document, and little investigation seems to have been done into HOW some of the proposed things are going to be achieved – e.g. creating the tracking device		
Project Design (500 words)		
Clear statement of which development methods are to be used and why	30	68

they are appropriate; Clear statement of which tools are to be used and why they are appropriate; Clear description of how data collected will be analysed A good start in term of the flowchart etc. Clear aims and objectives – although perhaps more thought needed on the practicalities of the actual experiment.		
Resources / Planning (200 words)		
List of any deliverables; Clear diagram showing both timing and resource use; Completed ethics form; Limited and relevant appendices Some good initial planning. No real detail on the actual hardware though.	15	70

Document Presentation		
Correct spelling, grammar and punctuation; Flow of narrative/fluency; Coherence; Word processed ; Correct use of referencing with bibliography; Strict word limit	15	70
TOTAL	100	68%

PAGE 1
PAGE 2
PAGE 3
PAGE 4
PAGE 5
PAGE 6
PAGE 7
PAGE 8

