Received: 09 March 2025, Accepted: 08 April 2025, Published: 08 May 2025
Digital Object Identifier: https://doi.org/10.63503/j.ijaimd.2025.59

Research Article

Visualizing Global Energy Transition using Tableau

Punyisa Phumiphol [1], Priyadarshini Pattanaik [2]* , Sanchit Sarhadi [3]

[1] Computer Science and Informatics, Berlin School of Business & Innovation,

[2] Faculty of Computer Science and Informatics, Berlin School of Business & Innovation (BSBI), Berlin, Germany,

[3] Universidad Azteca, 56600 Chalco de Díaz Covarrubias, Mexico.

punyisa.p@onesqa.or.th1, ppattanaik055@gmail.com2 , sanchitsarhadi95@gmail.com3

*Corresponding author: Priyadarshini Pattanaik, ppattanaik055@gmail.com

ABSTRACT

The world's transition to renewable energy sources presents opportunities and complex sustainability challenges. However, important elements like carbon emissions, renewable energy capacity, and economic indicators are frequently ignored by traditional energy development. Using Tableau's features and live connections for real-time data integration, this study employs a problem-oriented, solution-driven framework that uses data storytelling and visualization techniques. To support well-informed decision-making for a sustainable future, our goal is to gain a thorough understanding of the global energy landscape. Significant insights are revealed by analyzing global sustainable energy trends from 2000 to 2019. The animated line graph shows a steady increase in carbon emissions and renewable energy capacity, with Brazil showing stable emissions and rising renewable energy capacity. China's consistently high GDP growth and carbon emissions are highlighted by geospatial analysis, highlighting the significance of striking a balance between environmental responsibility and economic growth. The four-orbit charts also show regional differences, with Africa trailing behind Europe in wind and bioenergy, Asia leading in solar and hydropower, and Europe in both. For legislators and corporate executives looking to make strategic choices for a more sustainable future, the insights are priceless. Well-designed data visualization gives stakeholders a variety of viewpoints on intricate global trends, which helps them create specialized plans and distribute resources efficiently. This strategy encourages greater comprehension, cooperation, and creativity in the pursuit of sustainability.

Keywords: *Keywords: Tableau, Dashboard, Key Performance Indicators, carbon emissions, renewable energy, data visualization, CO2 emissions, GDP, sustainability.*

1. Introduction

A global shift to sustainable practices and renewable energy sources is urgently needed as environmental concerns and the need for economic growth become more pressing. Effective communication and data-driven decision-making are essential for navigating the challenges of this transition. By converting complex information into easily understood visual representations, data visualization is a useful tool in this endeavor that promotes understanding and well-informed decision-making (Luyo et al., 2023). Data visualization is essential for conveying patterns, trends, and insights that are concealed in intricate datasets. When raw data is transformed into visual representations like charts, graphs, and interactive dashboards, stakeholders can rapidly understand the significance and implications of the data. Perdana et al. (2018) claim that by giving data analysis a narrative structure, data visualization enhances comprehension and engagement and makes complex information easier for a variety of audiences to understand. Among the various data visualization options available, Tableau stands out for its adaptability and effectiveness in bridging the gap between data analysis and comprehension. Tableau allows users to explore data, gain insights, and make informed decisions through its dynamic visuals, interactive dashboards, and intuitive interfaces. Archambault et al. (2015) emphasize the value

of interactive visualizations in helping users customize parameters, filter data, and delve into specifics, all of which enhances their ability to derive valuable insights from the provided data. Tableau is widely used to display complex data about energy consumption, carbon emissions, and the adoption of renewable energy sources (Herodotou & Aslam 2022). Stakeholders can gain a better grasp of the difficulties associated with switching to renewable energy for sustainability by using interactive tools for data exploration and analysis.

The complexity of sustainability is still difficult to understand and manage, even with the development of data visualization techniques and tools like Tableau. Data visualization is not a quick fix for sustainability problems, even though it enhances communication and offers insightful information. It is crucial to remember that data visualization may not fully capture all facets of a complex issue and is only as good as the data it is based on. Instead, it is a crucial tool for decision-making, helping stakeholders navigate complexities and make informed choices that will lead to a more sustainable future for the environment. The main goal is to enhance data storytelling skills using sophisticated data storytelling techniques. We selected the dataset on renewable energy capacity globally that offered a range of variables, including year, latitude, longitude, and several numerical variables, to align with the objectives and use geospatial analysis and custom calculation techniques. Policymakers and business executives, who are crucial in this regard, can gain from the project's dashboard, which will offer insights into global sustainable energy trends. The goal is to share the findings and encourage well-informed decision-making, with a focus on policymakers and leaders in the sustainable energy sector. Leaders in the industry and legislators are the target audience in this case. Energy regulations can be made by policymakers, but industry leaders are responsible for putting them into effect. With the help of this visualization, the line chart could have an impact on policies that push the global community toward sustainability. One of the most important ways to get a conversation going is to highlight how important sustainable energy is. We start the paper by addressing the question, "How have renewable energy and carbon emission trends evolved in the top 10 countries (2000–2019)"? Due to their large populations, widespread industrialization, and high energy consumption, the ten largest nations account for a significant portion of the world's carbon emissions. This introduction calls for action, urging interested parties to take part in conversations about energy-related environmental protection initiatives. The animated line charts were used because they provide important information, efficiently track the variables in the dataset, and enable us to compare the revolution in carbon emission levels and renewable energy capacity. The major goal is to produce a visual representation of the changes by showing the percentage of carbon emissions and renewable energy capacity, as well as a compelling overview of the top ten countries over the past 20 years, illustrating the factors that have shaped their positions in the world. (Figure 1).

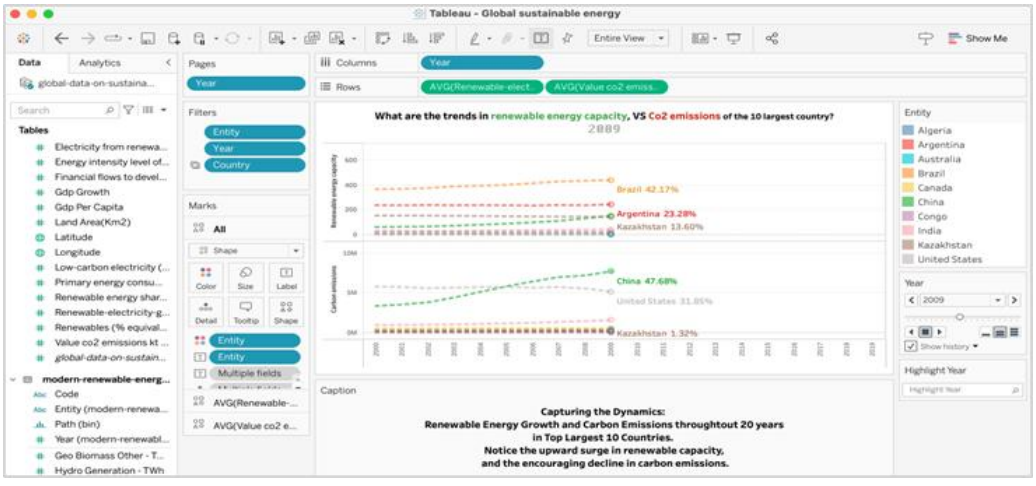

Figure 1. Animated line chart

Carbon emissions and renewable energy capacity both showed increasing trends, according to the analysis overview. 2009 saw notable expansion, with China and Brazil standing out as major contributors to the capacity expansion of renewable energy.

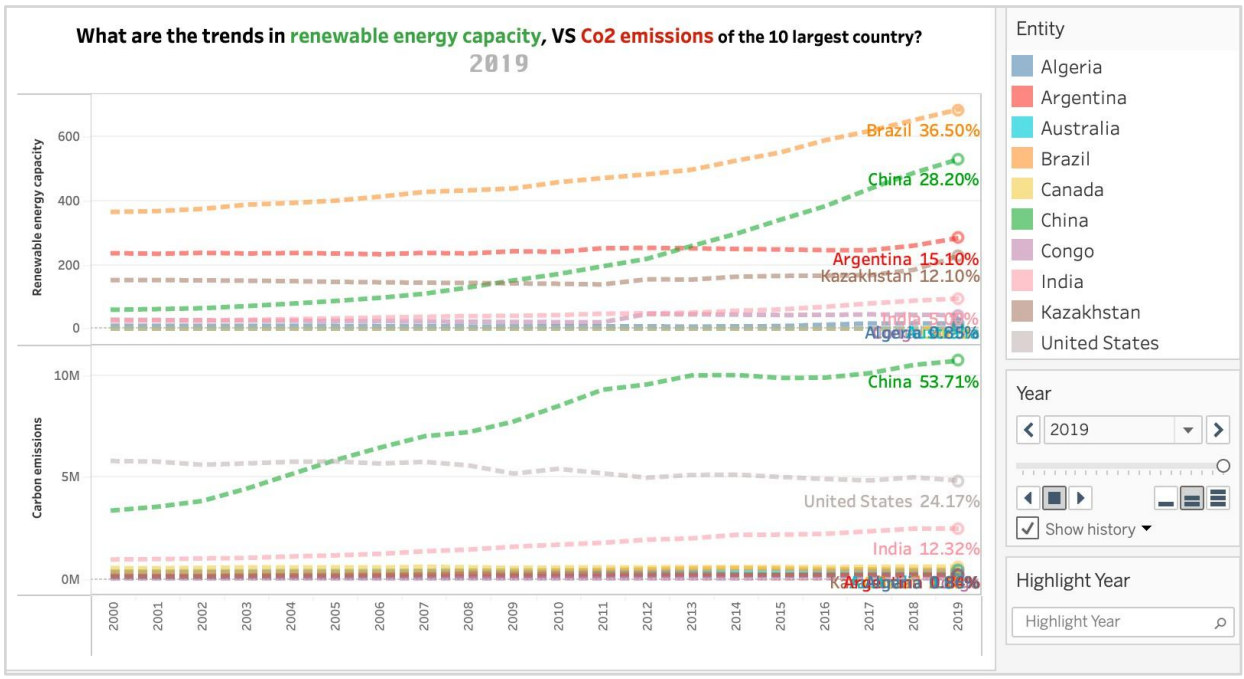

Figure 2. Overview of trends in renewable energy and carbon emission

The three trends that emerged from the significant increase in 2009 are the main conclusions drawn from this graphic. First, as China has shown, carbon emissions and renewable energy capacity are rising simultaneously. In contrast, Algeria is exhibiting a steady upward trend in both carbon emissions and renewable energy capacity. Lastly, Brazil's 2009 increase in renewable energy capacity while keeping carbon emissions constant was a positive trend.

According to the overall trends, carbon emissions and renewable energy capacity have been steadily rising, with a shift occurring in 2009. Implementing sustainable energy is made easier by the specific patterns that were found, particularly Brazil's model of growing renewable energy capacity while maintaining stable carbon emissions. Policymakers can use Brazil's best practices model to promote policies that hasten the shift to sustainable energy sources by comprehending these trends. This applies to the initiative of the large countries, as they can take the lead in implementing renewable energy sources.

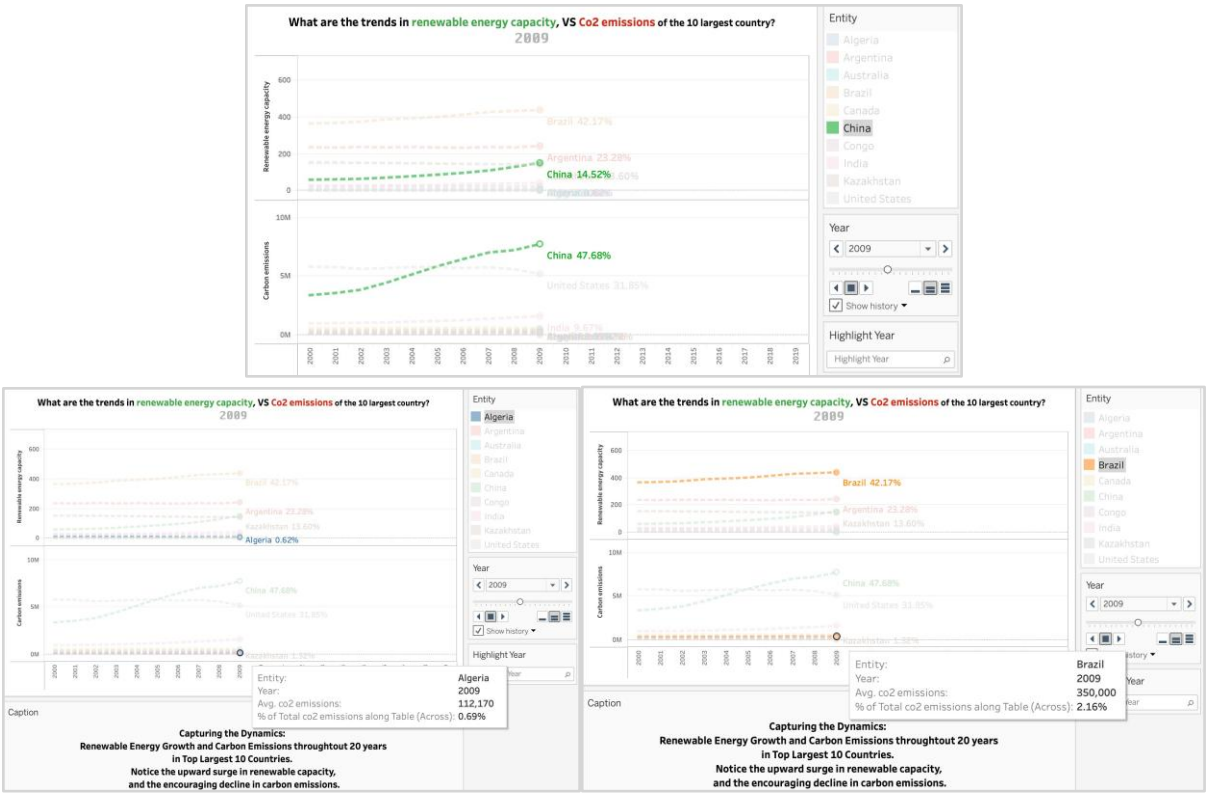

Figure 3. The significant trends of renewable energy and carbon emission

2. Methodologies

This paper will use a variety of datasets, sophisticated Tableau techniques, and geospatial analysis to illustrate the opportunities and challenges in the sustainable energy landscape. The development of data exploration and visualization skills has two goals. The first is to examine the complex relationship between GDP growth and global carbon emissions, with a focus on the balance between the economy and the environment. The second is to help with strategic decision-making by offering a comprehensive picture of energy capacities across continents.

Two datasets that were in line with the goals were carefully selected. "Global Data on Sustainable Energy (2000–2020)" is the primary dataset (retrieved from https://www.kaggle.com/datasets/anshtanwar/global-data-on-sustainable-energy), serves as the cornerstone for the analysis containing several types of data with most variables as calculated values. "Modern renewable energy consumption" was chosen as a second dataset for further investigation of the sustainable energy landscape." (obtained from https://www.kaggle.com/datasets/programmerrdai/renewable-energy), which offers raw data on each type of renewable energy capacity, including wind, bioenergy, hydropower, and solar energy.

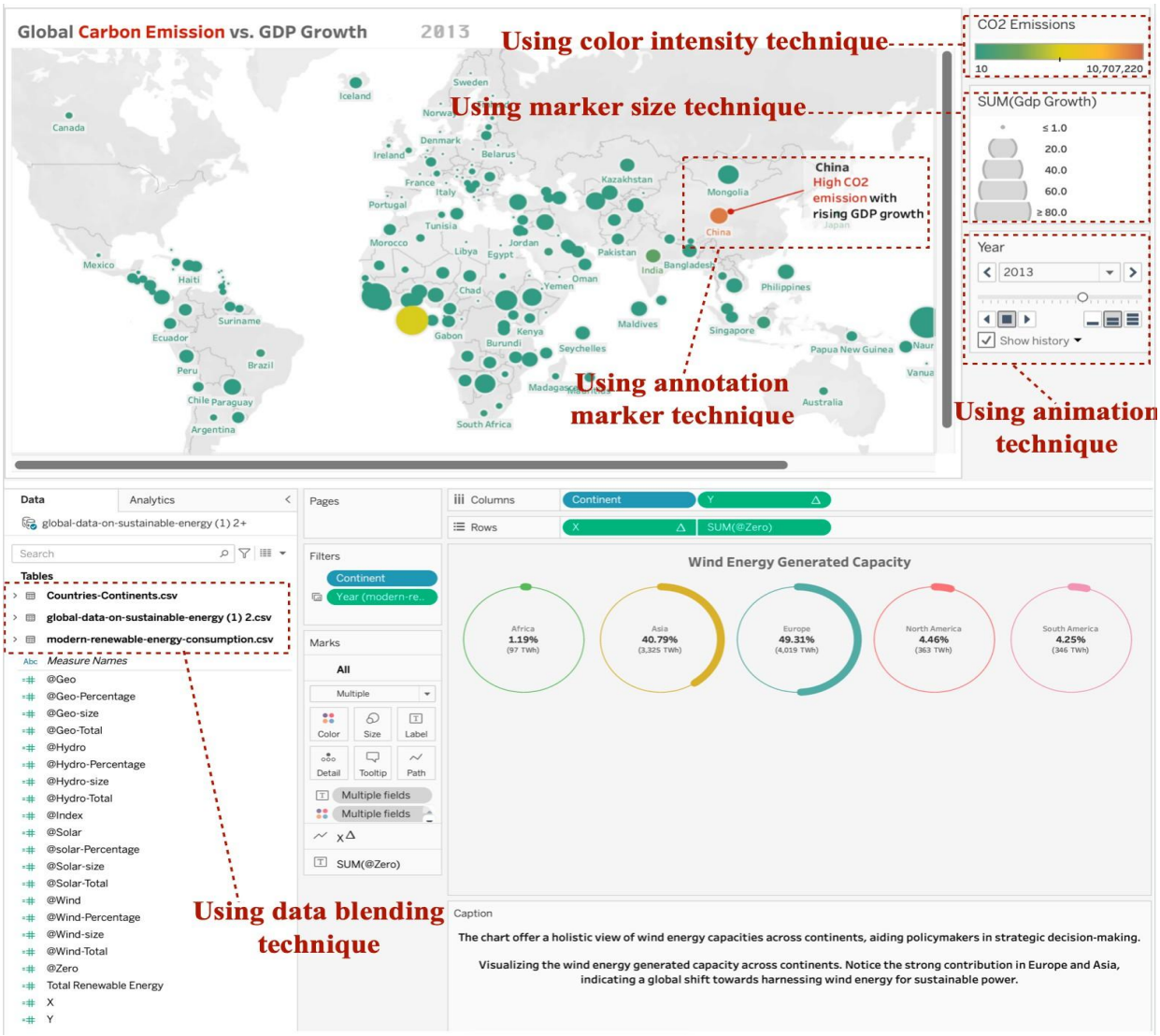

Figure 4. Methodologies for visualization

The extensive dataset on Kaggle that includes sustainable energy indicators and other pertinent information for nations worldwide provided the data for this study. The chosen dataset focuses on some energy-related metrics, such as emissions, pollution, sustainable energy, etc. The dataset's energy indicators are also entwined with other pertinent variables. It offers a thorough analysis of world trends between 2000 and 2020. Since the information was gathered from many reputable institutions and websites, such as the World Bank, the International Energy Agency, and ourworldindata.org, it is highly accurate and dependable. To guarantee data integrity and quality, the dataset has undergone the required pre-processing and cleaning. The dataset covers a lot of nations and shows variations in patterns of global energy production and consumption.

To shed light on the connection between global carbon emissions and GDP growth (2000-2019), two forms of sophisticated tableau visualization techniques were employed: animated geospatial analysis using animation, color intensity, marker size, and annotation marker techniques. Additionally, the four-orbit charts show how energy capacity (wind, hydropower, bioenergy, and solar) differs across continents using blended data and calculated fields, indicating global energy strategies (as Figure 2). Additionally, Figure 3 showcases the significant trends of renewable resources, and Figure 4 illustrates the Tableau advanced features using marker techniques, color intensity techniques, and annotation techniques, offering the view of wind energy capabilities across continents.

2.1 Custom calculations

The unique calculations used to create the orbit charts show how different continents have different capacities for solar, wind, hydropower, and bioenergy. To create the orbit chart, calculated fields must be used. "X," "Y," and “Index" are the four types of calculated fields that are used to identify axes and create a sequential order for data points. (the formula is shown as Figure 5), "@..(TypeOfEnergy).." to normalize energy values for consistent comparison, "@..(TypeOfEnergy)-Percentage" to calculate the percentage of energy contribution for each region (the formula shown as Figure 6), and "@..(TypeOfEnergy)-Size" to determine the size of markers based on the relative contribution of each region's energy (the formula shown as Figure 7).

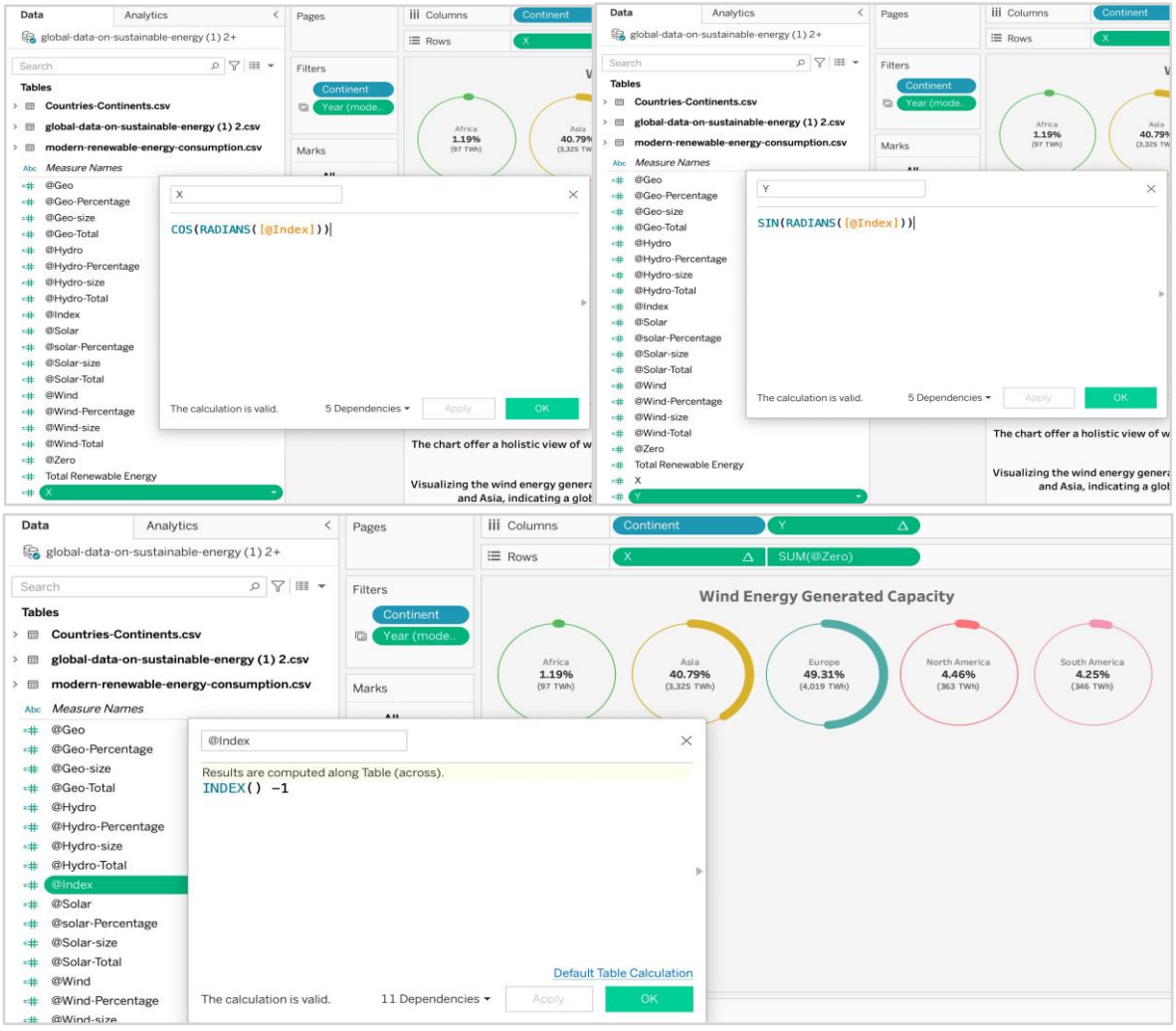

Figure 5. “X”, “Y”, and “@Index” formulas

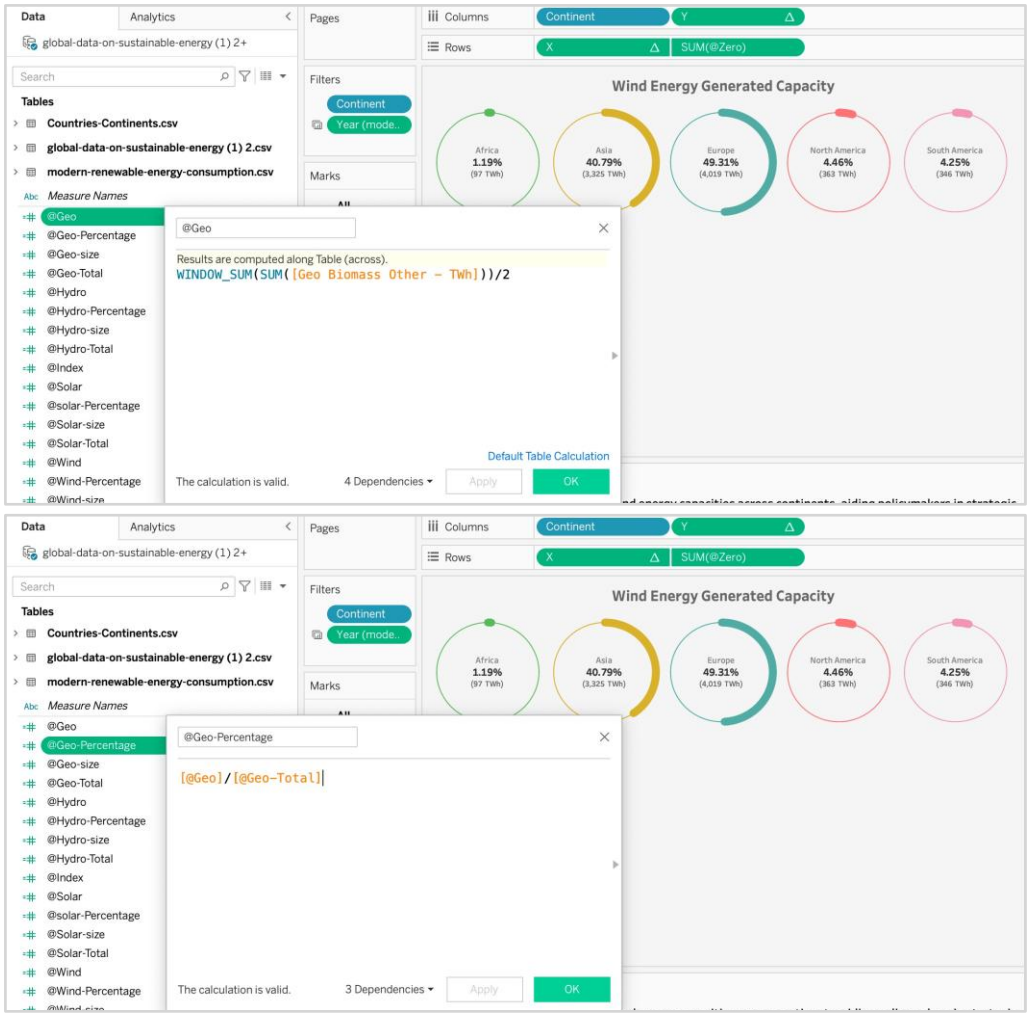

Figure 6. Normalizing and calculating the percentage formulas

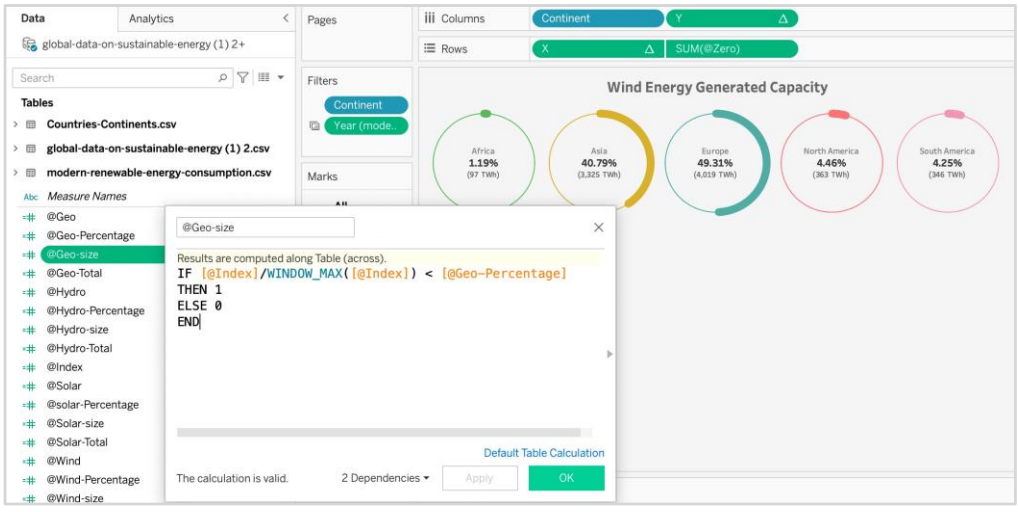

Figure 7. Determining the size of markers formulas

2.2 Utilizing advanced chart types

Two sophisticated chart types were used in this work: geospatial maps and orbit charts. Data relationships are visually represented by orbit charts, which compare the contributions of various

renewable energy sources to the overall energy mix. It facilitates comprehension of relationships and interdependence among various components (Figure 8). Figure 8 illustrates the revolution depicted in the animated geospatial map.

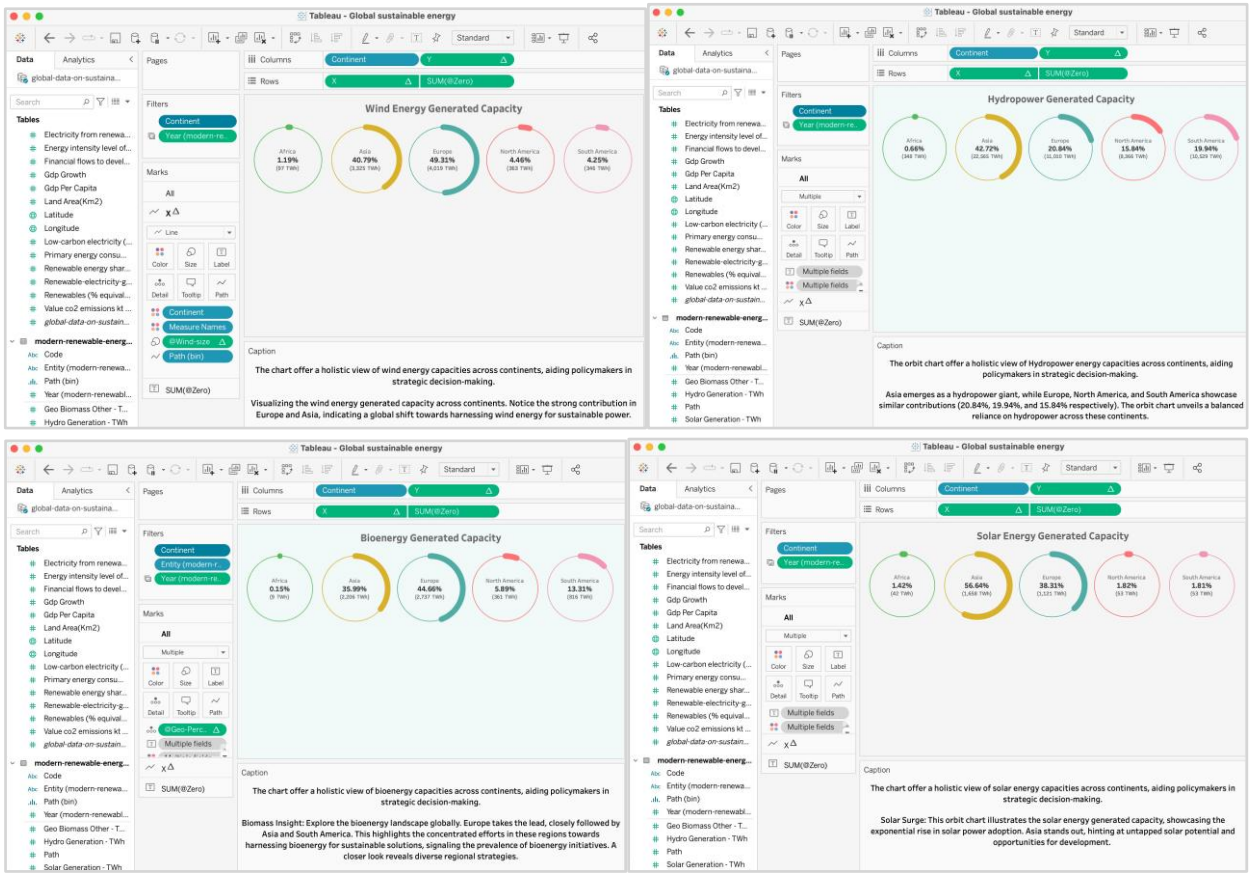

Figure 8. The orbit charts

2.3 Data blending for enhanced insights

The selected datasets make it easier to create insightful and effective reports, dashboards, and stories throughout the analysis. Data blending is used to combine various datasets on solar, wind, hydropower, and bioenergy capacities to create a comprehensive view that is represented by the orbit charts, guaranteeing a thorough understanding of global sustainable energy trends from 2000 to 2019.

3. Results and Discussion

Our dashboard's primary chart is a geospatial analysis that uses a map to illustrate regional differences in the adoption of renewable energy and pinpoint areas that require targeted investments, is shown in Figure 9. The color intensity for carbon emissions per person and the marker size for GDP growth rate help to interpret and analyze the patterns and correlations found in this analysis.

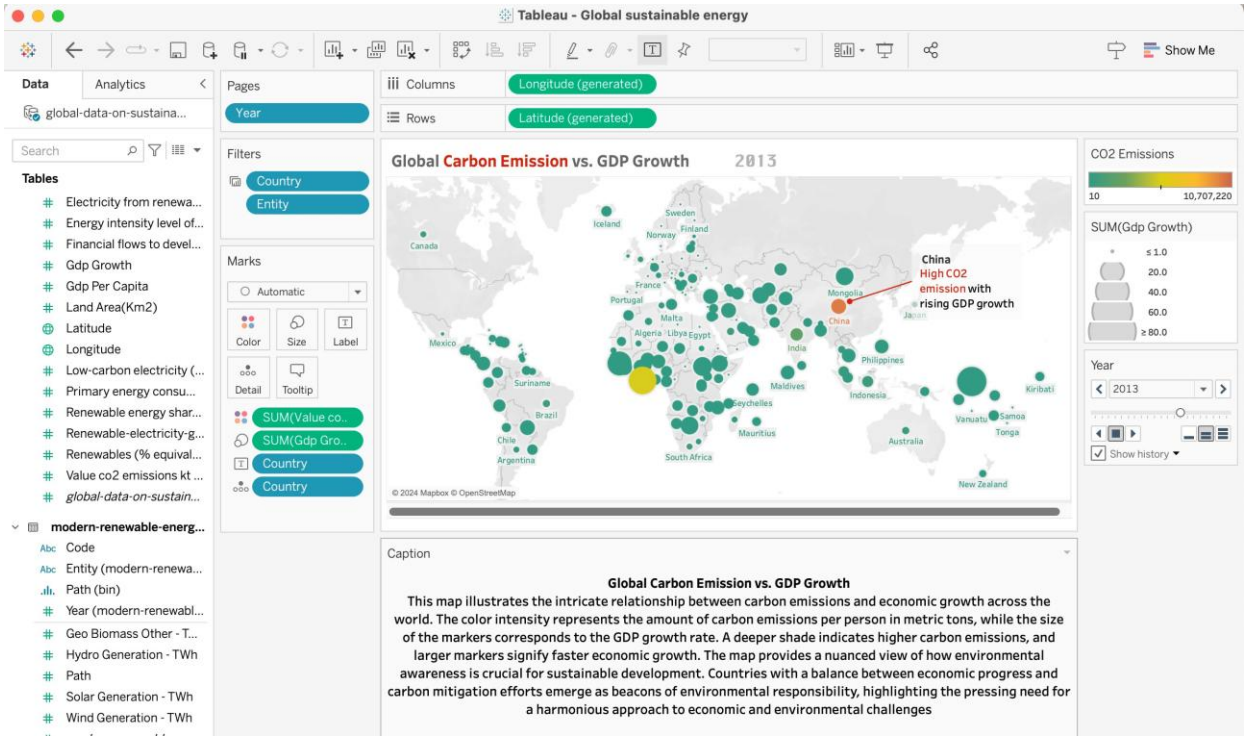

Figure 9. The Geospatial Analysis

3.1. Interactive dashboard for exploration

This section will concentrate on developing suitable interactive elements that complement the global renewable energy dashboard's data storytelling. The following are the three primary characteristics:

- The "Country" and "Year" filters allow users to personalize their views by excluding dates and times.
- Information in the Tooltip: When users hover over data points, interactive tooltips offer more details.
- Dynamic Animations: In charts 1-6, animated components draw users in and show trends over time.

3.2. Interpretation of Visualized Insights

The goal of the geospatial analysis is to highlight the balance between the economy and the environment by examining the complex relationship between global carbon emissions and GDP growth. China stands out among the data points. The medium-sized orange chart indicates that China has both high GDP growth and high carbon emissions at the same time. By offering a comprehensive perspective of energy capacities (wind, hydropower, bioenergy, and solar) across continents, the four-orbit charts facilitate strategic investment decision-making based on the geographical landscape of the continent and the geographical capacity of the nation. Every orbit chart provides information about which regions are most effective at capturing different forms of energy. Asia leads the world in solar and hydropower capacity, while Europe leads the world in wind and bioenergy capacity, according to the data visualization. The continent with the least capacity for renewable energy is Africa. Understanding the proportionate contributions is necessary for interpretation, which shows changes in energy adoption around the world. Gaining proficiency in data exploration has the primary advantage of enabling data-driven innovation by assisting decision-makers in discovering novel insights and patterns, which promotes innovation in

renewable energy policies, technologies, and business models. The primary goal of this paper is to draft a report for policymakers that emphasizes quickening the world's switch to sustainable energy. It determines an analytical or business use case and creates a sophisticated Tableau dashboard link: https://public.tableau.com/views/GlobalRENEWABLEENERGYDASBOARD/Dashboard1?:language=en-US&:sid=&:display_count=n&:origin=viz_share_link) and facilitates data-driven decisions.

Creating an advanced Tableau dashboard is our main goal in this section. We emphasize a well-structured layout by putting five essential steps into practice (Murray, 2013; Anoshin et al., 2019; Nerogic et al., 2023) to build data storytelling for an interactive experience. A geospatial map that provides a thorough summary of the analysis is presented at the beginning of the data story. The map is accompanied by an animated line chart that provides additional information about the ten biggest nations. The audience is led from left to right by this arrangement, which follows the natural reading flow. At the top of the Figure 10 dashboard, there are 'Country' and 'Continent' filters to allow you to customize your exploration. To improve user interaction and focus, four-orbit charts are also placed at the bottom to explore more specific details and make cross-continental comparisons easier. The 'year' filter was added to allow users to extract targeted insights by focusing on areas or periods. The dashboard's filters feature helps policymakers make data-driven decisions by enabling them to tailor the report to their interests, whether that be by concentrating on regions or periods. To meet their needs and make decisions based on a better understanding of the complex relationships among energy capacity, economic growth, and carbon emissions, stakeholders can use a customized exploration experience to get actionable insights. In summary, the report's interactive features allow users to compare energy, economy, and emissions data, explore trends, and make decisions based on those findings. These features also improve the creation of powerful insights through user engagement, customization, comparative analysis, data-driven decision-making, and effective communication.

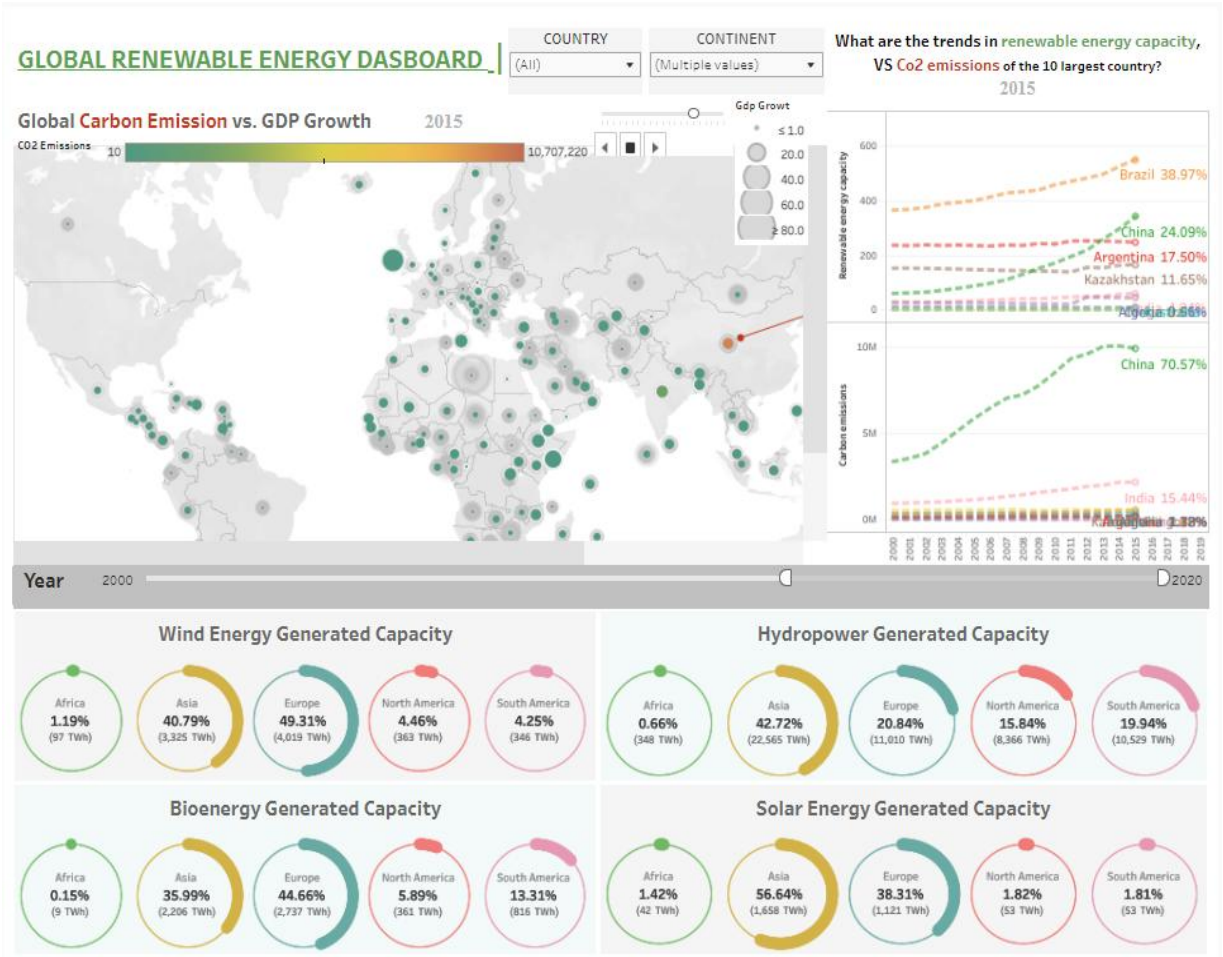

Figure 10. Tableau Global Renewable Energy Dashboard **(**https://public.tableau.com/views/GlobalRENEWABLEENERGYDASBOARD/Dashboard1?:language=en-US&:sid=&:display_count=n&:origin=viz_share_link**)**

The interactive dashboard address in Table 1 yields three important findings and analytics use cases.

Table 1. Determine the Analytical Use Case

Chart	Key Finding	Analytic Use Case
Animated Line Chart	Showcase increasing trends in the capacity for renewable energy, with China and Brazil leading the way in 2009's noteworthy growth.	Policymakers can direct future efforts for sustainable energy advancement by identifying successful strategies or projects by understanding the factors that led to notable expansion.
Animated geospatial map	Highlights the medium-sized orange color of China consistently indicates both high GDP growth and high carbon emissions.	Policies that strike a balance between environmental responsibility and economic growth can be studied by policymakers.
Orbit charts	Display Asia's leadership in solar and hydropower, Europe's hegemony in wind and bioenergy, and Africa's lowest capacity.	Using this data, policymakers can customize regional approaches to promote cooperation or alleviate inequalities. It uses regional strengths to inform decisions about development projects and resource allocation.

4. Conclusions

The key finding, which is consistent across all energy variables across all classifications, is that there are significant correlations between energy variables and CO2 emissions. Carbon dioxide emissions are regarded as a sign of environmental deterioration. An analysis of correlations revealed that the intensity of CO2 emissions increased with the amount of nonrenewable energy used. Conversely, there is a negative correlation between CO2 emissions and renewable energy consumption. Stronger negative correlations are found in high-level energy consumption clusters, and there is a consistent inverse relationship between fossil fuel consumption and renewable energy consumption. The top energy-consuming nations support sustainable global development, according to our data-based visual outputs.

In addition to discussing significant accomplishments and lessons learned for successful data communication in influencing investments and policies toward sustainable energy, the report's final section compiles the conclusions and insights obtained from the dashboard that was created. This analysis, along with the important conclusions outlined in the analytical use cases, improved our capacity to use data to tell stories and investigate cutting-edge ideas in sustainable energy. Effective data visualization based on the five steps of data storytelling is produced by implementing advanced features and techniques, showcasing significant accomplishments and lessons learned in sustainable energy. Our analysis shows improvements in communicating intricate insights into global sustainable energy trends, reflecting on developments in data storytelling. We emphasize the significance of impactful and transparent communication as we address the implications for effective data communication, which are informed by visual analysis using Tableau. The information gathered about developing a dashboard to monitor research data requests highlights how important clear data communication is in influencing investments and policies in the direction of sustainable energy. By incorporating these perspectives, the report highlights the critical successes and lessons learned, considers the developments in data storytelling, and highlights how important it is to communicate data clearly to influence investments and policies in the direction of sustainable energy. The dynamic evolution of national energy consumption from 2000 to 2020 was illustrated, and it showed that the top

energy-consuming nations were entering a period of change. Due to the clear trend of declining fossil fuel consumption and increasing renewable energy consumption, energy leaders in Asia and the European Union are shifting towards a low-carbon economy. However, many Asian and European nations are far behind schedule in fulfilling their commitments to renewable energy by 2020 or 2030.

Acknowledgements

Not Available

Funding source

"This research received no external funding."

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Anoshin, D, Gillet, JC, Peri, F, Biyani, R, & Makarenko, G, “Tableau Desktop Certified Associate: Exam Guide: Develop Your Tableau Skills and Prepare for Tableau Certification with Tips from Industry Experts”, Packt Publishing, Limited, Birmingham, 2019.

[2] Archambault, S.G., Helouvry, J., Strohl, B. & Williams, G, "Data visualization as a communication tool", Library Hi Tech News, vol. 32, no. 2, pp. 1-9, 2015.

[3] Herodotou, H. & Aslam, S., "Data-Intensive Computing in Smart Microgrids: Volume II", Energies, vol. 15, no. 16, pp. 5833, 2022.

[4] Janvrin, D.J., Raschke, R.L. & Dilla, W.N., "Making sense of complex data using interactive data visualization", Journal of Accounting Education, vol. 32, no. 4, pp. 31, 2014.

[5] Karsten, R., Şen, Ö.O., Malte, S., Hartmann, T., Firdovsi, G., Johannes, N., Bauer, S. & Olaf, K, "An environmental information system for the exploration of energy systems", Geothermal Energy, vol. 10, no. 1, 2022.

[6] Kubovics, M., Zaušková, A., PhD & Ščepková, S., "Perception of data from the ecological activities of companies using innovative communication tools", Communication Today, vol. 12, no. 2, pp. 84-99, 2021.

[7] Lombardi, M., Berardi, D., Galuppi, M. & Barbieri, M., "Green Tunnel Solutions: An Overview of Sustainability Trends in the Last Decade ", Buildings, vol. 13, no. 2, pp. 392, 2023.

[8] Luyo, B., Pacheco, A., Cardenas, C., Roque, E. & Larico, G., "Unlocking Insights: A Cloud Tool for Data Visualisation in a Smart Meter Project", Processes, vol. 11, no. 11, pp. 3059, 2023.

[9] Mete, M.O., “Geospatial Big Data Analytics for Sustainable Smart Cities”, Copernicus GmbH, Gottingen, 2023.

[10] Murray, DG, “Tableau Your Data: Fast and Easy Visual Analysis with Tableau Software”, John Wiley & Sons, Incorporated, Somerset, 2013.

[11] Nerogic, A., Lawson, V. & Rodgers, L, "401 Creating a Dashboard to Increase Efficiency in Tracking and Reporting on Research Data Requests", Journal of Clinical and Translational Science, vol. 7, pp. 119-120, 2023.

[12] Perdana, A., Robb, A. & Rohde, F., "Does Visualization Matter? The Role of Interactive Data Visualization to Make Sense of Information", Australasian Journal of Information Systems, vol. 22, 2018.

[13] Sun, Y., Liu, H., Gao, Y. & Zheng, M., "Research on the Policy Analysis of Sustainable Energy Based on Policy Knowledge Graph Technology—A Case Study in China", Systems, vol. 11, no. 2, pp. 102, 2023.

[14] Wang, C., "China's energy policy and sustainable energy transition for sustainable development: green investment in renewable technological paradigm", Environmental Science and Pollution Research, vol. 30, no. 18, pp. 51491-51503, 2023.

[15] Zhang, T., Yin, J., Li, Z., Jin, Y., Arshad, A. & Jiang, B., "A dynamic relationship between renewable energy consumption, non-renewable energy consumption, economic growth and CO2 emissions: Evidence from Asian emerging economies", Frontiers in Environmental Science, 2023.

[16] Nana Kwarteng Dei Duffour, P. Pattanaik., "Environmental Sustainability Audit Analysis to Maintain Operational Excellence", Green Futures: Navigating the Path to Environmental Resilience, Springer Nature Singapore, pp. 531-549, 2025.

[17] Sanchit Sarhadi, Priyadarshini Pattanaik., "Impact of e-business Services on Product Management", Handbook of Computational Sciences: A Multi and Interdisciplinary Approach, pp.273-297, 2023.

[18] Zachrisson, L., B Stahre, W., Engström, A., Beneduce, L., Larsson, C. & Thuvander, L., "SolVis: A pilot study to facilitate understanding of real-time solar energy production through energy visualizations in learning environments", IOP Conference Series.Earth and Environmental Science, vol. 1196, no. 1, pp. 012083, 2023.