Project Requirements and Analysis of the problem.

The project is about the impact analysis of renewable energy adoption in the UK to achieve net-zero goals by 2050. By analyzing the data on renewable energy generation and consumption, the project will provide valuable information into the effectiveness of renewable energy adoption in reducing greenhouse gas emission and achieving net zero goals. The project will also highlight the best practices and policies that can be adopted by other countries to accelerate their progress towards net-zero targets.

In the project we have discussed the current scenario of greenhouse gas emission and also the impact of covid 19 on GHG emission. We have also given a brief description about emission from various sectors and the contribution of each sector to total greenhouse gas emission. By analyzing all these data we are getting a more clear understanding of how renewable energy can lead to net zero. We are putting forward the idea of hybrid microgrids for the transition to renewable energy sources. We are expecting that by implementing microgrid techniques along with this deep learning technique can help us find out the rate of energy needed with respect to time.

Literature Review:

Introduction:

After the Paris agreement 2015, countries around the world have set net-zero targets, which aim to balance the amount of greenhouse gas produced with the amount removed from the atmosphere. Transitioning to renewable energy sources is seen as a key solution for reducing greenhouse gas, as they have a low carbon footprint and are sustainable over the long term. The "Impact analysis of renewable energy adoption in the UK on their net-zero goals" project aims to study the impact of renewable energy adoption on the UK's progress towards its net-zero targets.

Net zero Goals:

Net zero can be defined as cutting GreenHouse Gas emissions as much as possible to zero, with the remaining emission to be reabsorbed by trees. Climate change is the most important problem faced by today's world and to reduce the effects of global warming, it was decided in the Paris Agreement of 2015 to reduce GreenHouse Gas emissions by 45% by 2030 and reach net zero by 2050. The energy sector is one of the major contributors and the place where we need to focus more to reach net zero.

Replacing traditional energy resources like fossil fuels, and burning coal with renewable resources (Wind, Hydro, Solar) will reduce GHGemissions drastically.(Benham-Crosswell, 2021)

Renewable energy and its importance:

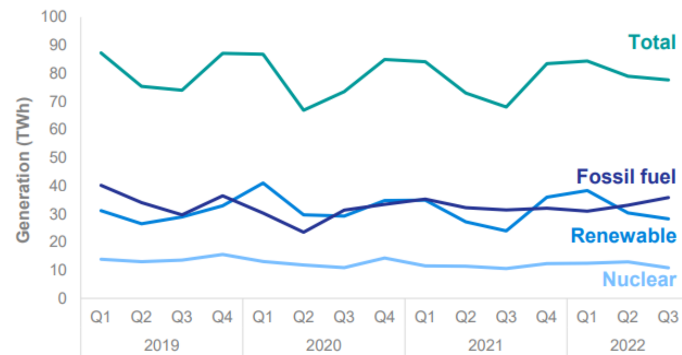
Renewable energy is the energy generated from natural resources which can be replenished at a higher rate than it consumed and creates far lower emissions compared to fossil fuels when generated, for example, solar energy, wind, hydro, etc. Renewable energy is inexhaustible and cost-effective, it reduces overseas dependence, creates new economic opportunities, reduces living cost, and creates local job opportunities. Even though it has so much importance, the most important one is that renewable energy is clean, it comes from clean sources such as sun, water, and wind. It is the cleanest alternative energy available. Transitioning to renewable energy will strengthen the energy system thereby uplifting the community.

Renewable energy in the Uk plays a significant role in electricity, transport, and heat generation. Renewable energy started playing a vital role in Uk's energy production sector from the mid-1990s onwards. Wind power has become the main source of renewable energy in the UK. By 2020, renewable sources generated 40.2% of the electricity produced in the UK, around 6% of total energy usage. With the UK aiming to reach net zero by 2050, a crucial part of the strategy is clean power generation. Increasing the energy from renewable energy and lowering carbon emissions will make sure that Uk has a stable and secure energy supply. (Boyle, 2004)

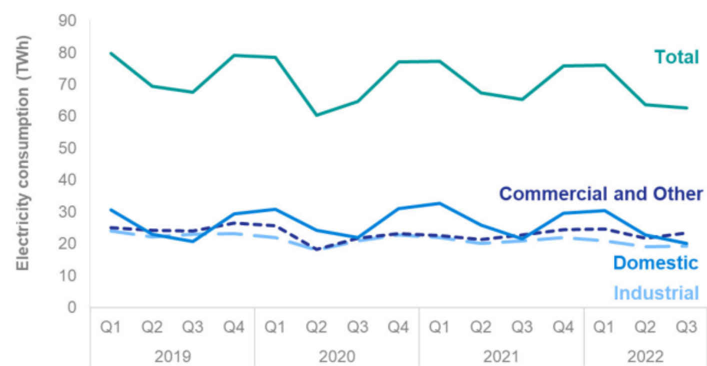
The UK has emitted about 3% of the total human-caused CO2 in the world, even though the population is less than 1%. A significant decrease in GHG emissions can be seen from 1990 to 2020. In 2020, total greenhouse gas emissions in Uk were estimated at 405.5 million Tonnes of CO2, which is 9.5% less compared to 2019 and 49.7% compared to the 1990s. The covid 19 impact can be seen in this estimation. Covid 19 and its restrictions had major impacts on different sectors of society, which led to significant impacts on GHG emissions. We can see that this decrease is from the reduction of GHG emissions from transport, decreased demand for energy supply, industrial processes, waste management, etc.

Various resources for electricity generation:

Compared to previous year electricity production in Q3 has increased by 14% to 77.7Twh. The most interesting part is that about 50% of the electricity comes from low carbon emission sources such as Renewable resources and Nuclear sources. Renewable resource generation was 18% higher than last year. But still in the total electricity generation the renewable energy is slightly lesser since the demand for the electricity in 2022 increased and it was satisfied by the increase in fossil fuel usage.()

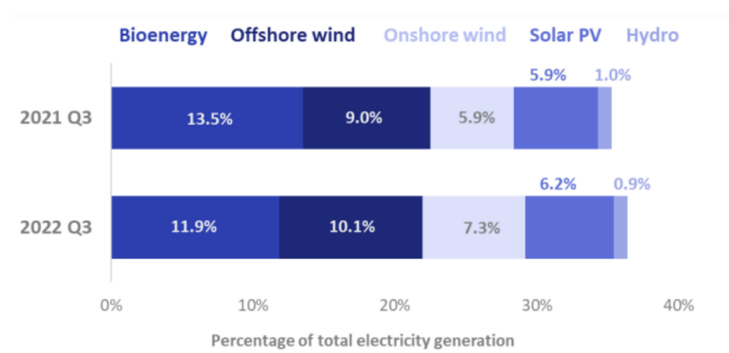


Energy consumption by sector:



Total energy consumption of 2022 is less than 2021 by 4.5%. Both domestic consumption and industrial consumption in Q3 decreased by 7.1 and 7.8% respectively.

Major contributors of renewable energy:

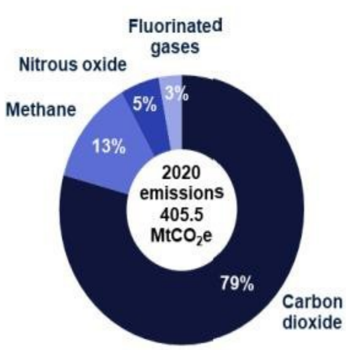


Comparing 2021 and 2022 Q3, the wind energy and Solar energy increased slightly whereas the bioenergy is decreased by 1.6% (Mcgarry, 2022)

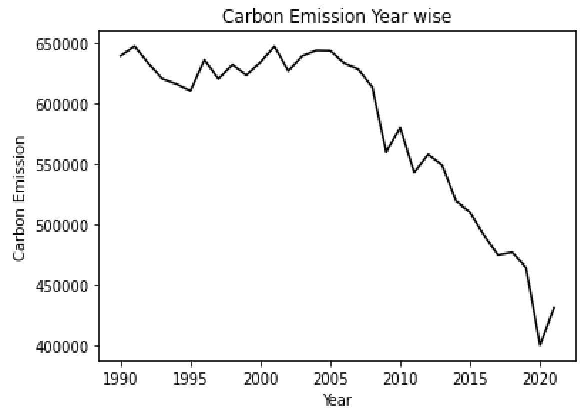
2020 Total Green House Gas Emission

2020 faced the largest fall in GHG emissions since 1990 due to the covid 19 impact. Even though there were significant falls seen in 2009 and 2011,2020 is considered to face the largest fall in GHG emission, which is 49.7% lower than that in 1990. Although it's impossible to calculate the exact size of the reduction in all factors during covid 19, we can surely say that there was a major impact in the transport and energy sectors.

When broken down by gases, UK GHG emission is dominated by CO2, which is estimated to be 79% of the total GHG production in 2020. The rest of the GHGs like CH4 form 13%, N2O form 5%, and fluorinated gases from the rest.



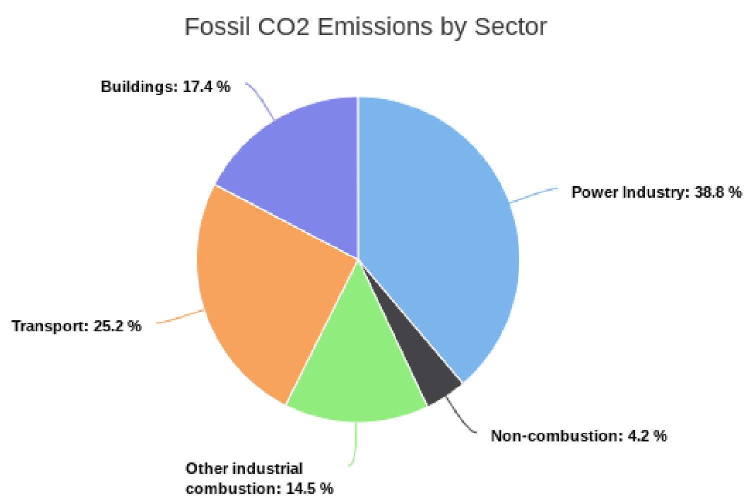
CO2 has always been the dominant GHG emitted in the UK. The emission of CO2 has been reduced by 47% in 2020 compared to 1990. There has been a significant decrease in other GHG emissions. (Waite, 2022)



In 2020 it is estimated that 28% of greenhouse gas emissions were from the transport sector, 25% of emissions is from the business sector, 23% from the residential sector, and 11% from the agriculture. (Department of business, Energy & Industrial strategy, 2022)

Emission by sector

Historically, the energy sector had the highest GHG emission, but during the last few decades, the transport sector has taken its place.



Transport

The transport sector have been the second most emitting sector till 2016, after which it reached the first position surpassing the energy sector. The transport sector consists of emissions from road transport, railways, air, and water transport. It is estimated to be about 28% of the total GHG emission in 2020, entirely through CO2 emission. The main source of emission is fossil fuels.

Transport emissions fell by 19% between 2019 and 2020. Before 2020, there was never a significant decrease in GHG emissions in the last few decades. There was only a 5% decrease in GHG emissions from 1990 to 2019.

Greenhouse gas emission reached their peak in 2007. The graph shows a steady increase in GHG emissions till 2007 after which it started decreasing till 2013. After 2013 it started showing an insignificant increase in emissions. There is a significant decrease in 2020 due to covid 19 restrictions.

Road transport contributes more to CO2 emission in this sector, passenger cars being one of the main reasons. Motor vehicle traffic volume had a general increase during the period. Again, the covid 19 impact on road transport can be seen in 2020. There was a fall in the number of vehicles used during the pandemic period. With low petrol consumption and improved efficiency of petrol and diesel cars, emission by passenger cars has decreased.CO2 emission is related to the amount of fuel used, while N2O and CH4 emission depends on the type and age of the vehicle.

A considerable decrease in emissions can be seen in air, water, and railway transport during the pandemic time. Emissions from aviation fell by 60%, railways fell by 22% and domestic shipping fell by 13%.

Energy supply

The energy supply sector consists of emissions from fuel combustion for electricity production and other energy production resources. It handles almost 21% of GHG emissions in the UK in 2020, with CO2 being the most prominent factor. The major contributor to the energy sector is power plants. But since 2016, there could see a slight decrease in emissions from the energy sector, because of the use of renewable resources for power generation, improvement in technology, etc. since the last few decades there has been a significant decrease in the use of coal in power stations, which led to a reduction in CO2 emission. Dependence on power stations for generating electricity has been reduced by the increasing use of renewable sources for energy generation.

Manufacturing

The manufacturing sector occupies the third position in GHG emissions. Emission from this sector is primarily due to the combustion of fossil fuels in industry. Even though carbon occupies the prominent position of GHG emission in industries, the manufacturing sector is the largest producer of Florine gases. The heavy industry sector is still a challenge for reaching net zero because of its increasing demand. A major trend in GHG emission reduction can be seen from 1990 to 2020 due to distinct reasons. There has been a rapid rise in net zero announcements from companies in recent years. Around 40% of companies that have announced net zero pledges are yet to announce how they plan to achieve this.

And for those who have announced their detailed plans include direct emission reduction, use of co2 removal technology, etc.

Domestic

The domestic sector consists of emissions from heating, cooking, and other household activities.

CO2 is the most prominent gas in the sector. The main cause of emissions from this sector is the use of natural gas for heating and cooking. The CO2 emission in this sector is influenced by external factors like temperature, a decrease in temperature leads to more heating. The domestic sector is the only sector that faced a 1% increase in emissions during the pandemic, due to the restrictions imposed.

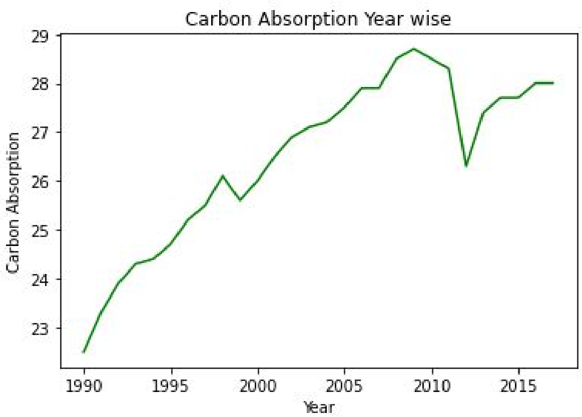
Others

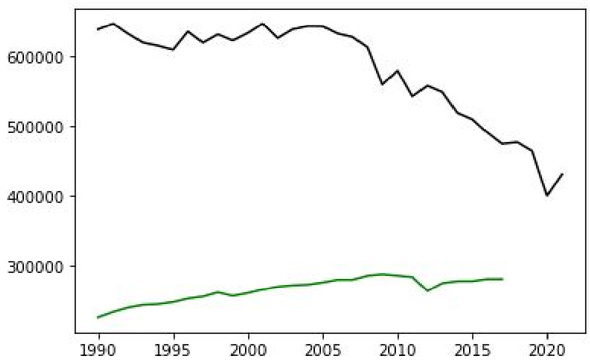
Apart from the transport sector, energy sector, and domestic and manufacturing sector, there are many other contributors to GHG emissions. The public sector, agricultural sector, and waste management are a few of them. The agricultural sector consists of emissions from livestock, various machinery, etc. Nitrous oxide and fluorine gases are the major GHG produced in this sector. The waste management sector holds emissions from waste disposal, wastewater treatment, etc. Methane is the prominent GHG produced in this sector. The public sector consists of emissions from combustion in public buildings like schools and hospitals. Carbon dioxide plays a prominent role in this sector.

All these sectors are experiencing a reduction trend in emissions due to the ongoing transition from traditional resources to renewable resources. Even though a prominent decrease can be seen in 2020 because of the pandemic, CO2 emissions will quickly rebound from their dip. Despite the small rebound, an advanced economy like the UK is expected to have a one-third decrease in CO2 emission between 2020 and 2050 because of the impact of policies and technological progress in reducing energy demand and switching to clean energy. (Thomas, 2020)

Green House Gas removal:

The carbon removal is constantly increasing over the years. But the rate of increase is too low and needs some acceleration to attain net zero. The vegetation for the year 2017 is 28 MtCo2 whereas the emission in the same year is 480 MtCo2 which is almost 17 times higher. To reach net zero the carbon vegetation should be equal to or greater than the carbon emission, for which we need a lot of procedures and measures to be taken both by the individuals and government. (Ainslie, 2019)



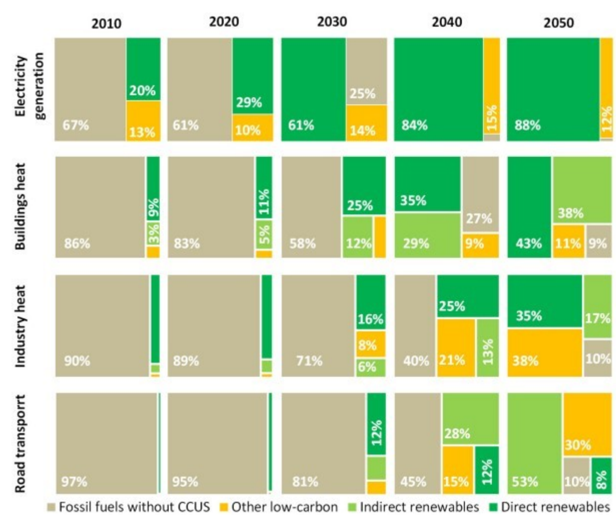


Solution Outline

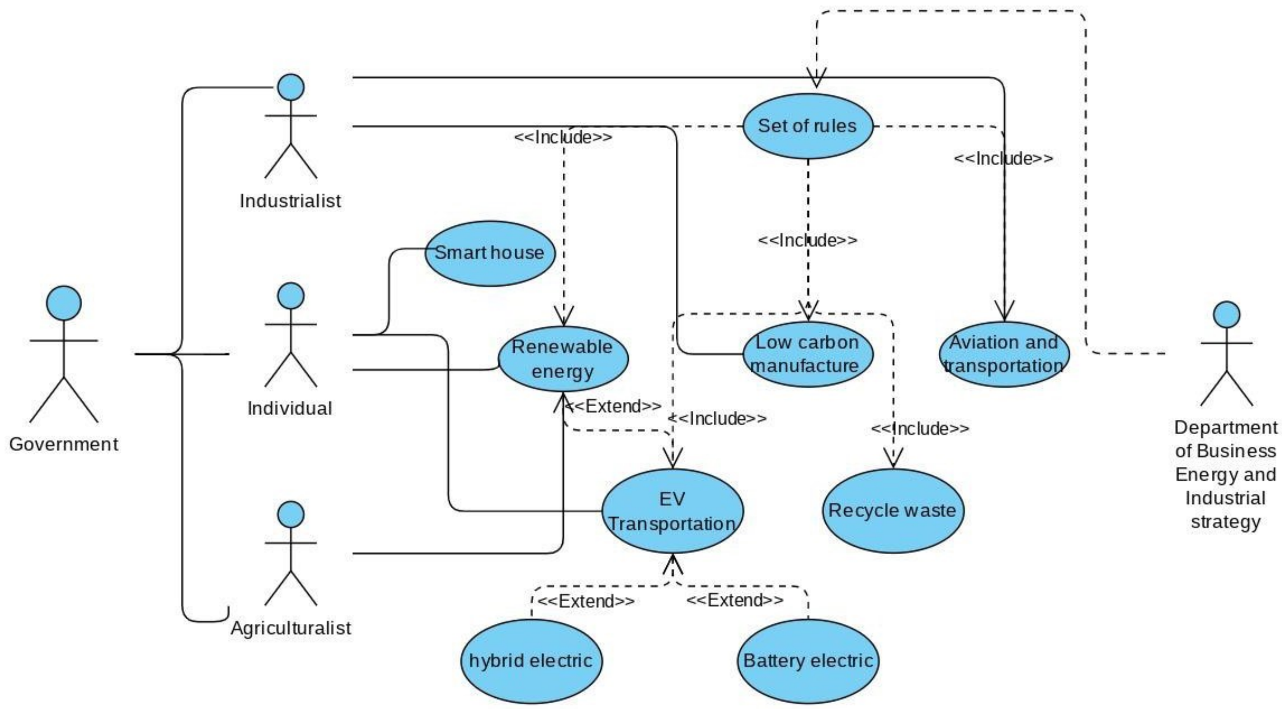
Achieving energy transition compatible with achieving net zero is unquestionably a formidable task. To achieve NZE by the next 30 years a broad range of policies and technologies are needed. The key pillars of decarbonization will include energy efficiency, transition to clean energy sources, behavioral changes, carbon capture, utility, and storage. At a global level, renewable energy technologies are the key to reducing CO2 emissions in the energy sector. Hydropower has been a low-emitting source for many years, but the expansion of wind and solar power will increase energy generation threefold by 2030 and eightfold by 2050 thereby playing a key role in reaching net zero emission.

Renewables play a vital role in reducing emissions from buildings and transport apart from electricity generation. In the transport sector, renewable energy plays a direct and indirect role in reducing CO2 emissions. The indirect role is by reducing emissions by generating electricity to power vehicles, the direct role is through biofuels. In buildings, renewable energy is used for water and room heating. Solar energy plays a significant role in that. Rooftop solar panels are installed in about 25 million buildings, which will increase to about 240 million by 2050.

Bioenergy is the most significant direct renewable energy in industry. Solar energy and geothermal energy also play a key role in supplying heat in non-energy-intensive industries. All these three combined will meet about 15% of the industry demand by 2030, and it will double by 2050. The indirect use of renewable energy through electricity will also add to it.

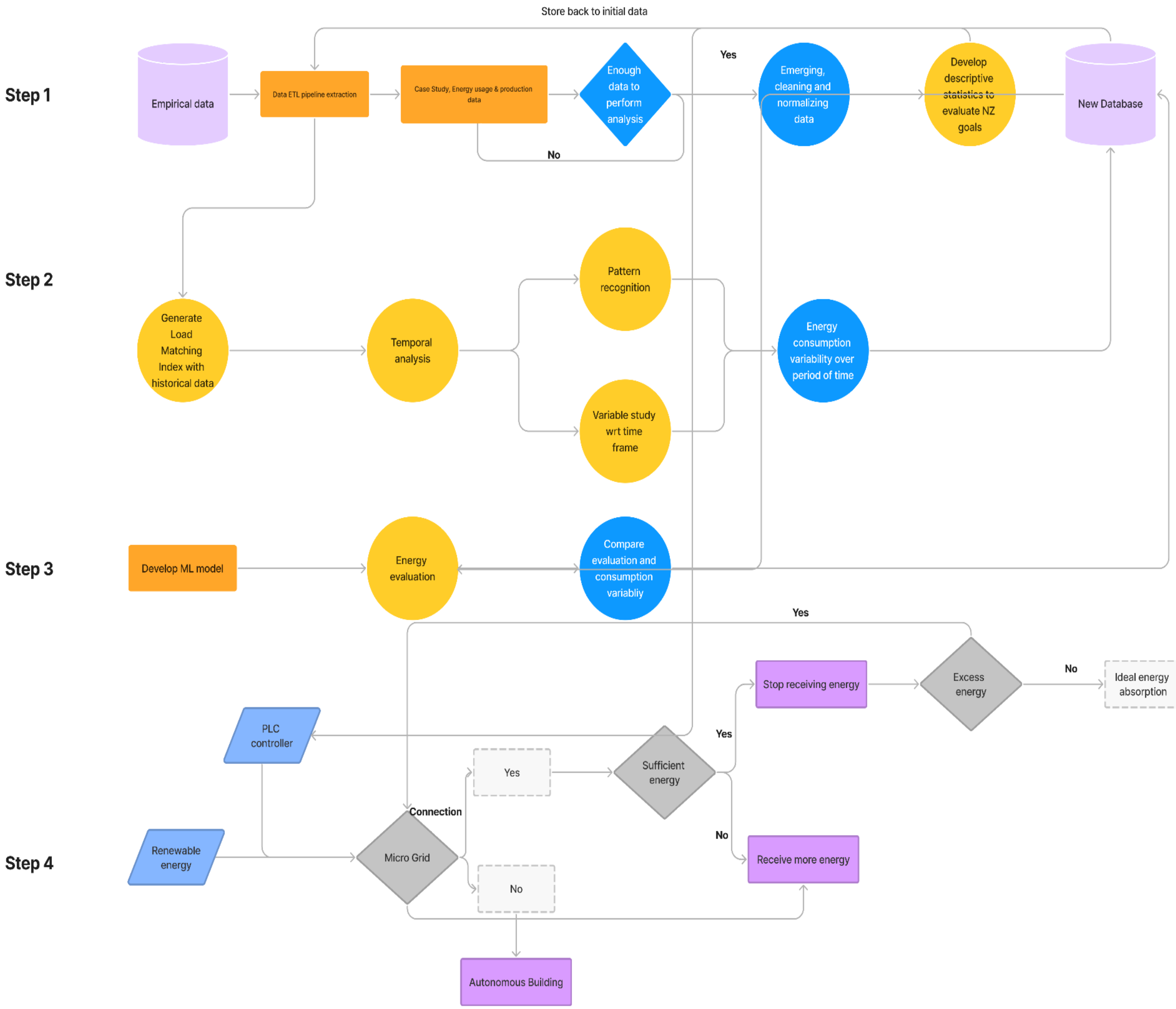


Use case diagram



The use case diagram explains the measures that are to be taken by the government to attain the net zero. It also defines the various set of rules that must be implemented by the department of Business Energy and Industrial Strategy to every individual and make them understand their role and contribution for Net Zero carbon emission by 2050. It includes all the sectors like Transportation, Manufacturing industry, Electricity Energy etc. It also describes the roles of an agriculturalist since 5% of the carbon emission is from agriculture for the past few decades and no measures were taken to reduce it.

Flowchart:


Store back to initial data
Step 1
Empirical data
Data ETL pipeline extraction
Case Study, Energy usage & production data
Enough data to perform analysis
No
Yes
Emerging, cleaning and normalizing data
Develop descriptive statistics to evaluate NZ goals
New Database
Step 2
Generate Load Matching Index with historical data
Temporal analysis
Pattern recognition
Variable study wrt time frame
Energy consumption variability over period of time
Step 3
Develop ML model
Energy evaluation
Compare evaluation and consumption variabliy
Yes
Stop receiving energy
Excess energy
No
Ideal energy absorption
PLC controller
Yes
Sufficient energy
Yes
Connection
Step 4
Renewable energy
Micro Grid
No
No
Receive more energy
Autonomous Building

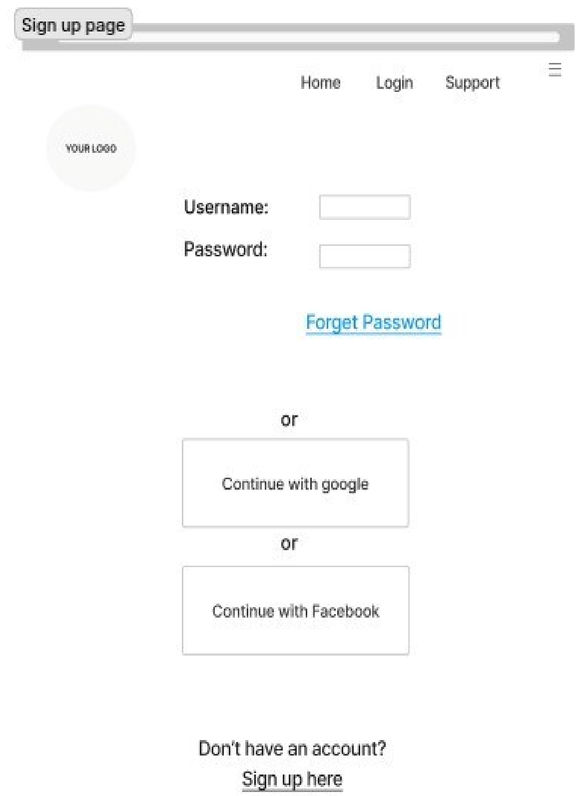
The figure shows our flowchart for impact analysis of renewable energy adoption in the UK to reach net zero goals.
The entire process is divided into 4 steps through which we reach our output.

In step 1, we extract data from the available empirical data using the ETL pipeline. An ETL pipeline is used to shift data from single or multiple sources into a database such as a warehouse. ETL stands for extract, transform, load - three independent processes of data integration to pull data from one source and put it in another. From this extracted data we use the case study, energy usage, and production to develop descriptive statistics to evaluate net zero goals.

Step 2 is temporal statistical analysis. We generate a load-matching index from the extracted data and do a temporal analysis. The temporal analysis enables us to examine and model the behavior of a variable in a dataset over time. So, we do the pattern recognition and variable study concerning time and get energy consumption variability over time as output.

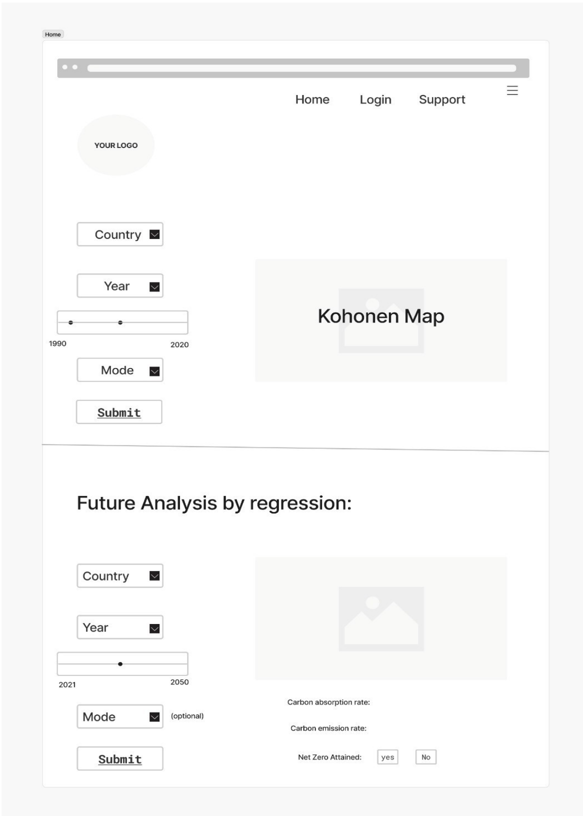
Step 3 is developing a machine learning model and doing energy evaluation. Then we compare the energy evaluation and consumption variability. The output from the first 3 steps is added to a separate database. The first three steps show the descriptive statistics to evaluate net zero goals, energy consumption variability over time, and energy evaluation.
Step 4 shows the amount of energy expected to be produced from renewable energy sources by implementing a microgrid. The data from the new database which holds the output from the first 3 steps are given to the PLC controller which further controls the energy input that should be given to each grid.

Wireframe
Login Page



Already existing users can log in using their user id and password, or they can continue with their google or Facebook accounts. If the user is new, they can sign up here.

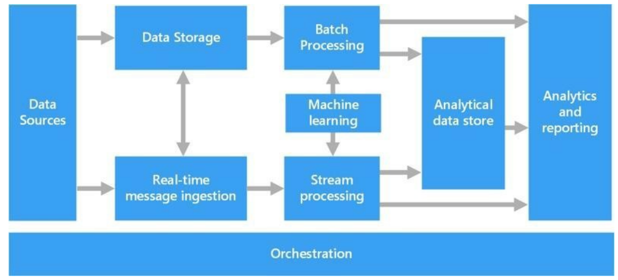
Home page



The user can choose independently one or more countries, discrete or continuous years, and modes for which they need to find the carbon emission and absorption rate and trend. A graphical representation will be supplied according to the user input using the Kohonen map. The users can visualize the future carbon emission and absorption prediction through the page.

Architecture

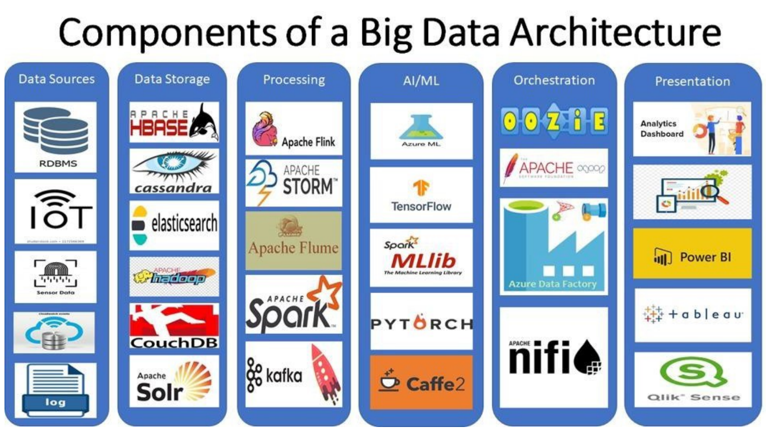
Data analysis procedure and architecture



The architecture for data analysis is a structured approach that involves collecting, preprocessing, exploring, modeling, evaluating, and deploying data to generate insights and make informed decisions. It includes several steps including data collection, data preprocessing, data exploration, data modeling, model evaluation, and deployment.

All big data solutions start with one or more data sources, this can include data from both rational and real-time sources. Real-time message ingestion is the first step for the data coming. Data is prioritized and categorized in this step. An all-encompassing big data platform requires a strong, linearly scalable data store because this layer is where the large data is received. It obtains data from various other resources and stores them, and this will help us redefine the data according to the system's needs. Following the system's needs, this layer can even alter the data's format.

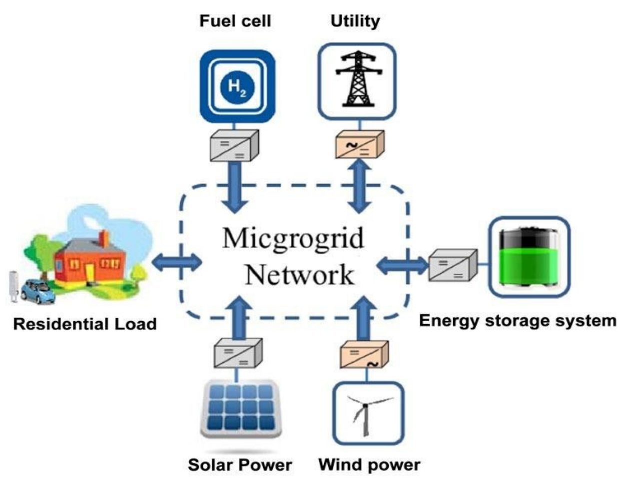
The next step is batch processing. The big data architecture usually uses huge batch operations to process data files to filter, combine, and get the data ready for advanced analytics because the data sets are often so vast. These tasks often include reading files, pre-processing them, and publishing the obtained results to fresh files. The well-proven batch processing architecture provided by Apache Hadoop and its MapReduce processing engine is best suited for handling bigger data volumes where speed is not a major consideration. Compared to Hadoop MapReduce, Apache Spark can perform programs up to 100 times faster in memory or 10 times faster on disc. Spark currently supports the following languages: Scala, Java, Python, and R.



After processing the generated data must be stored in the data store. Analytical data is best stored in a Data System designed for heavy aggregation, data mining, and ad hoc queries, called an Online Analytical Processing system, OLAP. Mostly big data solutions prepare data and then serve the pre-processed data in a structured format that can be used to obtain insights using various analytical tools. Some of them are Apache Druid, Apache SOLR, and others.

The goal of most big data solutions is to supply insights into the data through analysis and reporting. To empower users to analyze the data, the architecture should include a data modeling layer. The ultimate step is orchestration. Most big data solutions consist of repeated data processing operations, encapsulated in workflows, that transform source data, move data between multiple sources and sinks, load the processed data into an analytical data store, or push the results straight to a report or dashboard. To automate the workflow, orchestration technologies were employed.

What is the solution for renewable energy adoption?
Microgrid



Microgrid is a small-scale power supply network designed to provide power for a small community. It enables local power generation for local loads. It consists of multiple tiny power-generating sources that make it highly adaptive, eco-friendly, and efficient. It is connected to the local generating units and the utility grid, thus preventing power outages. Excess power can be sold into the utility grid. The size of the microgrid may range from housing estate to municipal region. Microgrids consist of four components - local generation, loads, energy storage, and point of common coupling. Local generation It presents distinct types of generation sources that feed electricity to the user.

Microgrids consist of four components

Local generation

It presents distinct types of generation sources that feed electricity to the user. Renewable generation sources include wind turbines, solar, etc.

Consumption or loads

It simply refers to elements that consume electricity. In the case of controllable loads, electricity consumption can be changed to the network's demand.

Energy storage

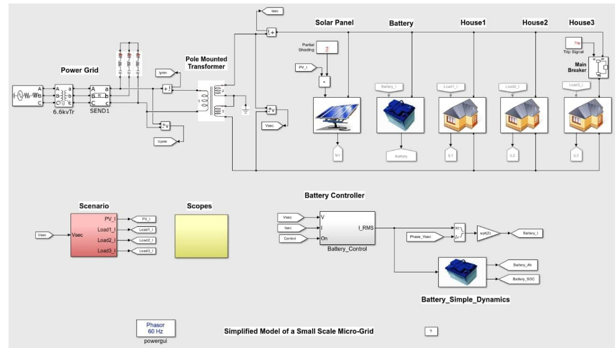
In microgrids, energy storage can perform multiple functions, such as ensuring power quality including frequency and voltage regulation, smoothing the output of renewable energy sources, supplying backup power for the system, and playing a crucial role in cost optimization. It includes all electrical, pressure, gravitational, flywheel, and heat storage technologies.

Point of common coupling (PCC)

PCC is one of the points in an electric circuit in which the microgrid is connected to the main utility grid. Microgrids that do not have PCC are called isolated microgrids.

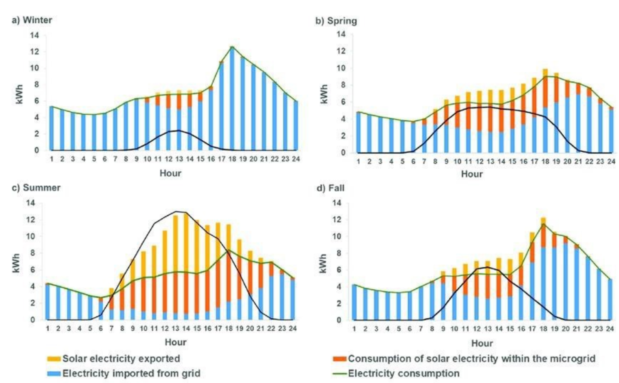
Working

The working principle of a microgrid is controlled by an artificial energy management system (EMS), which distributes the use of the available energy resources and ensures that the system meets the energy necessity of the connected loads. The EMS continuously watches the electricity demand, and the availability of energy resources and makes decisions on how to balance the energy supply and demand.



When there is excess energy available, the EMS can store it in energy storage systems or export it to the main power grid. When there is a shortage of energy, the EMS can start backup generators or draw energy from the energy storage systems. In this way, a microgrid can provide a reliable and resilient power supply to the connected loads, even during power outages or other disturbances.

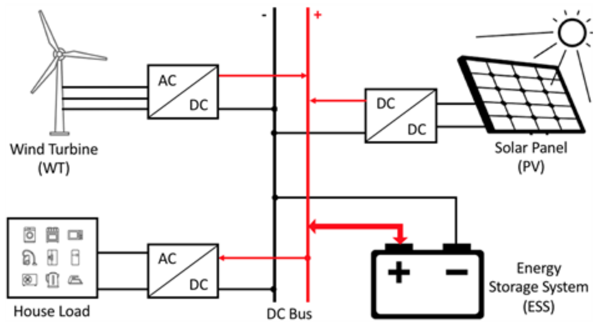
Microgrids are becoming increasingly popular in remote or off-grid areas where the main power grid is unreliable or unavailable. They can also be used in urban areas to supply backup power or to reduce the reliance on the main power grid during peak demand periods.



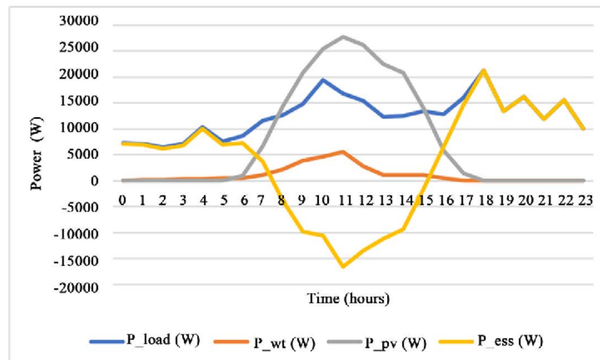
This image shows the result we obtain when we use the solar panel. It is clearly shown that the electricity is not constant. It is mandatory to look for an alternate solution in winter. The amount of energy produced by PV cells is less than the energy needed.

Hybrid microgrid:

The solution to this can be a hybrid microgrid. The hybrid microgrid is a combination of both solar and wind energy which would be more efficient, and we don't need to depend on any other resources.



In hybrid systems, the excess power in the daytime is stored in the battery storage and used back up when necessary. The performance of hybrid systems is far better than that of PV microgrids.



time. This can reduce energy wastage due to their transportation.

Evaluation:

According to facts, 20% of the energy from renewable resources in the past was wasted because of improper energy estimation and sending excess energy back to the utility grid. Implementing the microgrid along with this deep learning technique can help us figure out the rate of energy needed concerning the time. This can reduce energy wastage due to their transportation.

The inclusion of these practices will help us to utilize the natural renewable resources and reduce the carbon footprints. But to achieve net zero as we discussed earlier, the carbon emission should be drastically reduced with the similar trend it had since 1990s and at the same time we need to increase the vegetation, air-capture, carbon-capture and storage to get closer to the goal in future.

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