Briefing Note on Energy Market Analysis

Executive Summary

The purpose of this briefing note is to explore development trends in the energy sector globally and in the UK, focusing on wind and solar energy production. It addresses the adoption rates of renewable energy sources and trends in energy categories using robust data analysis from the UN global energy dataset. The analysis of question 1 utilised data from 2017 through 2021 to capture recent investments due to policy changes. Subsequent questions were analysed using data from 2011 - 2021.

Global Trends in Wind and Solar Energy Production (Response to Question 1a)

- Currently, China leads the world in both wind and solar energy production, with over 3 trillion Kilowatt-hours generated, illustrating the country's plans to increase renewable energy generation by 50 percent by 2025 (Energy Foundation China, 2022).

- In terms of aggressive investment, Zambia and Argentina are leading the pack in solar energy investments, with compound annual growth rates (CAGRs) exceeding 400% and 200%, respectively.
  For wind energy production, Kosovo has the highest CAGR of over 300%, indicating aggressive investment in wind energy. See *appendix A1* for chart.

Response to Question 1b.

- The total net installed capacity data is best suited to presenting the global energy mix by country. This is because it contains comprehensive observations about the various energy sources in each country. To generate the cluster for the energy mix, the ratio of the combined consumption of wind and solar energy to the total net installed capacity was calculated.

- Clustering algorithms like K-Means and Hierarchical Clustering are well-suited to grouping data into naturally occurring groups, which is essential for analysing countries based on their energy mix. Details can be found in *appendix B1*.

Trends in the UK – (Response to question 2a)

The use of wind and solar energy was compared to that of combustible fuel between 2011 and 2021. A steady decline in combustible fuel capacity was observed, while solar and wind power grew steadily. In the UK, however, wind has been observed to have grown significantly more than solar. With the growth in wind energy and reduction in combustibles, the UK is aligning its aggressive investments with the 2050 Net Zero target. The trend is illustrated in *appendix A2*.

Observed patterns in Flows (Response to 2b)

- **Energy production:**

There was an overall increase in the total installed capacity of electricity from 2011 to 2021, which may indicate investment in renewable sources. However, a decreasing trend in the UK's energy production over the years was observed. The decline was found to be associated with increased imports. Electricity imports consistently exceeded exports throughout the period, leading to a positive net import each year. Thus, indicating the UK's heavy reliance on imports. Such a rise in net imports signals a need to evaluate the competitiveness of domestic electricity. Energy and distribution companies might consider diversifying their energy mix, investing in renewable sources, or becoming more involved in the import market.

- **Household Consumption:**

Household electricity consumption fluctuated but showed a slight decreasing trend overall. The decrease in household energy consumption may reflect better energy efficiency in homes. Real estate managers and owners might be interested in this data to consider investments in energy efficiency measures to reduce costs and attract environmentally conscious tenants.

Techniques for Forecasting Wind Energy (Response to 3).

- **Time Series Analysis (e.g., ARIMA, SARIMA),** which are suitable for capturing trends, seasonality, and patterns in historical wind energy production data. These models can account for time-dependent structures in the data, making them useful for short-to-medium-term forecasts (Foley, Leahy, Marvuglia, & McKeogh, 2012).

- **Machine Learning Models (e.g., Random Forest, Gradient Boosting), which can handle nonlinear relationships and interact with multiple variables affecting wind energy production, such as wind speed, air density, and turbine efficiency. These models can be trained on historical data to predict future production levels** (Demolli, Dokuz, Ecemis, & Gokcek, 2019).

- **Physical Models, which support the incorporation of meteorological data and simulations of atmospheric conditions to predict wind speeds and subsequently, energy production. These models are particularly relevant for new installations where historical production data may not be available** (Zhang & X, 2021).

Different techniques would be used for the various regions or areas due to the following reasons:

- There is geographical and climatic variability. As such, using different techniques that address regional weather patterns and geography is crucial.

- Economic factors and governmental policies in various regions may impact the growth rate of renewable energy differently. As such, integrating local economic factors and policies into forecasting models may support a better prediction. These can influence the growth rate of renewable installations and the economic viability of projects in different regions (Orrell & McSharry, 2009).

- The maturation of the market in a region differ across regions, which may impact the model's performance. Hence, models would be adjusted based on the maturity of the local renewable market and pace of technological innovation.

Data Quality Issues (Response to question 4a)

- **Missing Values:** Key columns like 'Quantity', 'Year' have missing entries, impacting time series analysis and capacity calculations.

- **Data Type:** The year column is a float data type.

- **Data Variance:** The 'Quantity' column exhibits a wide range and high variance, suggesting the presence of outliers and diverse energy production scales.

- **Incomplete data:** Some countries do not have records for some years, which may be due to data collection issues. *See appendix 4.*

Findings (Response to 4b).

For Energy Generation & Distribution Companies:

i. Invest in Wind Energy Expansion: With wind capacity increasing and combustible fuel capacity reducing, focus on expanding wind energy infrastructure. This aligns with global trends toward cleaner energy and can enhance the company's renewable portfolio, potentially offering a competitive advantage as regulations and market preferences shift toward sustainability.

ii. Adapt to Changing Consumption Patterns: Given the flat trend in electricity consumption by commercial and public services, coupled with an increase in household consumption since 2019 likely due to COVID-19, adapt strategies to manage demand fluctuations. This could involve investing in smart grid technologies to improve demand response capabilities and enhance grid stability.

iii. Enhance Efficiency and Diversification: With the observation that losses and industry use have been relatively flat, there's an opportunity to focus on improving operational efficiency, particularly in reducing losses. Diversifying the energy mix further, by exploring advancements in stable renewable sources like hydro and innovative solar technologies, could mitigate risks associated with the variability of wind energy.

For Large Real Estate Managers/Owners:

i. Energy Efficiency Retrofitting: Given the relatively flat consumption trends, focusing on energy efficiency measures in buildings can yield significant savings, especially in light of increased household consumption patterns since 2019. Retrofitting buildings with energy-efficient systems and materials can reduce consumption and appeal to sustainability-conscious tenants.

ii. Invest in On-site Renewable Energy: With wind energy capacity on the rise and the gradual shift away from combustible fuels, investing in on-site renewable energy generation, such as small-scale wind turbines, could provide a hedge against future energy price increases and enhance the property's green credentials.

References

Demolli, H., Dokuz, A., Ecemis, A., & Gokcek, M. (2019). Wind power forecasting based on daily wind speed data using machine learning algorithms. *Elsevier*.

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Foley, A., Leahy, P., Marvuglia, A., & McKeogh, E. (2012). Current methods and advances in forecasting of wind power generation. Renewable energy. *Elsevier*.

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Orrell, D., & McSharry. (2009). System economics: Overcoming the pitfalls of forecasting models via a multidisciplinary approach. *Elsevier* .

UK parliament. (2023, November 28). *The Final Sector and the UK's net zero Transition.* Retrieved from publications.parliament.uk: https://publications.parliament.uk/pa/cm5804/cmselect/cmenvaud/277/report.html

Zhang, J., & X, Z. (2021). Three-dimensional spatiotemporal wind field reconstruction based on physics-informed deep learning. *Elsevier* .

Appendix

Click the link to Github repo for data analysis

Appendix A1

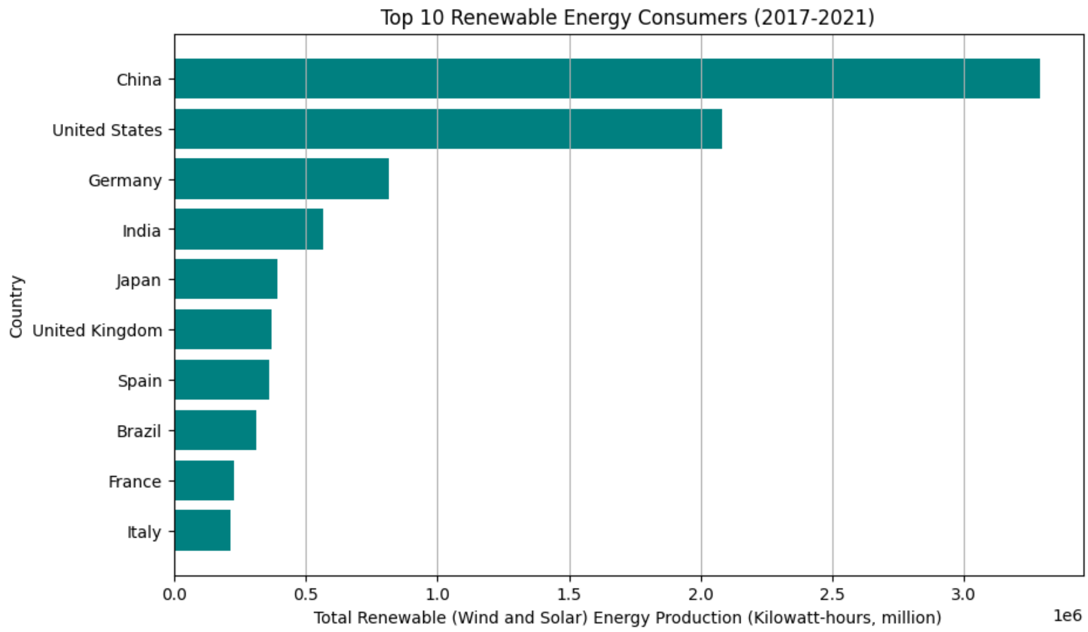

Figure 1: Total combined solar and wind energy production capacity from 2018-2022

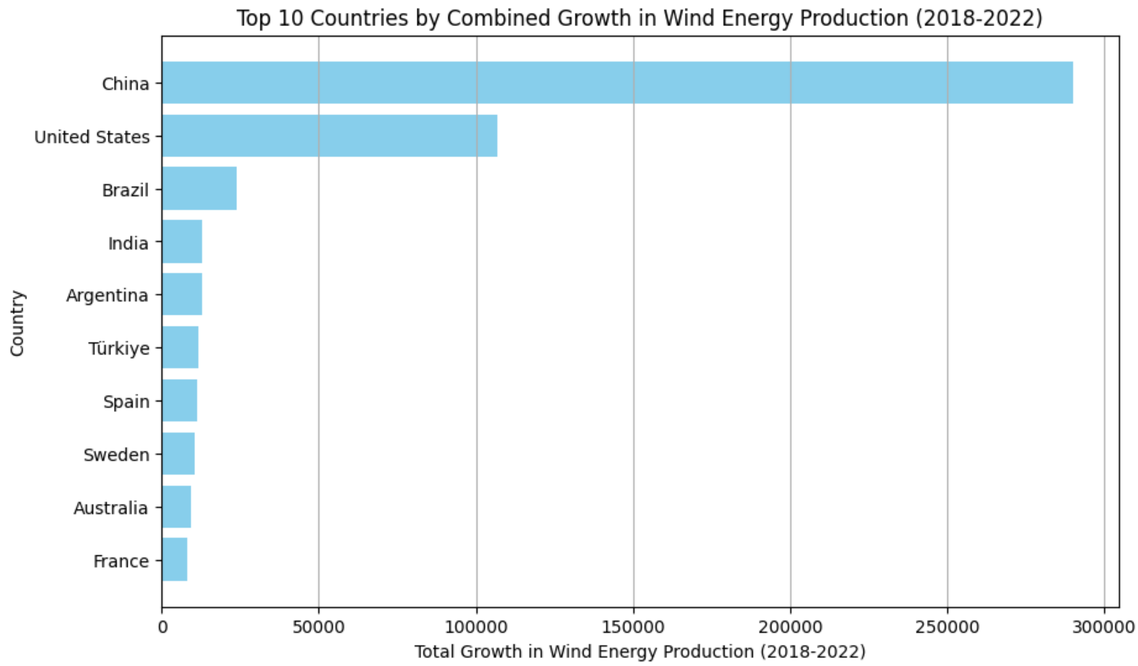

Figure 2: Wind energy emerging markets

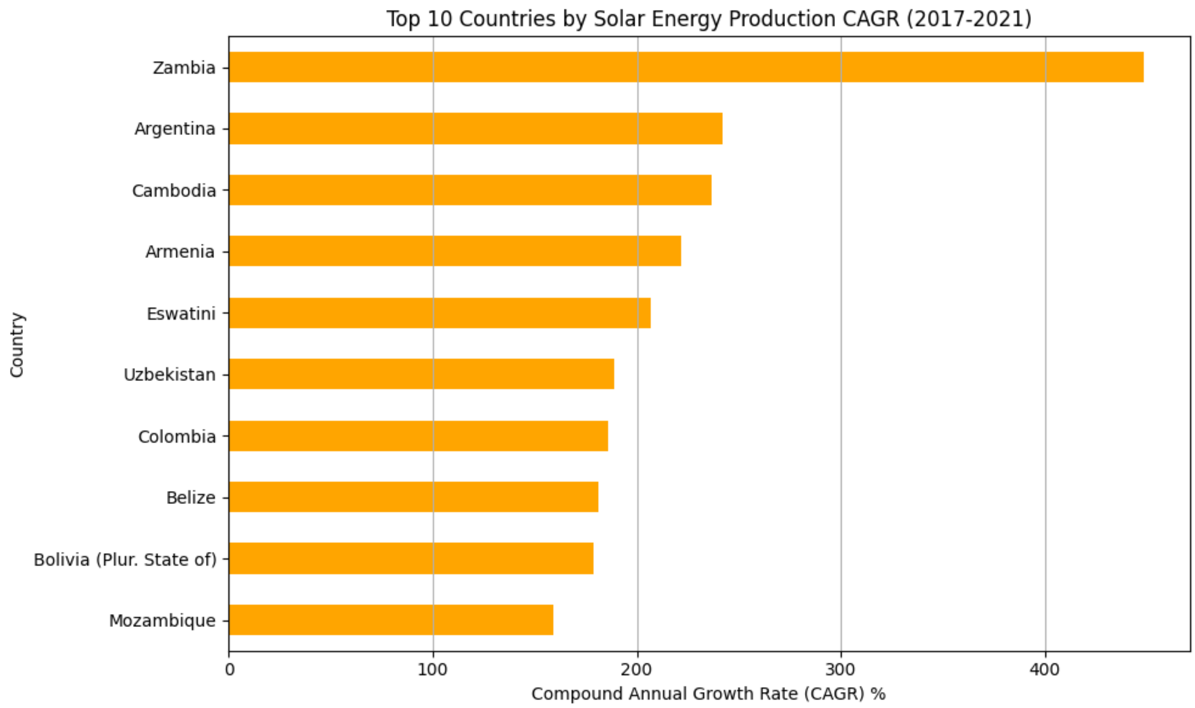

Figure 3: Emerging markets for solar energy

Appendix B1

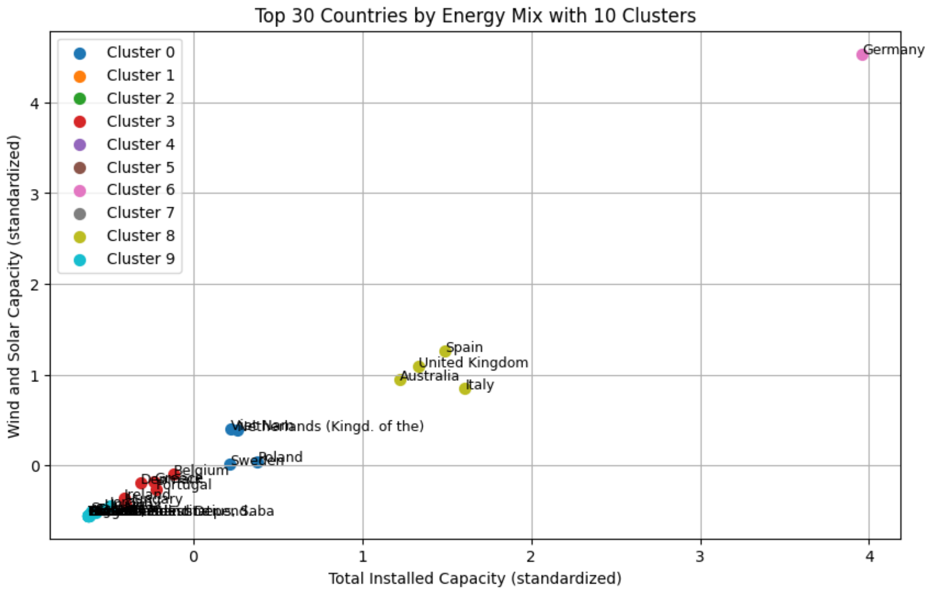

Figure 4: k-means clustering for global energy mix by wind and solar proportion

Appendix A2

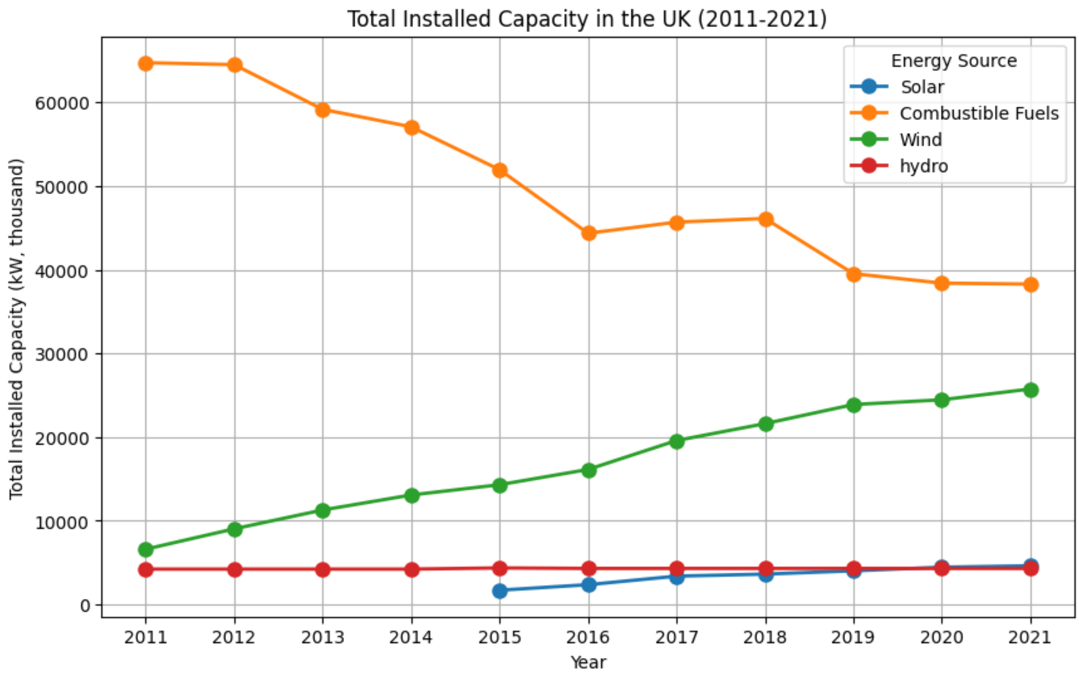

Figure 5: Increase in wind energy and decrease in combustible fuels in the UK energy mix

Appendix B2

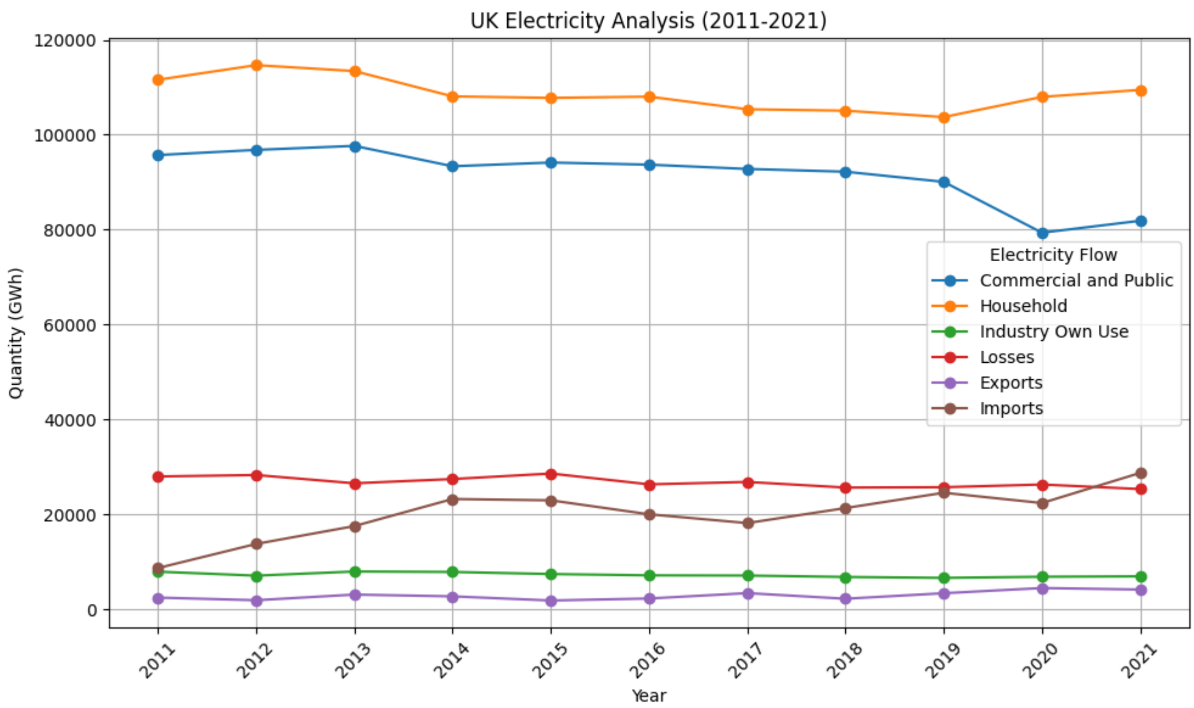

Figure 6: Energy Flows across sectors