Analysis on: Electricity, Water and Gas usage in Ireland
Database and Analytics Programming

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Abstract—This study presents a comprehensive analysis of gas, water, and electricity usage in residential and commercial settings in Ireland. Through advanced analytical methods and integration of diverse data sets, the research identifies distinct temporal patterns and seasonal fluctuations in energy consumption. Unexpected cross-resource correlations between gas and electricity in residential areas and water and electricity in commercial buildings are unveiled, suggesting opportunities for simultaneous resource optimization. Statistical analyses, including regression models, provide insights into influential factors and relationships shaping consumption behaviours. Python-generated visualizations, such as time series plots and scatter plots, effectively communicate these complex patterns. The evaluation acknowledges the study's strengths in offering actionable insights for sustainable resource management, while also considering limitations related to data quality. Recommendations for future research include fine-grained behavioural analysis and exploring the impact of individual appliances on residential resource consumption. This research contributes significantly to the understanding of resource utilization dynamics in Ireland, informing decision-makers and stakeholders committed to optimizing resource efficiency.

Index Terms—

I. Introduction

The Republic of Ireland, like many other nations, faces difficulties related to resource management. The increase in demand for gas, water, and electricity in both residential and commercial areas, makes it more important for a detailed understanding of consumption patterns. In this study, a thorough analysis of gas, water, and electricity usage in Ireland, with a focus on identifying different trends, boosting resource usage, and improving overall efficiency.

The importance of sustainable resource management cannot be put down. The decreasing speed of natural resources, along with the environmental effect of consuming more energy, makes think more on decision making about this domain. As Ireland continues to grow economically and technologically, a deep evaluation of energy and resource usage becomes important to make sure for a sustainable future. This research project has following objectives:

Identify Consumption Patterns: Analyse past data on gas, water, and electricity usage to observe patterns and trends in both residential and commercial areas.

Proper Resource Usage: Reduce waste and promote sustainable consumption behaviours.

This project contributes to the sustainable resource management by providing insights into consumption of energy in a real-world environment. The outcomes are expected to inform decision-making, guide on energy saving ways for individuals and businesses to reduce resource use.

II. Related Work

Energy Usage Analysis in Residential Settings: Previous studies have given us insights to energy consumption patterns in residential areas. Let's consider, a test was conducted a analysis of electricity usage in urban households. The test results were that the influence of socio-economic factors that is the type of work one does is equally proportional to consumption of energy. This research helps us in understanding the residential energy usage patterns.

Commercial Energy Management Strategies: The commercial sector has been an important point in energy management research. Another work that looks into effective strategies for minimal energy usage in commercial buildings. The study discusses the impact of building design, large occupancy patterns, and it includes the daily practices that a business observes in order to ensure safety of employees.

IoT and Smart Metering: The use of Internet of Things (IoT) technologies and smart metering systems together has been very helpful in collecting real-time data on energy usage. This Work explored the uses of smart meters in residential areas, enabling more perfect monitoring of electricity and gas consumption.

Data-Driven Approaches in Energy Analytics: Several studies have shown the importance of data-driven approaches in energy analytics. Using employed machine learning algorithms to guess the energy usage2 patterns in commercial buildings. Their work shows the need for advanced analytics in betterment of resource utilization.

Comparative Analysis in European Context: In a broader European context, a test was conducted as a comparison analysis of energy usage patterns among the different

countries. Though not specific only to Ireland, this study gives context for the results achieved and gives insights into regional differences in energy usage trends.

Sustainability Initiatives in Ireland: Within the Irish context, initiatives such as [National Governance Structures, SDG National Implementation Plan, etc] have aimed to address the issue of using energy efficiently. Research checked the impact of these initiatives on residential energy consumption, that gave important insights into the effective measures that were asked to be kept in consideration and it helped them in analysing the usage patterns.

III. Methodology

A. Data Collection

Gas, Water, and Electricity Datasets: Sources: Obtain the gas, water, and electricity usage datasets from [specify sources, such as government agencies, utility companies, or research databases].

B. Data Description

- CSV data set 1 - Commercial Electricity: Years: 2016 2022 Country: Ireland, Euro Area, EU 27 Amount: calculated Cent per watt Description: This data set provides information on commercial electricity consumption from the years 2016 to 2022. It includes data for Ireland, the Euro Area, and EU 27, with the consumption amount measured in cents per watt.
- CSV data set 2 - Commercial Gas: Years: 2016 - 2022 Country: Ireland, Euro Area, EU 27 Amount: Cent per watt Description: This data set details commercial gas consumption from 2016 to 2022. It covers Ireland, the Euro Area, and EU 27, with the consumption amount represented in cents per watt.
- CSV data set 3 - House Electricity: Years: 2016 - 2022 Country: Ireland, Euro Area, EU 27 Amount: Cent per watt Description: Focusing on residential electricity consumption, this data set records the years 2016 to 2022. It has the data for Ireland, the Euro Area, and EU 27, with the consumption amount measured in cents per watt.
- CSV data set 4 - House Gas: Years: 2016 - 2022 Country: Ireland, Euro Area, EU 27 Amount: Cent per watt Description: This data set give the information residential gas consumption trends between 2016 and 2022. It includes data for Ireland, the Euro Area, and EU 27, with the consumption amount denoted in cents per watt.
- CSV data set 5 - Mean Water Consumption: Statistical Label: Statistic label Years: 2016 - 2022 Country: Ireland Unit: Litre Value: The value of water consumption Description: Providing insights into water consumption, this data set spans from 2016 to 2022. The unit of measurement is in Liters, giving a detailed view of mean water consumption.
- JSON data set 6: Metered Electricity Consumption: Statistic Label: Metered Electricity Consumption Year: 2015 Sector: All sectors Unit: Gigawatt Hours Value: 2802 Description: This JSON dataset details metered electricity consumption in Co. Cork for the year 2015, covering all sectors. The unit of measurement is in gigawatt hours.
- JSON data set 7: Metered Gas Consumption (JSON): Statistic Label: Metered Gas Consumption Sector: All sectors Unit: Gigawatt Hours Value: 16894 Description: This JSON dataset outlines metered gas consumption for the first quarter of 2011, covering all counties and Dublin postal districts. The unit of measurement is in gigawatt hours, providing valuable insights into gas consumption trends.
- CSV data set 8- Waste Water Treatment Systems: Statistic Label: Registrations of Domestic Waste Water Treatment Systems Year: 2017 to 2022 County: All Counties Registrations: users who got registered Value: The value of water treatment.

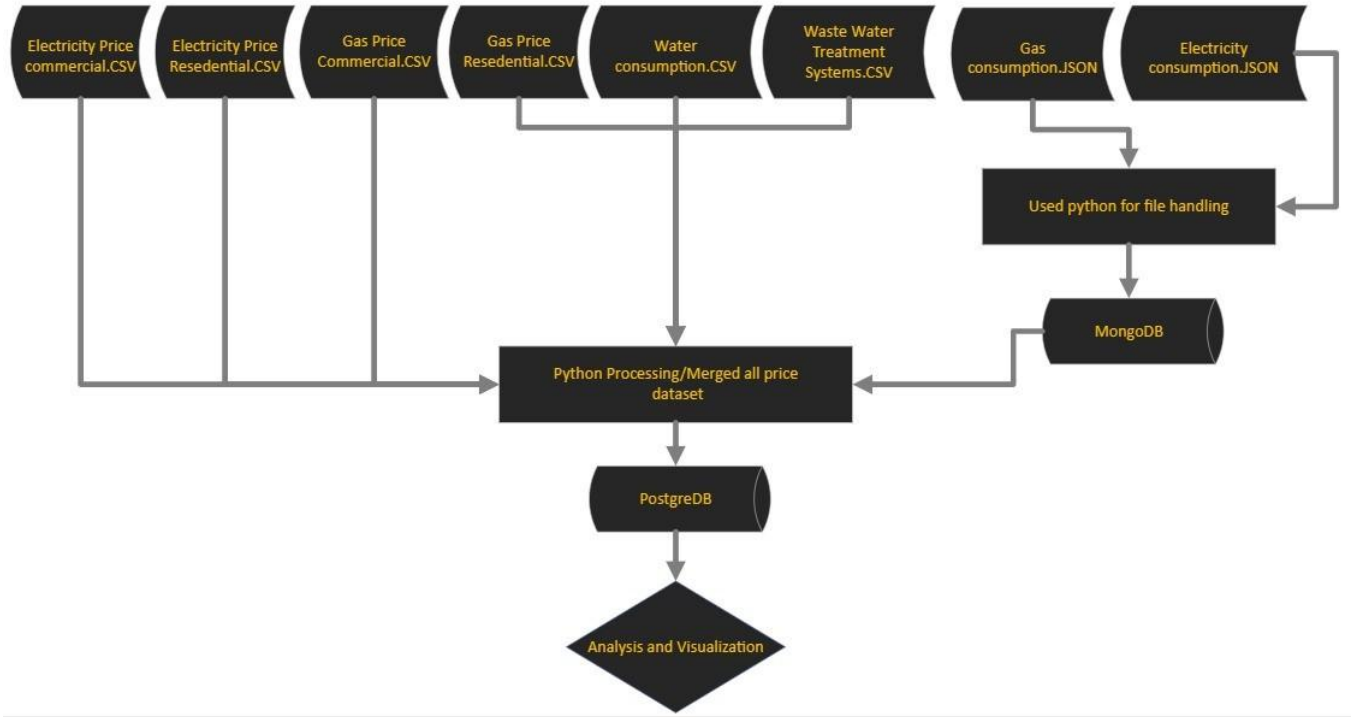


Fig. 1. Process Flow

C. Detailed Description of Data Processing

In the given flowchart gives the flow of action of extract Transform, Load. processes and visualize has been carried out here where we extracted the data then transformed the data accordingly to the work we are doing and then finally load the data as per the requirement. This whole process is performed and in the final, we merge the data which is used for the analysis and visualization.

In this work, a total of eight data sets has been used and later out of these eight data sets, four data sets, that is electricity for house and commercial and gas for house and commercial were merged together and rest four data set were kept as it is. The data we got were, six data sets in Comma Separated Value or CSV and the other two data sets were in Java Script Object Notation or JSON format. Where in the JSON format data sets are semi structured and python was used for file handling and later all this Json data have been stored in the MongoDB. The reason behind choosing the MongoDB database is that this database supports flexibility and scalability of the data that is not data is stored or allocated in sequence wise inside the memory. As this a schema-less database so here no need to make a schema where it saves a lot of valuable time of a user. Next, the data has been fetched from the MongoDB, after that pre-processing and cleaning of the data has been done here where columns has been selected and removed as per the need. Along with these the rest csv format data all together have been stored in the PostgreSQL database which is the Structured Query Language Database. This gives freedom to the users and programmers to use, modify and implement as per the business needs, requirements and logic and python provides a flexible and suitable package called as the pyscopg2 library for connection to the PostgreSQL database. After storing the data in PostgreSQL database, data has been fetched from this particular table of the database where the data was in tabular format and used finally has been used for the visualization.

Results and Evaluation

D. Visualization of Electricity Trends

- Electricity trends in commercial and residential regions: Given figure1, Ireland, Euro Area, and EU 27 showed that there is a similar trend from year 2016 to 2018 and there was increase in usage of electricity for commercial

purposes across all the sectors but Ireland had drastic increase in trends during the years 2019 to 2022. As compared to residential region, there is a decreasing trend in electricity consumption for Ireland during the same period. *This decrease may be influenced by factors

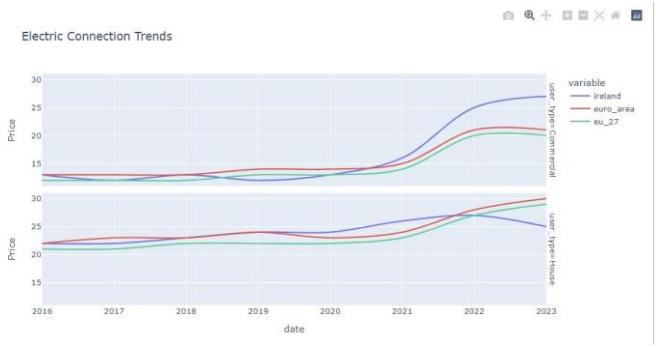


Fig. 2. Electricity Trends

such as improved energy efficiency in homes, adoption of energy-saving technologies, or changes in consumer behaviour. *

- Electricity usage by County: As shown in the figure 2, this filter visual helps in identifying electricity usage from 2016 to 2022 across all the all sectors, commercial and residential regions respectively. If we would want to know the electricity usage for one particular county, filter visuals allow customised visualizations and is user friendly.
- Residential: Top 10 Countries for Each Year for electricity: Given figure 3, shows the top 10 counties for the year 2022 as selected from filter, displaying which county has

Fig. 3. Electricity usage by County

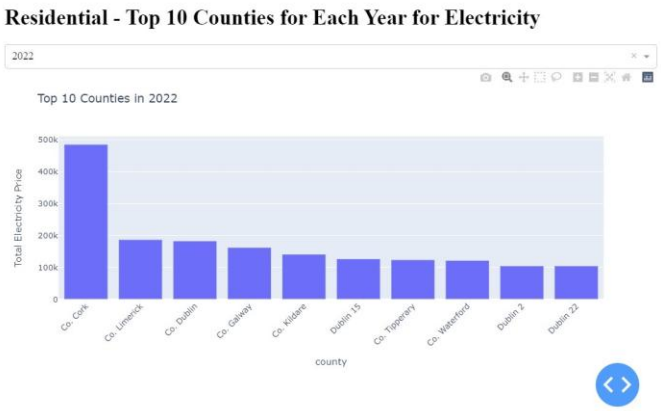
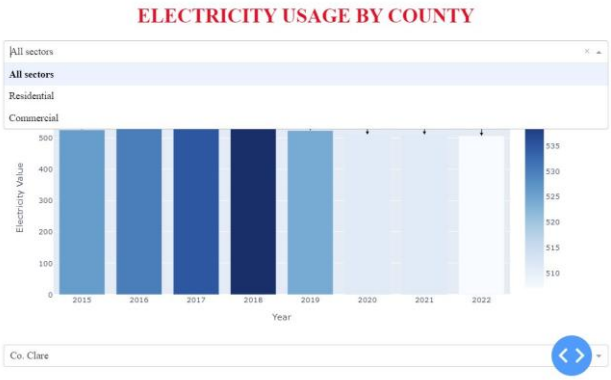


Fig. 4. Residential: Top 10

the highest electricity price for the year 2022, here its co. Cork, across all the residential region. As this is a filter



visual, years can be selected accordingly between 2016 to 2022.

- Commercial: Top 10 Countries for Each Year for electricity: Given figure 4, shows the top 10 counties for the year 2022 as selected from filter, displaying which county has the highest electricity price here its co. Cork, for the year 2022, and the least is co. Donegal, across all the commercial region. As this is a filter visual, years can be selected accordingly between 2016 to 2022.

E. Visualization of Gas Trend

- Gas usage trends in commercial and residential regions: Given figure5, Ireland, Euro Area, and EU 27 showed that there is a similar trend from year 2016 to 2022 and no much difference in the pricing in the commercial sector but there was increase in usage of gas in Ireland during the year 2022 in the residential sectors.
- Gas Usage by County: Given figure 6 shows the gas usage trends of all sectors including commercial and residential for the years 2016 to 2022, showing the increased gas consumption was in the year 2019, trends can be filtered by selecting counties based on which the user needs.

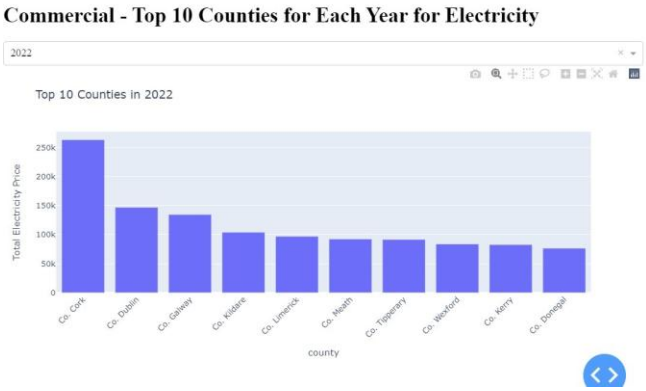


Fig. 5. Commercial: Top 10

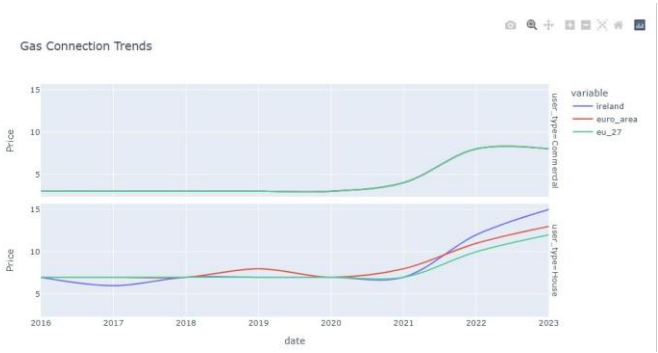


Fig. 6. Gas connection Trends

F. Visualization of water consumption Trends

- Different visualizations of water consumption from the years 2016 to 2022 for all the counties.
- Water consumption of top 10 counties among all the counties. Given figure 12 shows, Dublin 17 has highest water consumption and Dublin 2 has least consumption of water among the top 10 counties.

  The figure 13 shows the water consumption trends for Dublin 24 for the years 2016 to 2022. As this is a filter visual, it can be customized for required county consumption trends.

G. Visualization of waste water treatment Trends

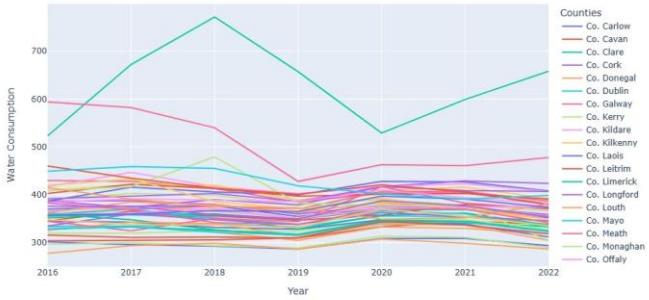


Fig. 8. Line Graph

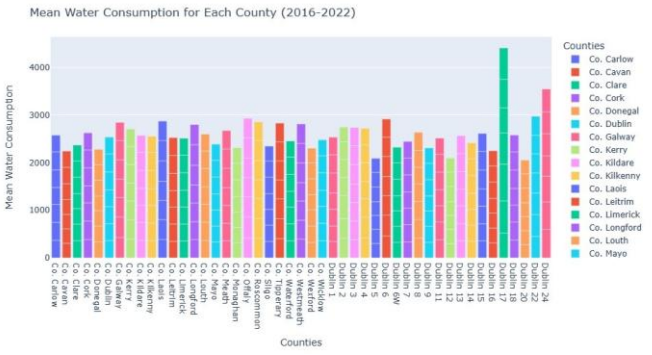


Fig. 9. Bar Graph

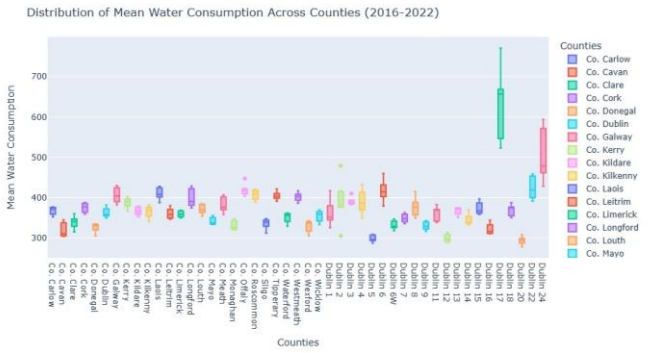


Fig. 10. Box Plot

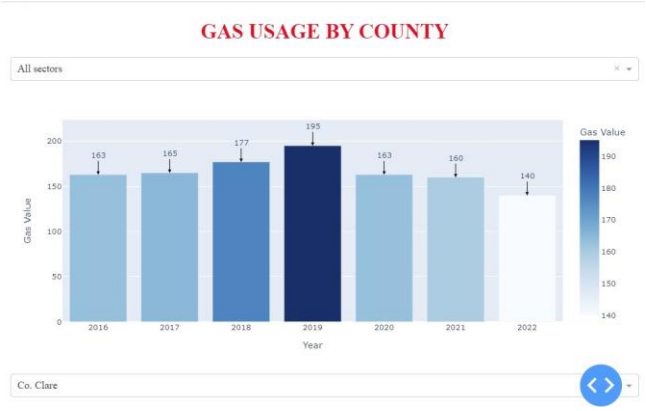


Fig. 7. Gas Usage by County

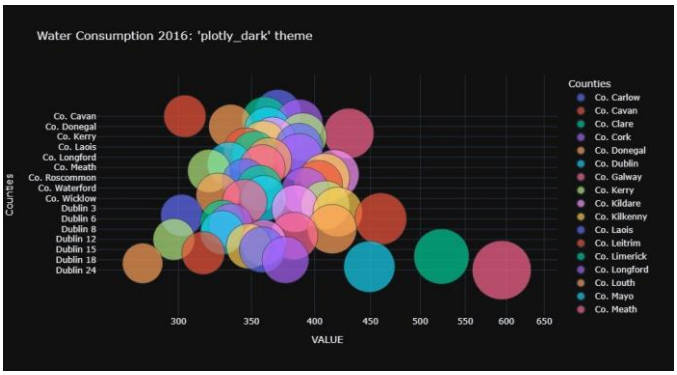


Fig. 11. Bubble Plot

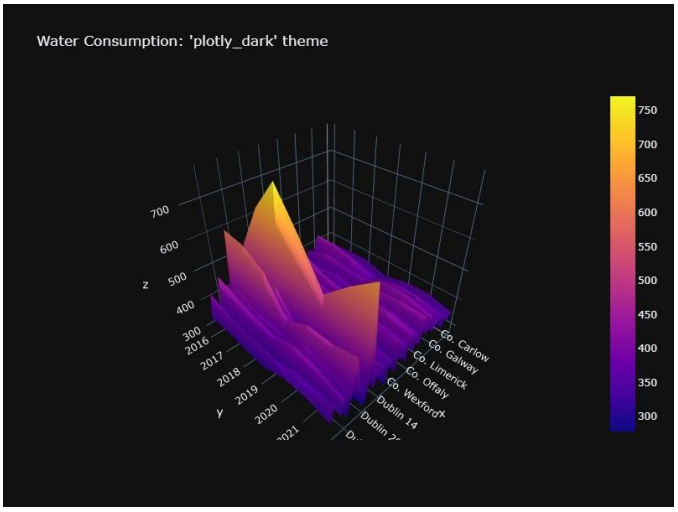
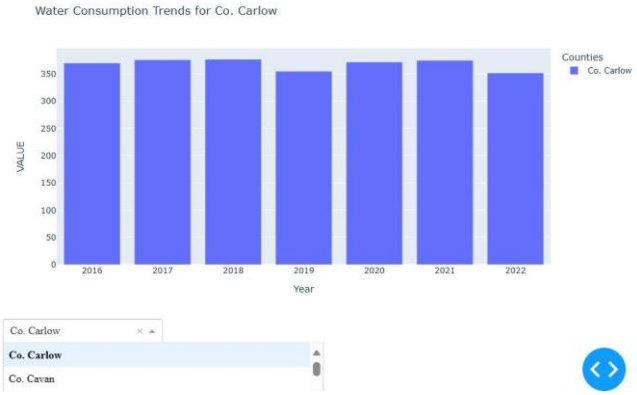


Fig. 12. 3D Plot



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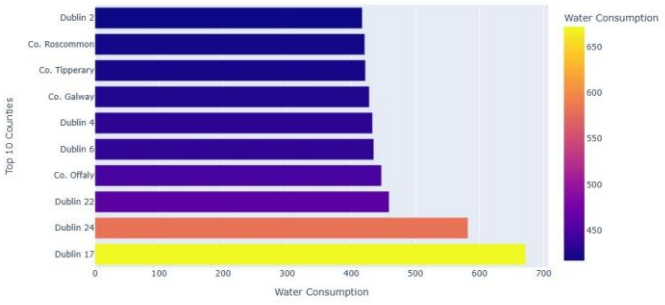
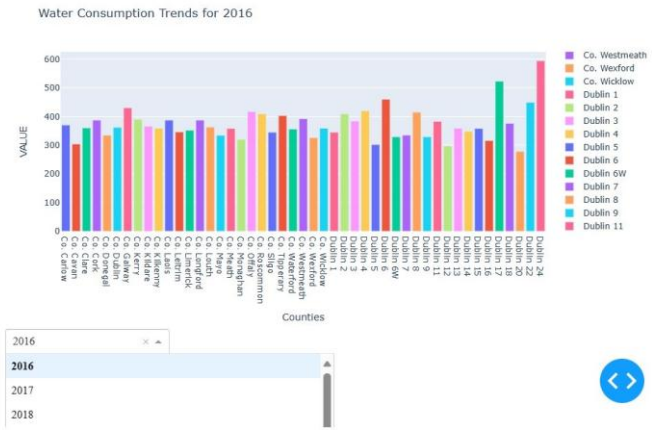


Fig. 13. Water Consumption: top 10



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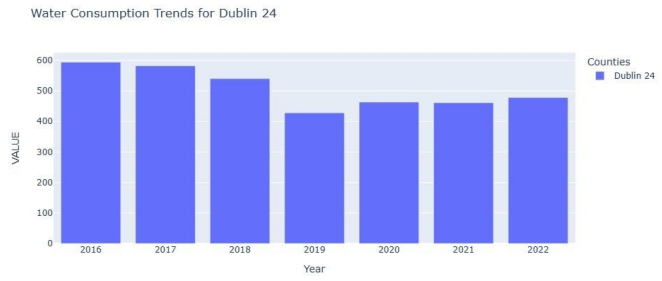

Fig. 17. Enter Caption

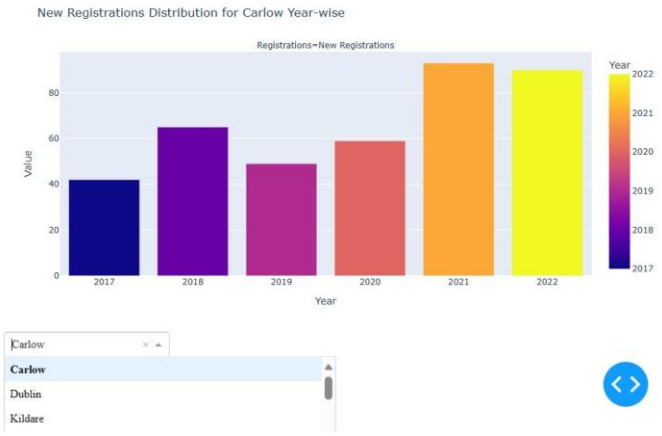

Fig. 14. Water consumption trends

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Fig. 18. Enter Caption

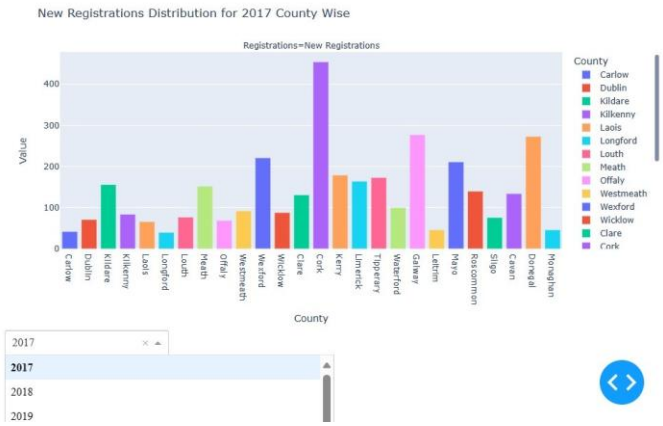

Fig. 19. Enter Caption

CONCLUSIONS AND FUTURE WORK

This study gives us a detailed analysis of gas, water, and electricity usage in both residential and commercial regions in Ireland. The different visualizations give us information about the consumption patterns based on different counties from the year 2016 to 2022 for understanding of the efficient usage of resources. In conclusion, this study contributes to the area of sustainable resource management by giving analysis and visualizations of gas, water, and electricity usage in Ireland. This analysis will provide valuable insights to stakeholders, for making informed decisions and all individuals committing to proper resource utilization for a more sustainable future.

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