Using Python for Energy Mix analysis in the UK between 2009 and 2023

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Abstract:

This study investigates the variation of electricity generation from different sources in the UK between years 2009 and 2023. Analysis was made by implementing Python code to analyse the Historic Generation Mix & Carbon Intensity data from the National grid ESO website. The analysis focuses on the changes of electricity generation for different energy sources, including gas, coal, nuclear, wind and solar. The research results show the considerable increase in electricity generation from alternative sources like wind and solar and decrease in usage of gas and coal, which is related to environmental policies and government goal of becoming Net-Zero by 2050.

Introduction:

This study aims to analyse the daily fluctuations from the National Grid ESO during the period of 2009 and 2023. The goal is to compare the production of energy of different sources, including gas, coal, nuclear, wind and solar, understand what caused changes in the levels of production. Python code was written to read data from the file, extract it and visualise it using matplotlib and datetime libraries. The code was written by the set of instructions given on the CoCalc 'Final project' notebook, part B. Method section explains how the code was written and gives an explanation for each line of code written. Results section shows the graph of energy variation and explains the reason for the fluctuation in energy generation.

Method:

Data set was analysed and visualised by using the python code. The datetime library was used to create datetime objects in a time format identical to a data file. The function with four parameters, readDatabyDate, was created to read in data line by line between two dates. Four parameters(f, startDate, endDate, col) include opening a file in reading mode, start date, end date and column index in a file. Inside the function the file was opened in a reading mode and assigned a value f, returned the next value to the iterator using the 'next' function. Two lists named 'dates' and 'column_values' were created. The for loop was then created to extract the dates in given range. Inside the loop rows, values in the data file were extracted by using strip and split functions, which broke up the string and returned the list of all strings. The date column have been called by indexing rows with 0 ([0] in python). The date was then assigned a format, using the strip time function. Another if loop was created to set the boundaries in which data should be analysed, in this case between the given start date and end date. For the data inside the time range, dates and column_values lists were appended with dates and corresponding energy values and returned. When this function is called, the output will give the date and corresponding energy generation value of some source, which depends on the value assigned to col parameter.

In the next part of code, the function with four parameters (startYear, endYear, dates, column) called averageByYear was written. The function calculates the average value of a given column over a specified range of years between startYear and endYear. The function first calculates the number of years in the year range by using the difference between the endYear and startYear, adding one to include the starting year. It creates two lists, entries and total, with length equal to the number of years in the range. The entries list keeps track of the number of entries in the column, and the total list keeps track of the sum of the values in the column for each year. A for loop was then created to analyse the data within the given time range. After the loop finishes, the function calculates the average value for each year. It creates an empty list called output, loops through each element total and entries lists. If the number of entries for the current year is 0, it appends 0 to the output list. If it is not 0, it calculates the average value for the year by dividing the total by the number of entries and multiplying by 48 (due to the fact that data was given in 30 minutes intervals), and appends the result to the output list. Then the function returns the output list containing the average values for each year in the specified range.

The final piece of code imports the matplotlib library. It then defines startDate and endDate as datetime objects representing January 1, 2009 and December 31, 2023, respectively. An empty list called years is then created. The code opens a file and reads data by date using the readDataByDate function which was defined previously for different energy sources: gas, coal, nuclear, wind, and solar using different column indices. The averageByYear function is used to calculate the average daily energy generation for each energy source over the entire time range. The resulting averages are stored in the variables called gasavg, coalavg, nuclearavg, windavg, and solaravg. The graph was plotted using plt.plot function, with years as x values and average daily electricity generation in kWh as y.

Results:

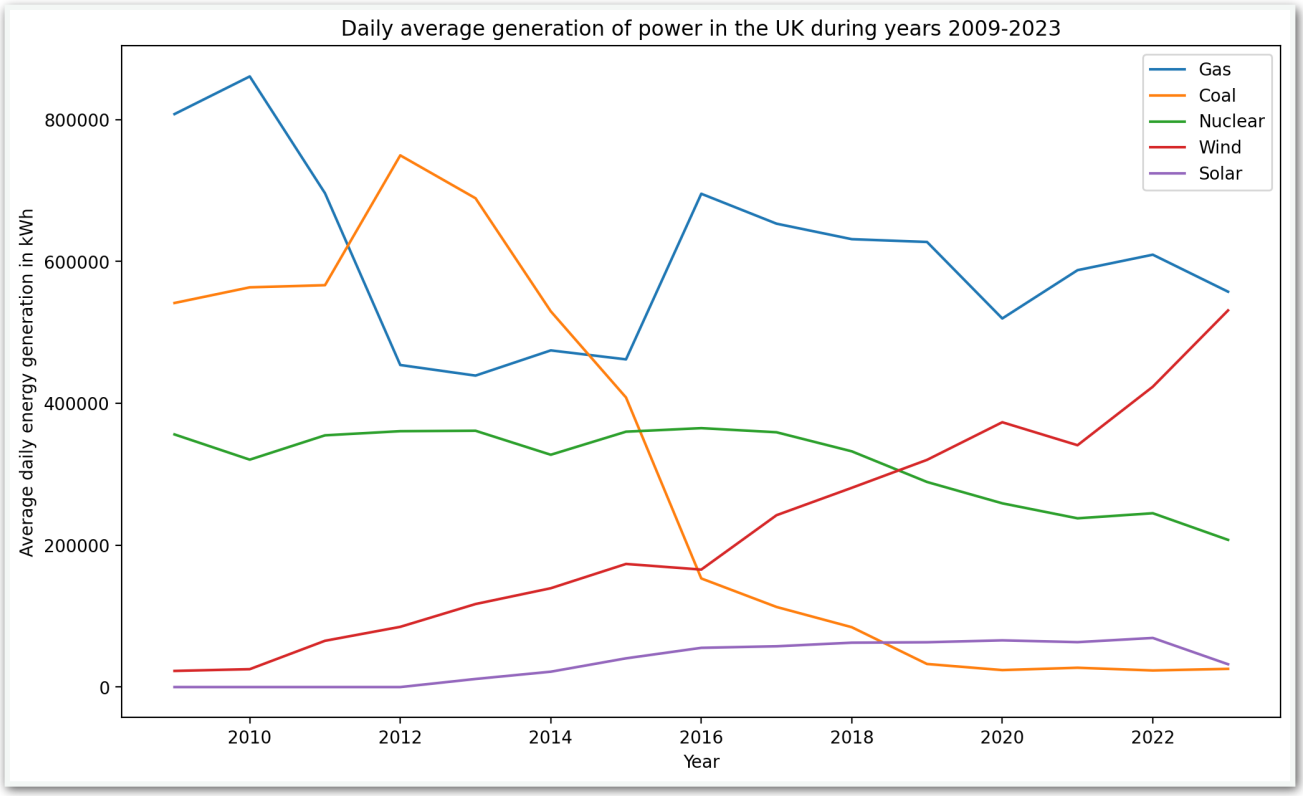

Figure 1: *The graph shows average daily generation in kWh for the gas, coal, nuclear, wind and solar energy generation sources throughout the period from 2009 and 2023.*

Almost all energy generation sources varied significantly during the span of 15 years. Usage of coal to generate electricity reduced drastically over the time period, due to recognition of environmental impact and increase of usage of alternative energy sources, mainly wind farms. UK set the goal of becoming coal-free by the year 2024, which represents rapid decrease in the graph [1].

Amount of energy generated using wind power increased from nearly zero to almost 600000 kWh a day. UK plans to reach Net-Zero by the year 2050 by transitioning to alternative energy generation sources, of which currently the biggest contributor is wind, which amounts to 26.8% of total energy generated in UK as for 2023 [2].

The solar energy generation stayed at zero mark until the year 2012, after which gradual increase followed. The reason for its increase is due to the reduction of solar power cost by 70% since year 2010. It is now the cheapest source of electricity around the world, including UK [3].

The nuclear power generation has declined gradually from nearly 400000kWh to approximately 200000kWh a day throughout 15 years. UK government set to close most of the existing power plants before 2030 due to inefficiency. New designs for nuclear power plants will require further development and will not be available at least for the nearest decade because of projects overrun in cost and time, hence decreasing trend can be observed in the graph [4]

The gas energy generation has experienced rapid fluctuations over the given time period. It was the biggest energy contributor on average throughout the time period. Due to the decrease of gas reserves in the North Sea, the energy production has decreased from 800000 kWh to 600000 kWh a day [5]. The rapid changes in the graph represents the implementation environmental policies and the falling consumption of this type of energy [6].

Conclusion:

The analysis of National Grid Historic Generation Mix & Carbon Intensity data was performed in this study. To read data from the file, extract it, and visualise it using the matplotlib and datetime libraries, Python code was created. The code used two functions in total: one to read the data between two dates and the other one to calculate the daily average energy generation over the years.

Data from the National Grid ESO website was visualised and analysed for gas, coal, nuclear, wind, and solar energy generation sources. The thorough investigation of the graph showed how different external factors like environmental policies, reduction of consumption and reduction in gas reserves impact the energy production levels for different energy sources. The results showed a significant reduction in coal usage and an increase in wind power generation. This aligns with the UK's goal of becoming coal-free by 2024. It is evident that the UK is moving towards cleaner energy sources, such as wind and solar, as reflected in the data.

This scientific paper could be improved by analysing bigger amount of data by including different energy sources, as well as taking bigger time period for analysis of the data. The changes can also be implemented to a Python code like including the functions for additional data analysis, like analysis by date and improving overall efficiency of the code.

References:

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