CS310 Project Specification:
Efficient Allocation of Renewable Energy Sources Under Uncertainty Across the UK

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1 Problem Statement

One of the most substantial threats to the modern world is the ongoing climate crisis. With a need for more renewable technologies and energy being one of the key paths forward, the problem becomes where best to site these new energy sources. With so many possible locations to choose from and a finite budget the automation of these decisions would be an obvious help.
AI is a powerful tool in tackling optimisation problems such as this, where the number of variables affecting the outcome make the best choices difficult for a human to comprehend. As discussed, with such a wide range of varying locations across the country the choice of where to allocate funds quickly becomes a complicated one. Especially so when considering the statistically uncertain factors such as maintenance and most importantly for renewable energy, weather.
When considering a choice of location and energy source there are a range of factors to consider in evaluating the value of the decision. The costs of a choice will be impacted by the setup and connection costs, the initial production cost and the cost of repairs, meanwhile the output of a location will vary depending on the weather of any given day. This exposes the other area of the problem, the need to consider the statistical uncertainty of events such as faults requiring repair and "profitable" weather patterns occurring when evaluating a choice.

2 Objectives

The aim of this project is to create a program that will be able to take a user's budget as an input, and make decisions in allocating that budget to different energy sources in different locations. These decisions will be made using a range of different techniques to ensure that the allocations are made result with the most efficient spending possible.

2.1 Core Objectives

The program itself will be made up of a few different components and in order to be successful should meet the objectives below:

1. A "performance" function will be able to evaluate a location for a given energy source type, using uncertain variables such as wind speed, sun light time and sun intensity.

2. A "cost" function will evaluate a cost of choosing a location according to the production cost of the energy source, transportation and connection costs for a given location, and an evaluation of repair costs against the chance of a fault occurring.

3. A "solver" function will implement a yet undetermined optimisation problem algorithm suited to an allocation problem of this type, and will make use of the "cost" and "performance" functions as heuristic values.

4. The program be able to access a data set of locations, curated to be viable for allocation.

5. Given an input budget value the program will return the user a set of allocations chosen as it deems to be the most performant based on the performance function defined in objective 1.

6. The program will run under a fixed time condition such that the user should not be waiting more than 30 seconds for a result.

These are the core parts of the project which are required to have successfully implemented the goal of this project. However these objectives have some areas for expansion which could potentially be investigated given the core aspects are implemented successfully with additional time to spare.

2.2 Potential Areas of Expansion

1. Extend the "performance" function to consider long term trends in the weather to all for the program to make allocations based on future worth.

2. Evaluate more than one of the most relevant algorithms, benchmarking performance on time taken, accuracy, and consistency.

3. Extend the location set by allowing users to input their own location data set, allowing the program to be used in different countries or more specific areas in the future.

3 Methods

3.1 Development Methods

The development process of this project will follow an agile iterative model of development. The project will be broken down into core sections that need to be implemented, with the aim to complete a new version of the project, including a new core feature, every 3 weeks. This give regular target milestones in the development and ensures that the order of development is structured with each prerequisite feature completed before work begins on a new one. This agile style will also allow for flexibility as it is likely that the initial plans for this project will change in the future if certain implementations do not perform as expected.

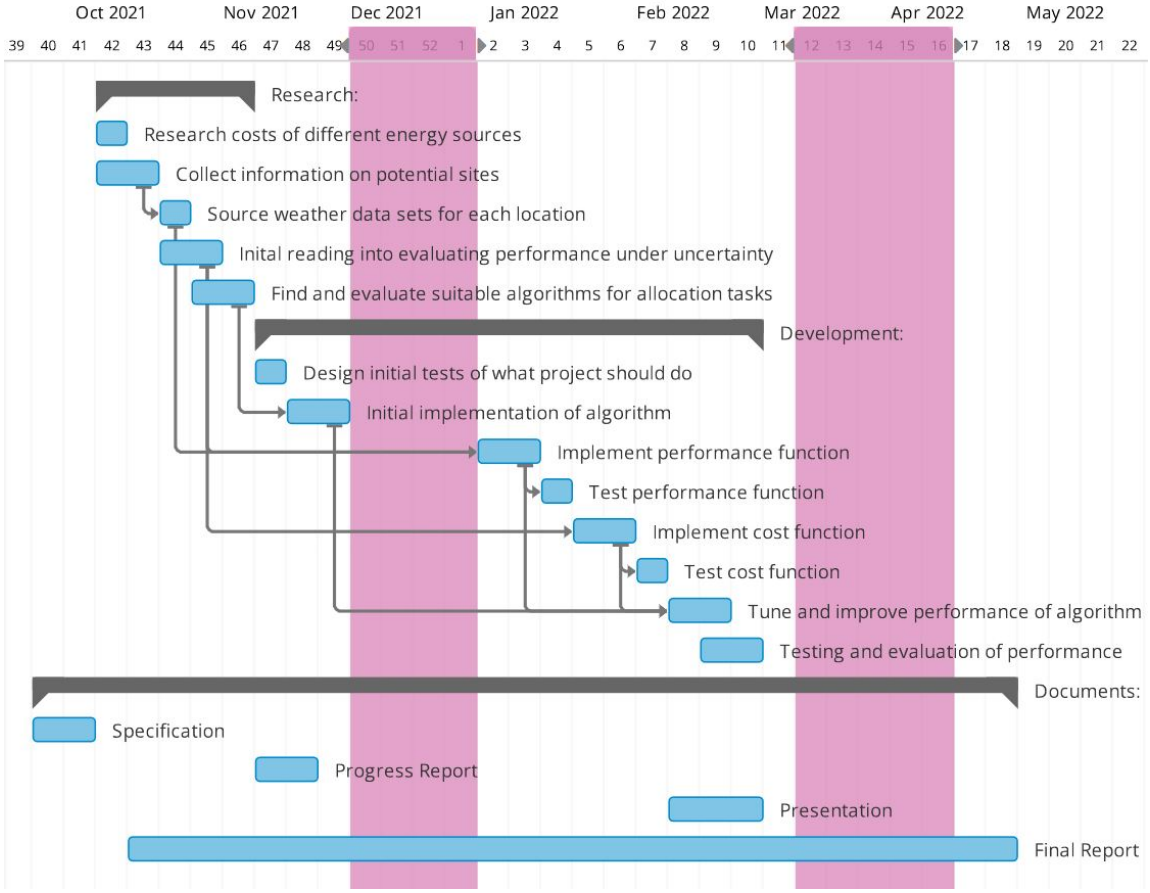
The project will make use of Git to separate the code base into versions throughout development, this will allow for different functionalities to be developed separately if needed, and give access to easy rollbacks to previous versions should some area of the code cause problems.

3.2 Testing strategy

In the iterative model chosen each version should be appropriately tested on completion. To ensure the end result meets expectation, at the start of each iteration a list of tests and expected results will be defined. If at the end of a version's development the tests are not met sufficiently, the next version developed should either rework the code to ensure it meets the tests or consider if the tests originally defined should be redesigned to be more achievable. This may lead to features taking longer to implement than planned so some flexibility in timetabling should be allowed.

4 Timetable

To organise the time spent on this project the key steps requiring work have been broken down and scheduled over the duration of the university year. The below gantt chart visualises what will be worked on each week and how different tasks are prerequisites to each other. The highlighted weeks are kept free for university breaks, by leaving them free it will allow for any versions dedicated to failed tests in prior versions to be completed without extending the overall project beyond the deadline of completion.



The majority of the development work will be done in term two as before it can be started a full understanding of concepts learned in the research phase is needed. This also works to fit availability of time as term two will have more free time to allocate to development each week. The current plan is for the majority of work on the project to be done on Tuesday, Wednesday and Thursday with 2-3 hours scheduled each day and any more work to be completed over the weekend.

5 Resources

The main resources needed for this project is the historical weather data required to evaluate the suitability of different locations. Using a mix of sources from visualcrossing.com [2] and the Met Office [1], will help ensure a full range of data for each chosen location as well as acting as a fail safe in the unlikely event of either sources removing access to this information. The project will be built in the base Python 3.9 language, this is a widely supported language with no chance of becoming unavailable within the duration of this project.

6 Risks

The main risks this project will face are data loss and issues with falling behind schedule. In order to prevent and mitigate the problems caused by these risk we will take the following measures:

- Data Backup:
  - By using Git as a version control protocol for the project we can make use of GitHub's private repositories to keep a regularly updated backed up to a central online location.
  - To avoid the unlikely case of losing access to the repository causing any issues we will also be pulling up to date versions of the code base and project documentation to at least 2 different computers (a personal Laptop and Desktop most regularly).
- Time management:
  - As part of this document the timetable will help build an expectation of where the project should be every week.
  - Project management tools such as Kanban boards can be used to break down the tasks ensure regular progress is being made on the development.

7 Ethical Considerations

As this project will be using publicly available information as sources and is isolated in the development and testing of the program there are not an ethical concerns to be raised at this time.

References

[1] Met office - historic station data. `https://www.metoffice.gov.uk/research/climate/maps-and-data/historic-station-data`. Accessed: 10-10-2021.

[2] Visual crossing - weather history. `https://www.visualcrossing.com/weather-history`. Accessed: 10-10-2021.