Project title

Name

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for the degree of

MASTER OF SCIENCE IN COMPUTING

DATE (e.g., AUGUST 2021)

Abstract

Add your abstract here. Approximately 300 words, maximum 500 words.

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I declare that this report describes the original work that has not been previously presented for the award of any other degree of any other institution.

Signed

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Acknowledgements

Add any acknowledgements here. It is customary to thank your supervisor for their support.

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# Introduction

Global warming is the root cause of major climatic changes occurring around the world. As the global warming increased, it lead to increase of the surface temperature by 1 degree Celsius in the last 100 years [1]. The projections from latest IPCC report include the raise of surface temperature up to 6 degree Celsius [2]. The global warming is caused due to rapid industrialisation and progress in the last few decades [2]. This increase in surface temperatures is raising the sea levels. It is expected that the sea levels raise by 12 to 26cms by 2050 drowning most sea cities [3].

Global warming is caused by emission of the greenhouse gases mainly Carbon di-oxide, Methane and Nitrous oxide. Most greenhouse gases are emitted by the energy usage (Figure 1). Energy sector is an important sector for the developing mankind powering all the industries and homes by generating and distributing the electricity [4].

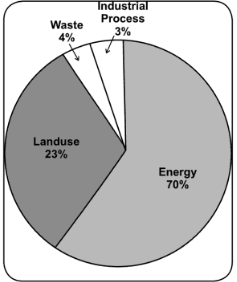


Figure Greenhouse gases emitted from various sectors [2]

In the recent past, several countries come together and formed Paris agreement and pledged to reduce carbon emissions in 2015 [5]. World has to reduce emissions by 4 times in 1/3rd of the time to save earth [6]. To honour the commitment UK government has switched to renewable sources of energy such as solar, wind, hydro, nuclear, biomass, etc. UK has planned to go carbon negative by the end of 2033 [7].

The efforts on this project is put towards helping the UK goal of turning carbon negative by pushing the demand towards the renewable sources of energy. The aim and objective of the report are mentioned in the following section.

## Aims and Objectives

The aim of the project is to present the global warming situation and drive the demand of electricity from UK households towards renewable sources of energy while saving the electricity bill on the utilized energy. A tradeoff between reducing carbon footprint and reducing electricity bill burden is to be found out motivating the individuals to help the UK pledge to reduce carbon foot print.

The objective of the project is to develop an automated tool which fetches, scraps and process the energy generated data by fuel provided trusted sources, collect weather and news data, predict the energy generation for the next 24hrs using machine learning techniques and suggest an ideal time to the user for using the home appliances reducing the carbon footprint while reducing the electricity charges burden on the consumer.

For e.g. It's better to use washing machine on a sunny day not just to dry things quickly outside but because then to make use of peak solar energy capacity and reduce the carbon footprint of the grid. This tool combines live data sources for example on weather forecasting with open API’s on energy production the algorithm works out when best to plan on doing your laundry and inform your users in good time.

## Breakdown of Report

List the different chapters and what they will cover.

# Legal, Social, Ethical and Professional Issues

Software development comes with inherent issues of social, legal, ethical and professional issues. These issues are to be minimised to make the software right for production. Few issues were also identified in the current software developed. They are:

1. The software is an open tool leading to Digital Ownership issues since the software is directly installed in the consumer’s computer or machines
2. To use the software the users must provide personal information such as current location and choices of the user.
3. Software required constant access to the internet to download, process and suggest the users in good time.
4. The software depends on machine learning which leads to incorrect predictions if the date provided to the machine learning model is biased or erroneous
5. The software uses the open sourced API completely for the data which can be inaccessible or moved to paid version which is a roadblock for the software
6. Any technical issues with the software are accountable by only one developer involved in the design and development
7. The software doesn’t have inbuilt cyber security support to protect against the cyber crimes
8. Large scale deployment of the software makes it obsolete since the demand in the suggested timings increase therefore increasing the dependency on non-renewable or interconnectors to meet the demand

# Literature Survey

We depend on carbon sources, mostly carbon for electricity generation. Coal is the highest used source for energy generation in UK in 2016. It accounts for the 42% energy generated in 2016. It is a non-renewable energy source, and prices are also rising [8]. Although the dependency on these carbon rich fuels has reduced from 1990, this is not enough to curb the alarming rate of rising global temperatures [9]. It would be more efficient to reduce carbon dioxide emissions by switching to renewable energy sources such as Solar, wind, water, etc. The grid consists of both renewable and non-renewable energy sources. Depending on the supply and demand on the contour, the amount of Coal raised in solar power capacity changes [9]. Goal is to use this data efficiently from the energy side of our devices. Detailed information about solar generation is already available on various websites via the APIs for receiving and analysing data [10]. This data was collected and used to find the optimal time for such a "smart home" device as a washing machine or other appliances. On a warm sunny day, and the amount of energy generated by solar power is too large. Thus, it would be good to use the washing machine in the room.

In the recent years, the environmentalists raised caution against burning fossil fuels causing global warming which is raising earth surface temperature by few degrees and sea levels by few cms which could drown few major cities across the world such as Miami, Shanghai, Osaka and other cities by 2100 [11]. This concern has let to global adaptation and pledge to reduce global warming. In this interest the grid has adopted various renewable sources of energy such as wind, solar, geothermal which have least carbon footprints. UK national grid expects to be least reliable on fossil fuels by the year 2030 by switching to alternate sources safe for environment [7].

Major source of electricity across the UK comes from the national grid. National grid is a central platform that collects and distributes electricity to homes and hubs [9]. The grid collects electricity from various sources such as coal, nuclear, wind, solar, geothermal, etc. The UK grid also have interconnectors from Norway, France, Denmark, Netherlands, etc to overcome the deficiency of the electricity supply during high demand days [12]. Over the day the amount of energy generated from each unit varies. The combination of all the sources of energy is adjusted for demand across the houses at different periods in a day [13]. The energy from the national grid is distributed to 14 Distribution Network Operators (DNO) who are responsible to transmit and distribute to local distribution via towers and cables [14]. The agile tariffs are set by DNO and collected from the households. All the data related generation, distribution and tariffs are available by Balancing Mechanism Reporting Service (BMRS) via open APIs [15].

Application Program Interface (API) allows multiple applications to communicate between each other. They communicate via request and response method. Modern day APIs adhere to HHTP and REST which can be treated as products to be used in the Software Development Lifecycle (SDLC) [16]. APIs add layer of security for transferring data since the data is only transmitted in smaller packets only when necessary. This reduces the risk of the cybercrimes while increasing security layers [17].

Solar-API offers an approach that focuses on using all the energy output and resources in the network [8], and a cheap intelligent home protection system, for security and video surveillance in the house, is powered by green energy [18]. However, so far not much work has come out in the field of renewable energy, predictions and should be used for smart home devices. To describe the current market, the generation is migrating towards renewable energy from conventional coal-based electricity generation. In many developed countries, the grid that provides electricity to millions of homes are dependent both on the renewable and non-renewable sources of energy. A webtool [19] based on the grid information displays the amount of energy generated from various energy sources at given point in time. The figure below shows the time chart of the energy demand vs production from various sources of energy in UK grid at 6:00 BST

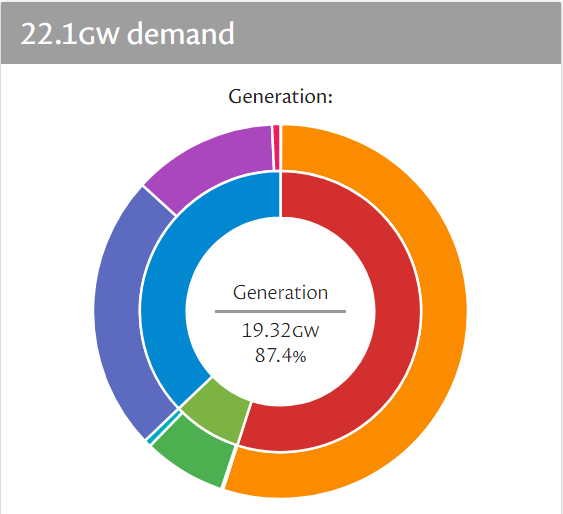


Figure Sample pie chart of demand vs grid generation differentiated by various energy sources

The amount of energy generated from various sources of energy varies during the day varies with the amount of the natural sources available such is solar energy, wind energy, geothermal energy, etc. These forms of renewable sources are available only during time of the day or year such as solar energy is available during the day light [18]. The renewable sources cost less than the conventional coal-based sources [19]. The grid also charges accordingly to the energy generation from these sources. These challenges make it difficult to completely rely on the renewable sources of energy for grid.

To make use of these renewable energy sources and make them cost-effective methods many households around UK and USA are using roof panels on their respective homes and using solar energy [20]. This only has a capital of installation charges where the solar panels price has also decreased in the recent years and efficiency of the panels has also increased thanks to the efficient manufacturing methods and mass production of these in countries like China [21]. Companies have produced inverters and storage batteries to save this energy generated by the solar roof panels. Inverters automatically switch from grid to the solar panel energy depending on the availability of the solar energy captured.

There are few companies/tools/apps which facilitate the use of the appliances to reduce the power bill and carbon footprint. We will explore the possibilities to capture the amount of solar energy from the photovoltaic cells spread over the farms. In this project we will try to build an app that notifies the user when to use the high-end appliances at home to save both money and environment. The app is based on the APIs available online which helps us fetch data. There are devices available for mass public to fix in their roof top homes to monitor the generation of the solar power and switch automatically from grid to the solar power if it generated enough power to run the house. They are broadly classified into 3-types:

**Solar-powered solar systems** [22]- these systems use an inverter to change the low DC voltage generated by photovoltaic modules into alternating current, the voltage, and frequencies that are required for the power supply can be 110 V or 230 V, 50 Hz or 60 Hz depending on the country in which you live. Power is therefore reversed at a higher voltage than the mains, so that energy flows online as well as its own electrical charge. If the current is turned off, the inverter will turn off to protect people who are working on the power lines, which means that there is an electric charge on the power supply.

**Off-Grid Solar Systems** [23]- These systems as the name suggests are not connected to the grid, instead they are built with large battery banks, and store the electricity generated by PV panels in these battery banks. These systems use electrical inverters to convert DC power from PV panels into AC power to grid power and the amount of land you live in. These systems are designed to power your cargo power from the PV system automatically, but only when one can power the power switch to connect the cargo to the power grid when the battery banks are removed and the PV panels also fail to generate power for any reason.

**Hybrid Solar Systems** [23]- These systems have been designed to provide the best of both systems described above. They are tied to the grid", meaning that they are not only able to push excess electricity back into the grid via a bidirectional electric meter, and at the same time, they will also be supplied with a battery pack. These systems can be programmed to control the load power from the default photovoltaic power output, and then use the excess power inside the capacity on the unit. And then every transition to the power supply can be transmitted to the network. And if the grid fails, solar panels and batteries feed the load, and photovoltaic cells and accumulators are not or do not exhaust, the electrical load will be fed from the grid. Such hybrid systems are much more expensive than the other two types mentioned above.

Existing smart home devices provided by various companies have enhanced the ability for consumers to watch their electricity spending day-by-day and appliance-by-appliance. These smart meters help the consumers to make ideal choices and change the patterns of consumption to reduce the electricity bills [24]. Another company named Agile Octopus has taken the battle step ahead to provide consumers with agile pricing and notify the users plunge pricings to save electricity bills and Octopus Go, tariff designed for EV owners offering super cheap night rates [25].

While there are several products available in the market none of them give an advantage to the customers by reduce carbon footprint while saving the electricity bills. This project focuses on the aspect to develop a software which make uses live/historic data available on the open APIs regarding the grid energy and recommend the user with appropriate timings to use the home appliances which saves both nature and money to the consumer.

Discuss about APIs

Discuss about Python

Discuss about web scraping

Discuss about time series forecasting

The detailed project plan and design are detailed in the following section.

# Software development

In the previous section the overall survey of the existing infrastructure and the opportunity available in the market are detailed. In this section I have detailed the project plan and the technical elements required in the project are highlighted. To summarise this section, have given brief idea of collecting data from open source APIs, ethical web scraping, time series prediction methods and optimisation methodology followed for the project.

The user story that defines the work to be done in the project:

As an Engineer, research and develop a tool useful to automatically the alert the user timings for the usage of washing machine while reducing carbon footprint and electricity bill

Description as a Gherkin Story:

**Agenda***: Develop tool to automatically alert the user to use washing machine*

**Scenario***: User wants to know the ideal time to use the washing machine at home*  
**Given***User’s home is connected to the grid which dynamically adjusts between the various sources of energy*   
**And***the information about the energy sources by percentage and the flexible tariff details are available*  
**When***user checks his mobile/email for the notification from the app*  
**Then***according to the alerts raised by the tool the user can use the washing machine or other high voltage appliances to save environment and cost*

The skeleton wireframe of the workflow is as follows:

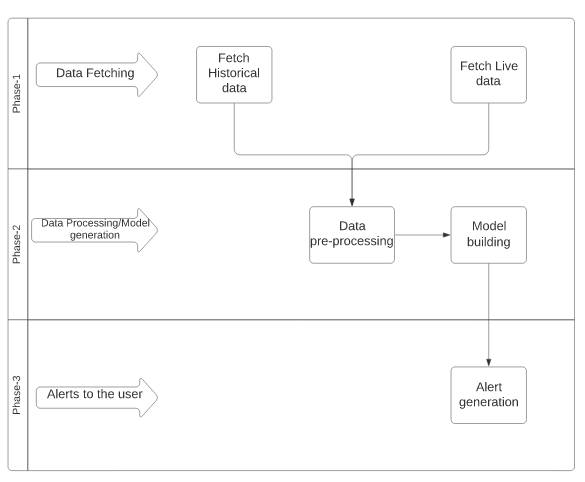


Figure Project wireframe

The user personal mapping is as follows:

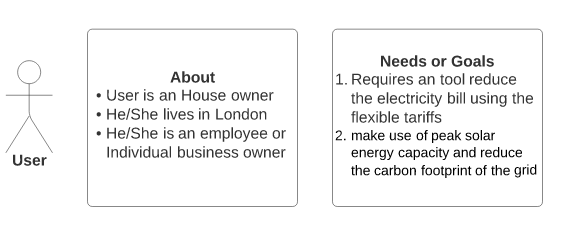


Figure User persona map

## Data fetching

The core of the project is fetching data from all the existing APIs. There are many rules to access the APIs. Most of them were open while premium data APIs are paid versions. According to programmable web [26] there are around 24237 APIs registered around the globe by 2021. There are many energy related APIs both free and paid. Since our objective of the project is to rely on open sources and related to energy data of United Kingdom.

## Data processing

## Time series forecasting

## Optimisation methods

## Recommendations

## Testing

# Results

# Future work and Conclusion

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