IRELAND
ENERGY FORECASTING

A DATA-DRIVEN APPROACH TO FORECASTING ENERGY CONSUMPTION

GROUP 26

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WHY THIS?

SCENARIO 2

ENERGY FORECASTING

Ireland is at a **pivotal point** in renewable energy adoption, with unique geographical and economic conditions influencing energy consumption patterns.

Current Energy Mix (2022 Data)

- **Petroleum Products**: *Predominant Contributor*
  - Accounts for 45.9% of Ireland's energy consumption.
  - One of the highest oil dependencies in the EU.

- **Natural Gas**: *Substantial Contributor*
  - Provides 32.8% of the nation's energy.

- **Renewables**: **Rising Contributor**
  - Wind energy makes up 12.7% of the energy mix.

- **Solid Fossil Fuels**: Significant but Decreasing
  - Coal constitutes 8.6% of energy usage.

Progressive Shift (2023 Update)

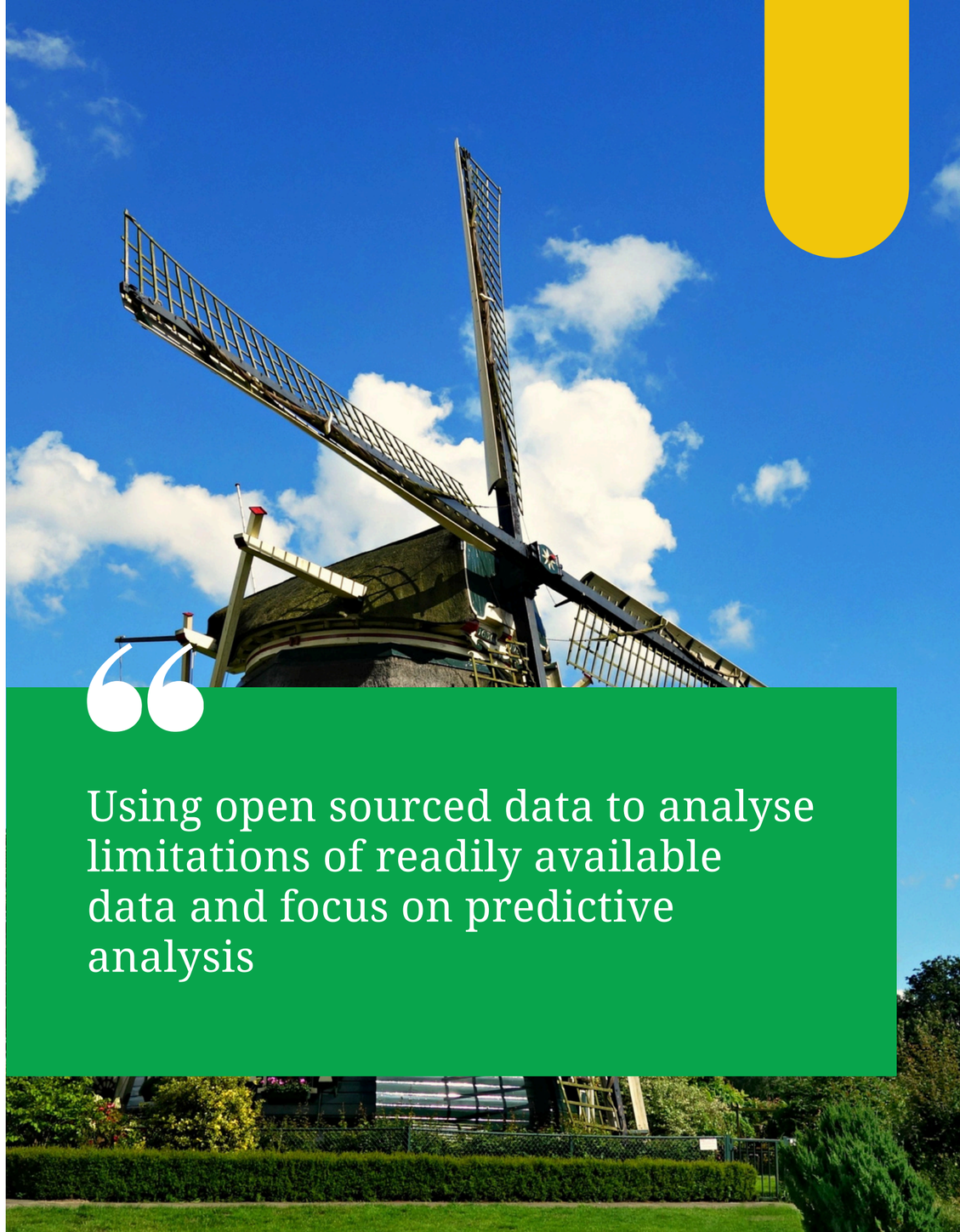
- Accelerated Investment in Renewable Energy
- Wind Farms' Remarkable Growth
  - **Supplied 35% of Ireland and Northern Ireland's electricity.**
  - Demonstrates significant progress towards sustainable energy.

PROBLEM STATEMENT

Background: Despite improvements in renewable energy usage, Ireland remains dependent on non-renewable sources.

Challenge: Accurately forecast energy consumption trends to guide policy and investment towards renewables.

Objective: **The core objective is to leverage predictive analytics to effectively forecast Ireland's energy usage trends. This will aid in identifying key areas for investment in renewable energy, supporting a strategic transition to a more sustainable energy future.**



> Using open sourced data to analyse limitations of readily available data and focus on predictive analysis

OUR APPROACH.

Using Machine Learning Models to predict energy consumption trends

Evaluation
Assessing model performance using relevant metrics.

Model Implementation
Integrating machine learning models that can learn from historical data and make accurate predictions.

Data Integration
Combining datasets from various sources to create a unified data model.

Data Cleaning
Ensuring the data quality by removing irrelevant records and handling missing values.

DATA COLLECTION

PROCESS

01

We targeted open-source repositories for data collection to ensure transparency and reproducibility

02

Identified datasets related to energy consumption and generation.

03

Ensuring the data pertained specifically to the Irish market.

Datasets Used

01 Electricity Demand

Overall consumption in Terawatt-hours (TWh). Contains data on generation and demand,

02 Energy Source Aggregate

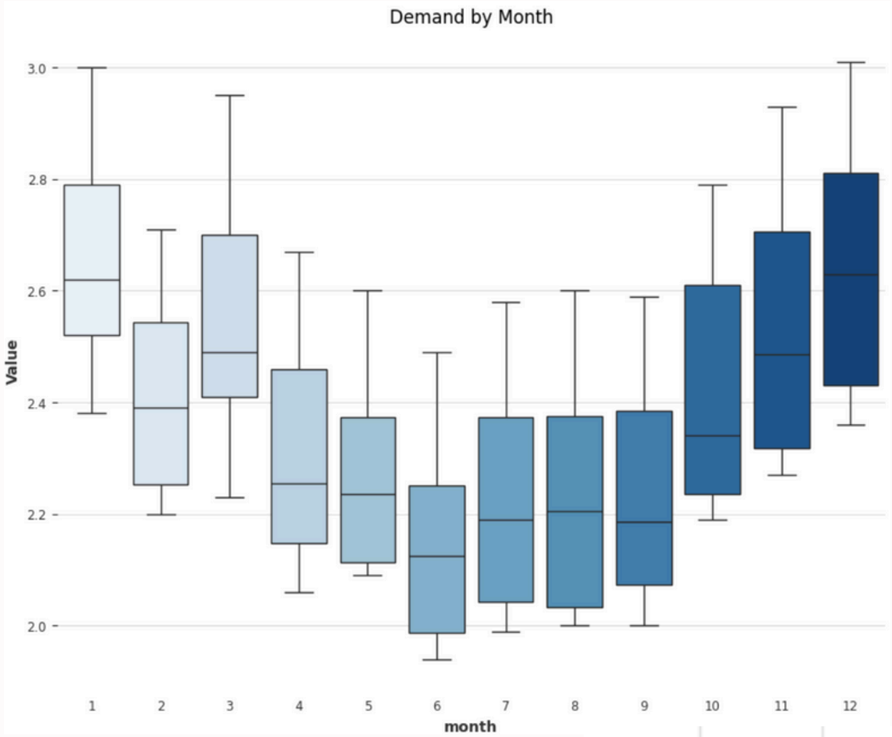
Contribution of different energy sources (clean, fossil, gas and oil, hydro, bio, wind, and other renewables) to the total energy produced, in both percentages and TWh

03 Wind Speed

Wind speed (in m/s) across different regions [IE0, IE4, IE5, IE6]

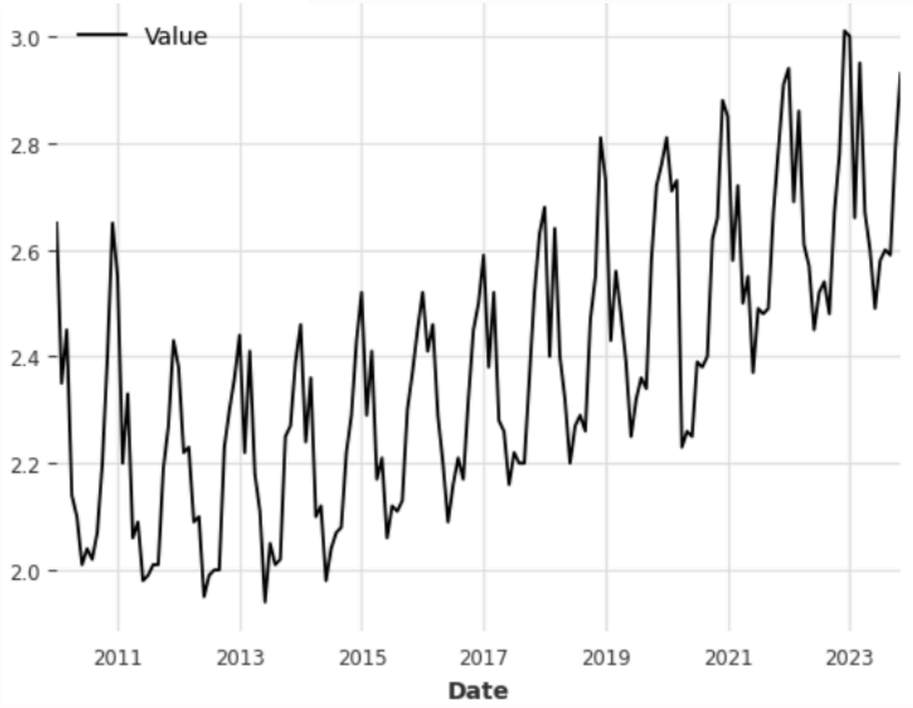
04 Price/Cost

Contains data on household and commercial consumption, price, and value.



Monthly

Annual



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What the electricity demand look like?

ABOUT OUR DATA

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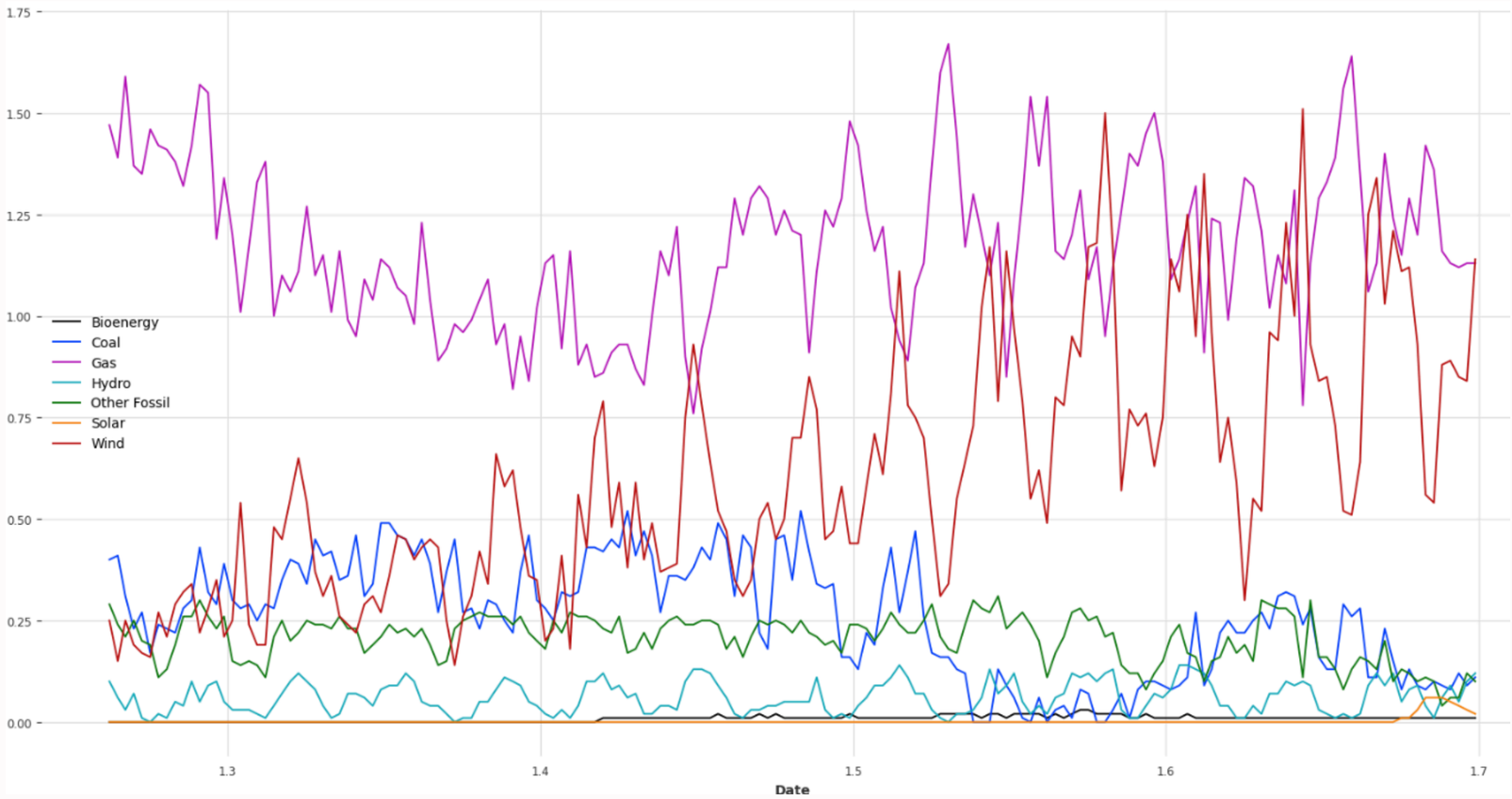
Energy Sources

BIOENERGY
WIND ENERGY
HYDRO ENERGY
SOLAR ENERGY
COAL
NATURAL GAS
FOSSIL FUELS



What the energy consumption look like?

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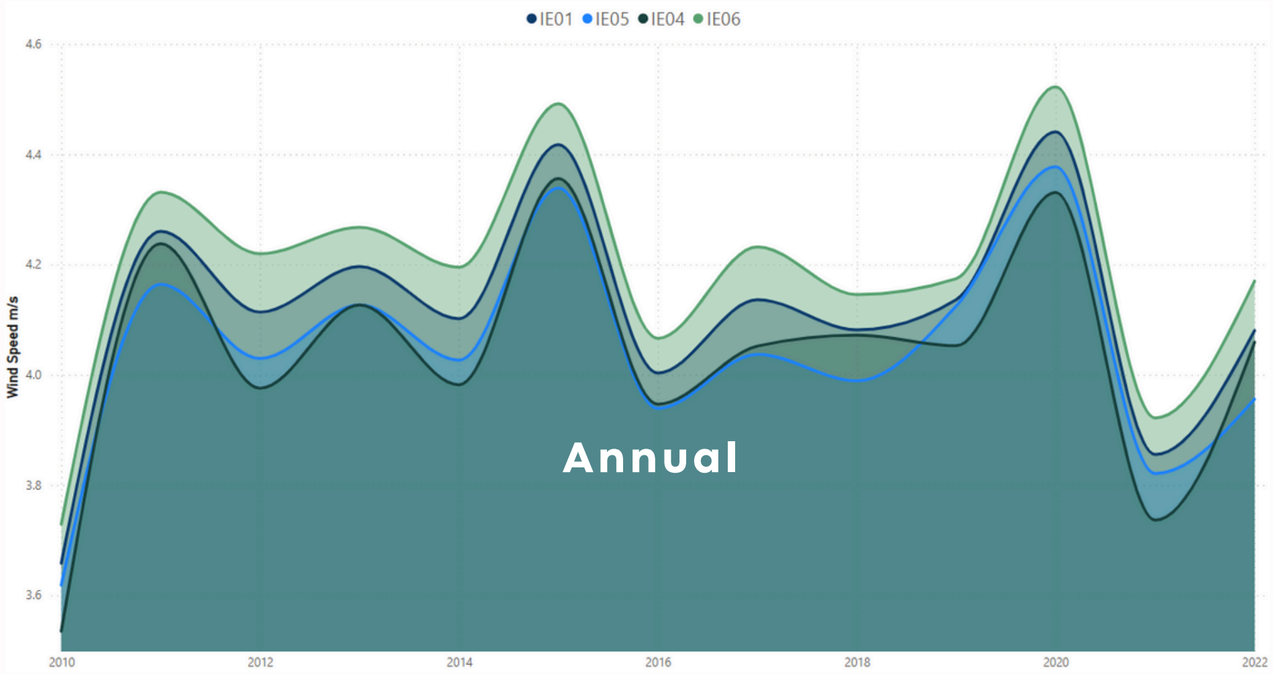

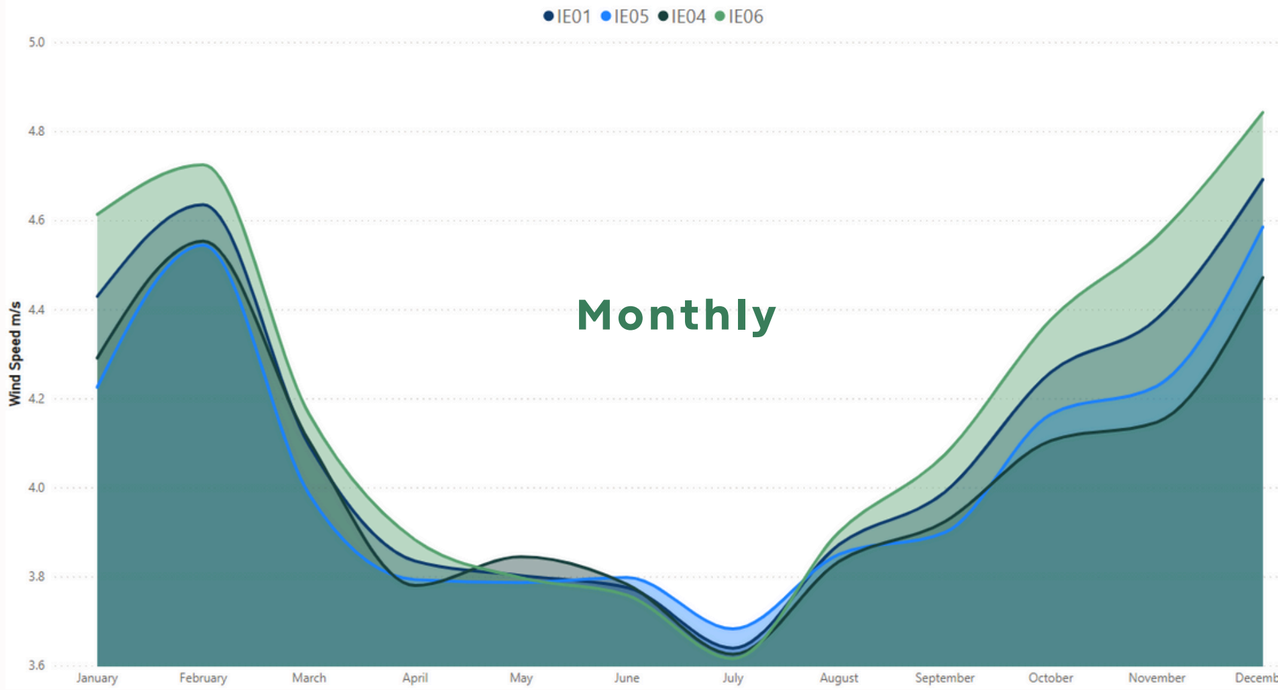

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What is the wind speed across regions?

ABOUT OUR DATA

Cost-Value Correlation

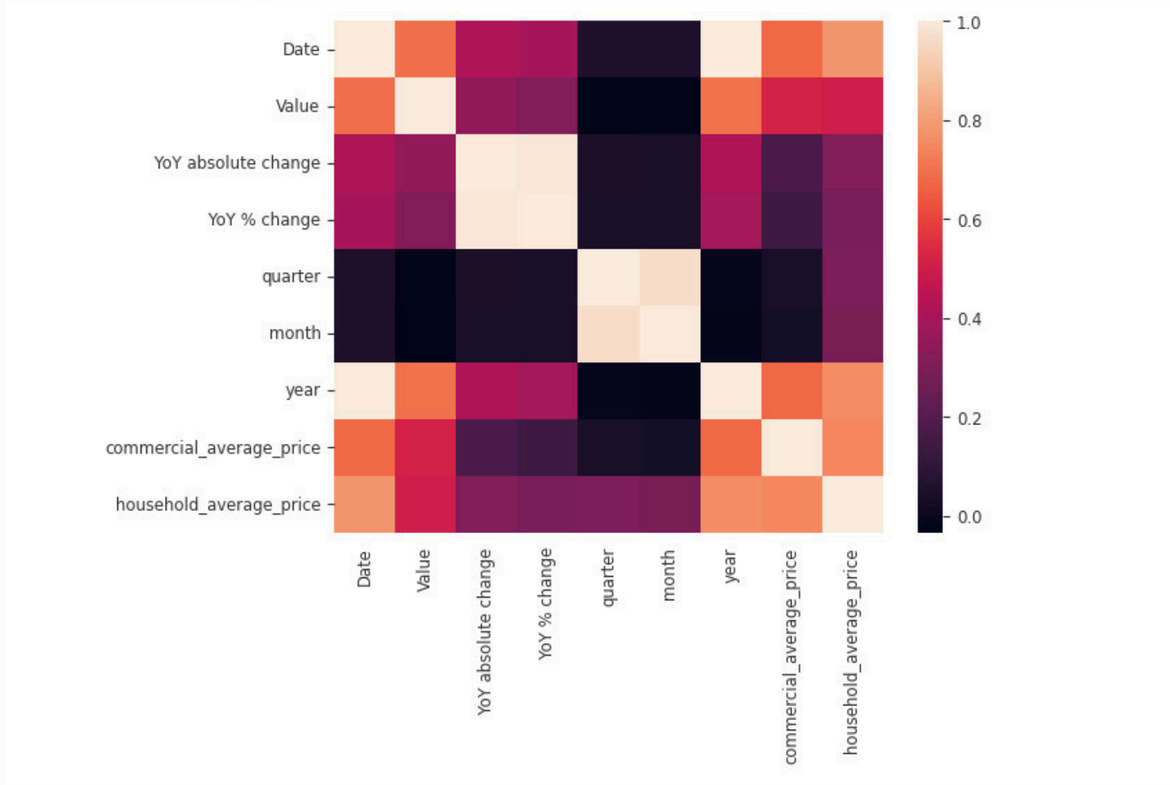
via HEAT MAP

Findings:

We find that as the economy grows ('Year'), both consumption/demand ('Value') and prices ('Commercial_Average_Price' and 'Household_Average_Price') are rising.

There is a strong positive correlation between Commercial_Average_Price and Household_Average_Price (0.752 indicating that commercial and household energy prices tend to move in tandem, which could suggest that factors affecting energy prices impact both sectors similarly.

	Value	quarter	month	year	commercial_average_price	household_average_price
Value	1.000	-0.030	-0.035	0.695	0.519	0.500
quarter	-0.030	1.000	0.971	-0.013	0.038	0.297
month	-0.035	0.971	1.000	-0.016	0.033	0.283
year	0.695	-0.013	-0.016	1.000	0.678	0.759
commercial_average_price	0.519	0.038	0.033	0.678	1.000	0.752
household_average_price	0.500	0.297	0.283	0.759	0.752	1.000



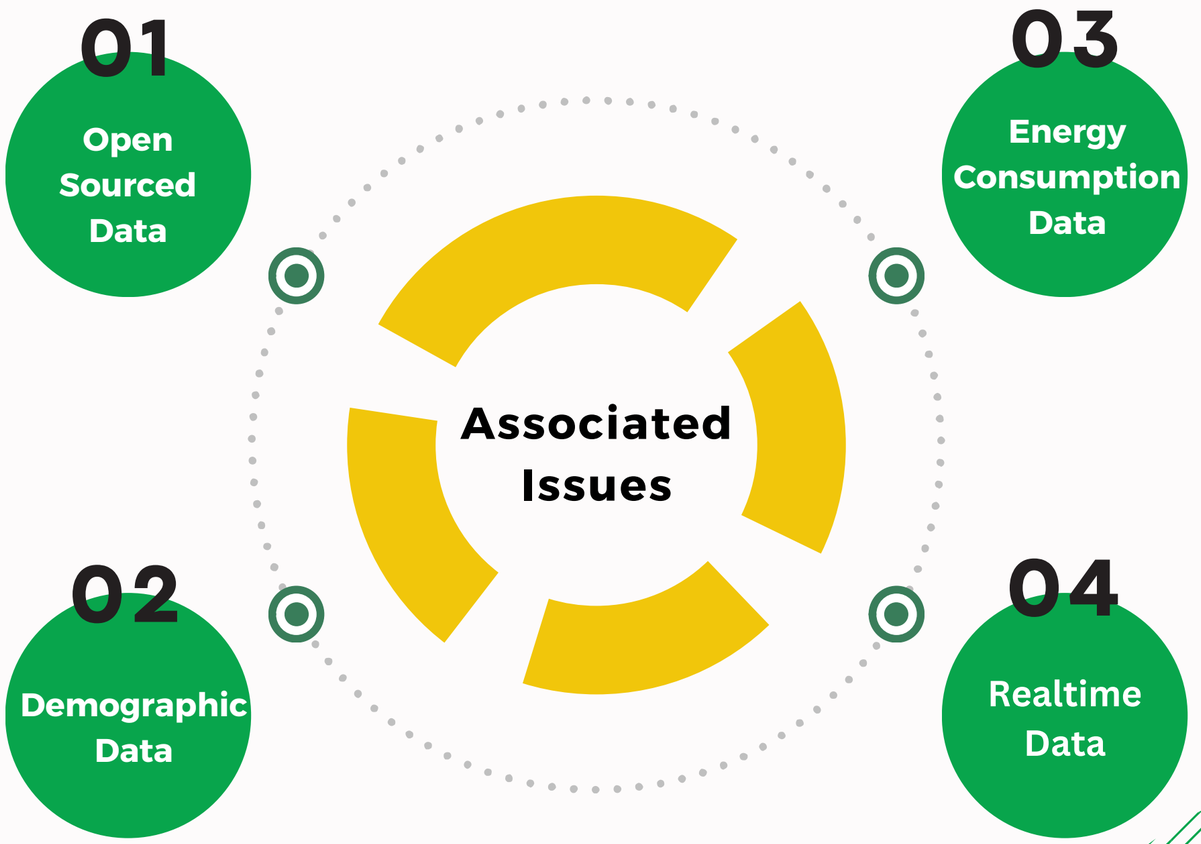
LIMITATIONS

01 The data is open-sourced, which ensures accessibility but may limit comprehensiveness.

02 Absence of granular data such as population density or region-wise consumption prevents a more detailed analysis.

03 External factors like economic trends or policy changes are not directly accounted for.

04 The aggregated annual data might overlook seasonal trends or monthly fluctuations, while the dataset's absence of real-time data could hinder forecasting short-term changes.

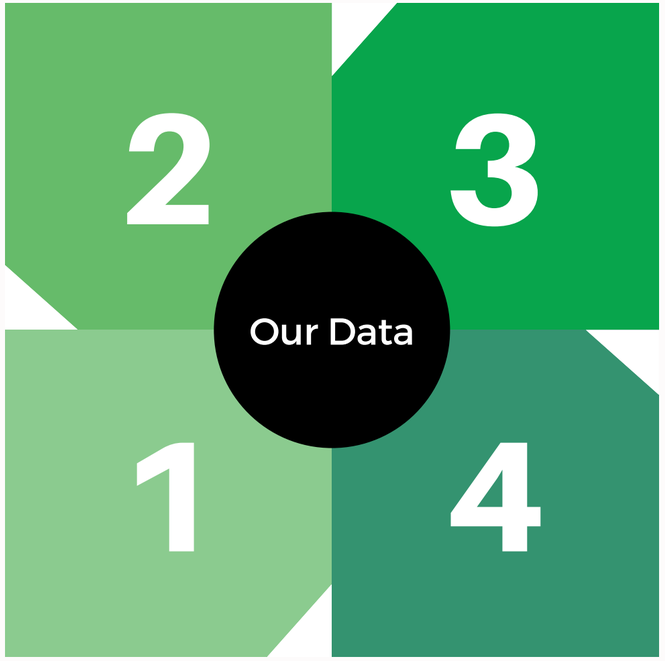


SEASONALITY

We have data that is spread across years and months which reflects seasonal changes

MISSING DATA

During the cleaning, we encountered several instances of missing data, which is a common occurrence in open source datasets.



TRENDS

We observed repetitive patterns in data, suggesting reccuring trends.

LARGE DATASET

The size of the environmental dataset is generally large.

Model Selection

01 Facebook Prophet

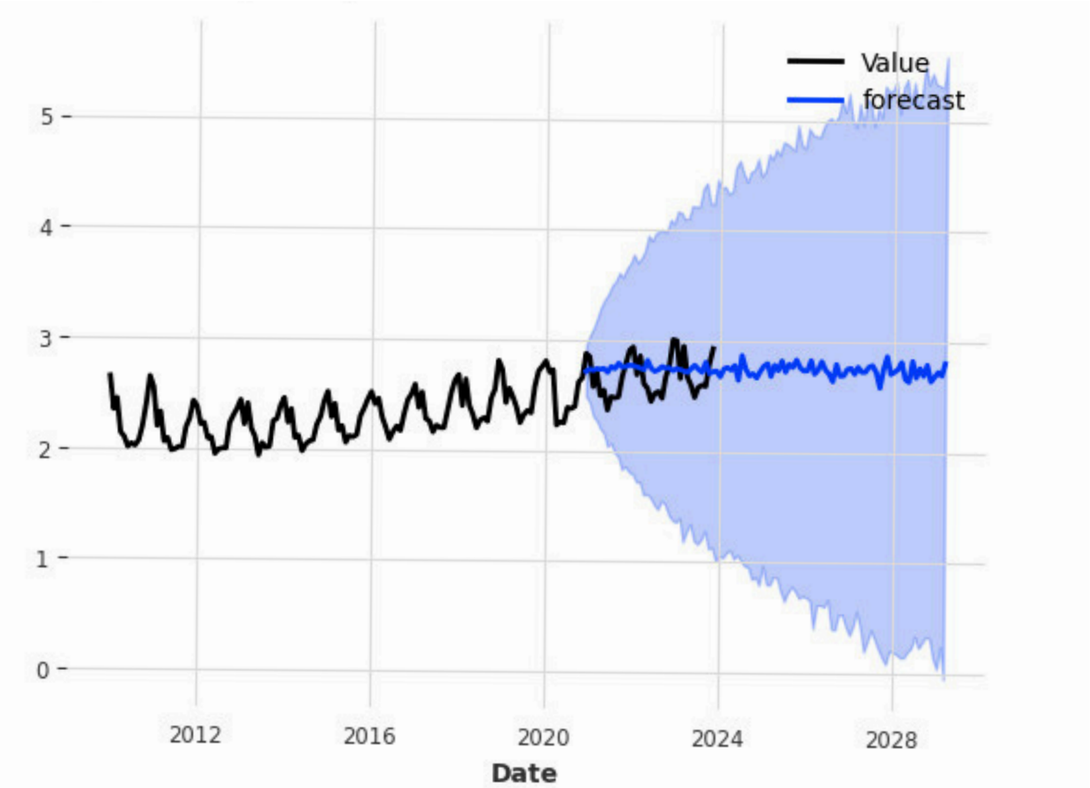
02 AutoARIMA

03 Exponential Smoothing (ES)

04 XGBoost

AUTOARIMA

Automatic Autoregressive Integrated Moving Average Model

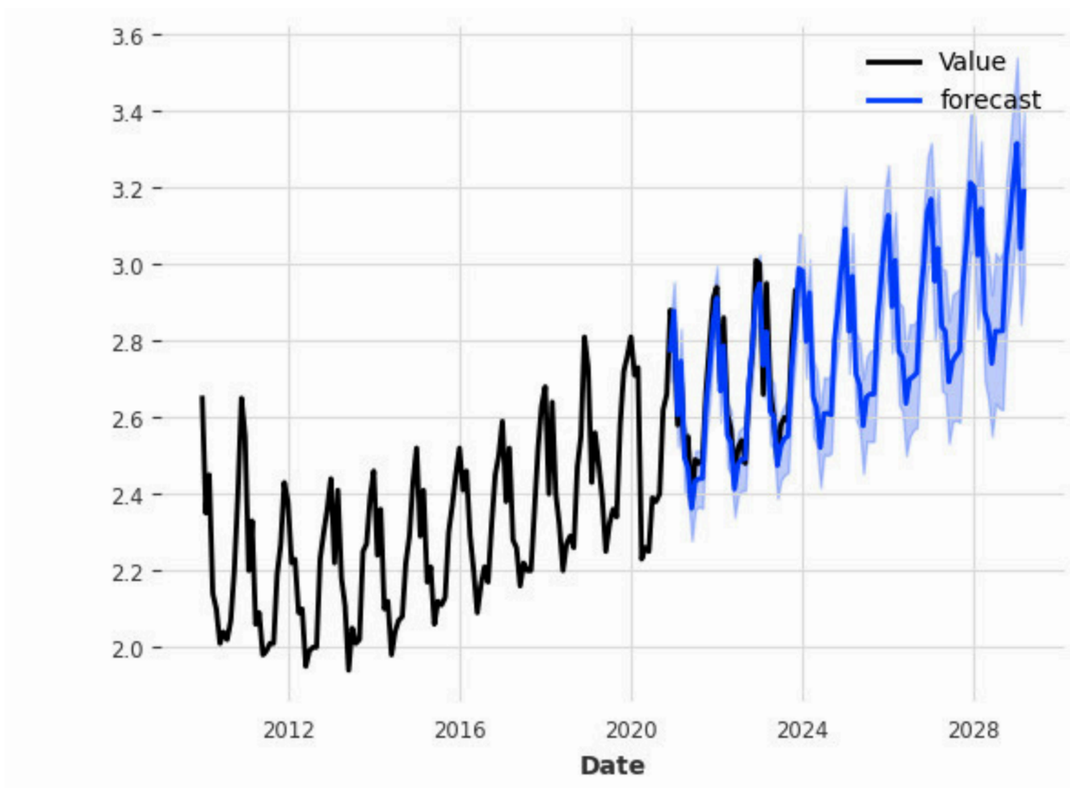


Utility

- Great for univariate time series without trend and seasonal components.
- Well-established.

PROPHET

Facebook Prophet Model

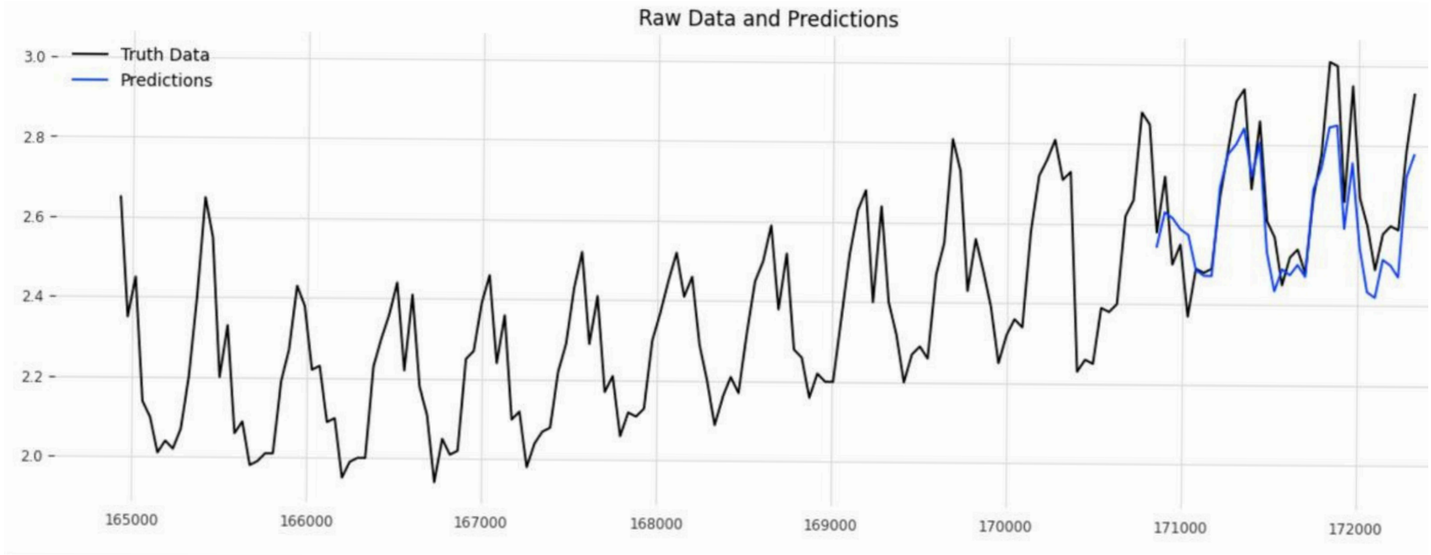


Utility

- Useful on data with multiple time scales, missing data, and outliers.
- User-friendly for non-technical users.
- Robust to Noise

XGBOOST

Extreme Gradient Boost Model

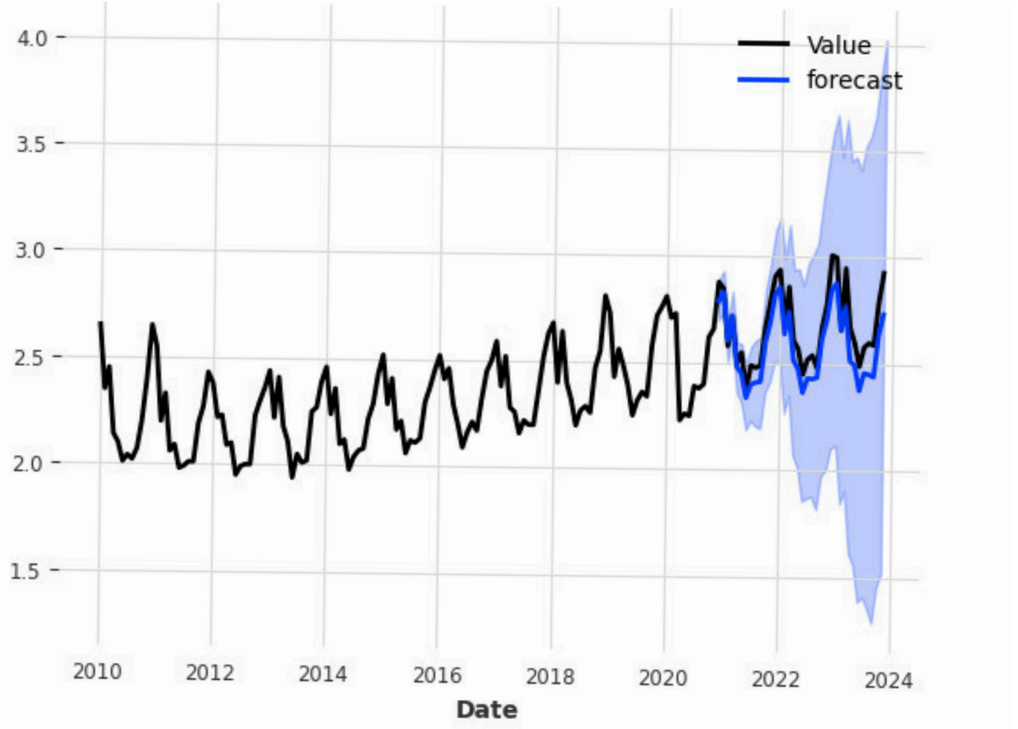


Utility

- Efficient handling of missing data.
- Handles both categorical and numerical data.
- Regularization to prevent overfitting.

ES

Exponential Smoothing Model



Utility

- Useful to handle seasonality and trends.
- Simple and computationally efficient.
- Regularization to prevent overfitting.

PERFORMANCE ANALYSIS

Comparing different Machine Learning Models

	Prophet	AutoARIMA	Exponential Smoothing	XGBoost
	✅	❌	❌	✅
RMSE	0.052831	0.190406	0.102821	0.042065

RMSE, or **Root Mean Square Error**, is the value that measures the average mistake the forecast makes. It's essentially a measure of predictive accuracy that assesses the extent to which the predicted values deviate from the true values. It helps understand how accurate a model is: the smaller the RMSE (CLOSER TO 0), the better the accuracy.

Further Testing

After obtaining successful results using the Prophet model, we decided to extend our exploration to forecast trends over the next 12 years till 2036. Here's how it performed:

Impact/Value Addition (if implemented):

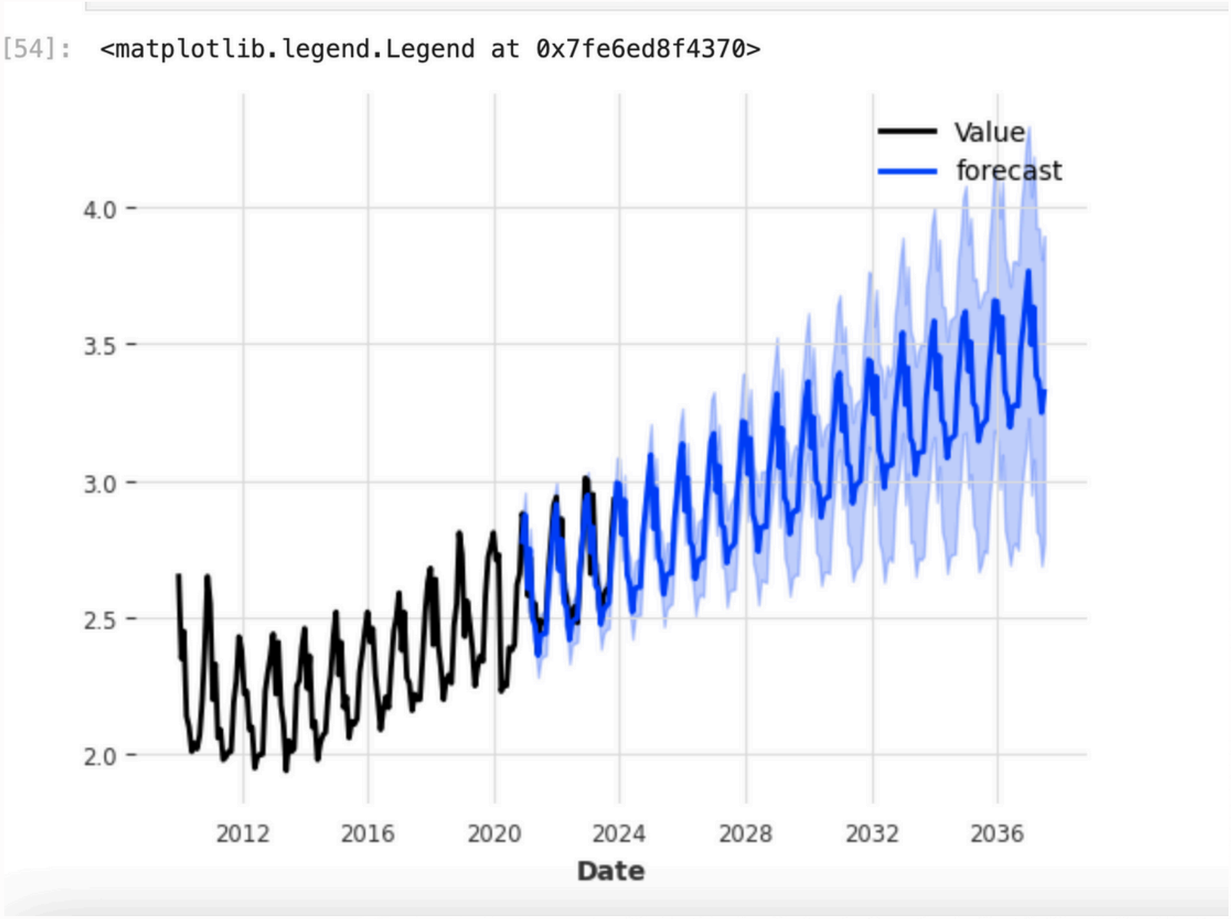
- Helps identify peak times for renewable energy production.
- Optimizes renewable and non-renewable energy source mix.
- Improves load balancing for efficient energy distribution.

Appropriateness of Data:

- Works well with higher-frequency and varied data.
- Assumes clean data without anomalies or missing values.

Accuracy in the Real World:

- Forecasts easily updated with new data given the data is diverse to avoid overfitting.
- May face challenges with unforeseen events.



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Date	Real Value	predicted_value
01-12-2020	2.88	2.777917413
01-01-2021	2.85	2.875237315
01-02-2021	2.58	2.606341925
01-03-2021	2.72	2.747125467
01-04-2021	2.5	2.494143269
01-05-2021	2.55	2.469918852
01-06-2021	2.37	2.360331664
01-07-2021	2.49	2.434050232
01-08-2021	2.48	2.43997425
01-09-2021	2.49	2.442175808
01-10-2021	2.67	2.634054318
01-11-2021	2.79	2.728638292
01-12-2021	2.91	2.84937966
01-01-2022	2.94	2.912327986
01-02-2022	2.69	2.671472931
01-03-2022	2.86	2.786907947
01-04-2022	2.61	2.555238705
01-05-2022	2.57	2.536909401
01-06-2022	2.45	2.41802893
01-07-2022	2.52	2.480610885
01-08-2022	2.54	2.49125995
01-09-2022	2.48	2.496907746

So where do we go from here?

In our analysis, we've observed a promising trend in wind energy consumption within the country. Wind farms, according to Wind Energy Ireland, contributed 35% of both Ireland and Northern Ireland's electricity in 2023, showcasing a growing reliance on renewable energy sources. Currently, there are just under 400 wind farms spread across the island of Ireland.

However, there's still ample room for improvement to reduce our dependence on costly energy sources. Presently, Ireland heavily relies on imported oil, with only a small fraction of indigenous biofuel production. Given the policy stance against future offshore oil exploration licensing, this reliance is unlikely to diminish. Gas remains the most consumed energy source in Ireland, and all these resources are finite and exhaustible.

Future goals

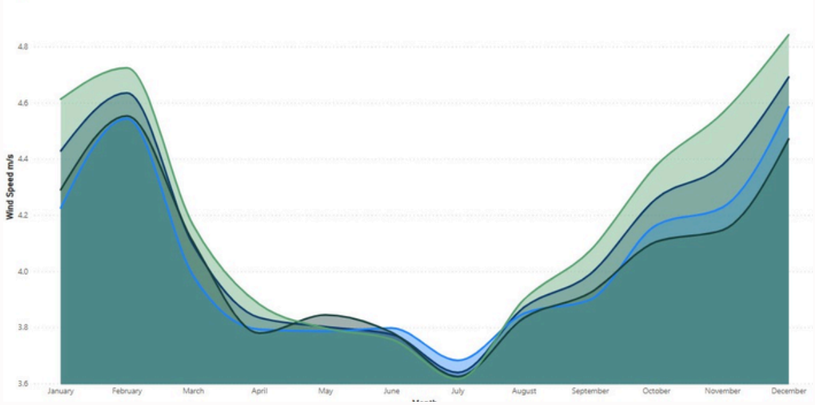
So where do we go from here?

01 Site Selection Based on Wind Speed

Strategy: Utilize the line graphs of wind speed to identify regions with consistently high wind speeds as potential sites for wind farms.

Action Plan:

- Conduct a detailed geographical survey using the data to pinpoint specific locations.
- Collaborate with meteorological experts to validate the wind speed trends and ensure the chosen sites will provide a sustainable and reliable source of wind power.

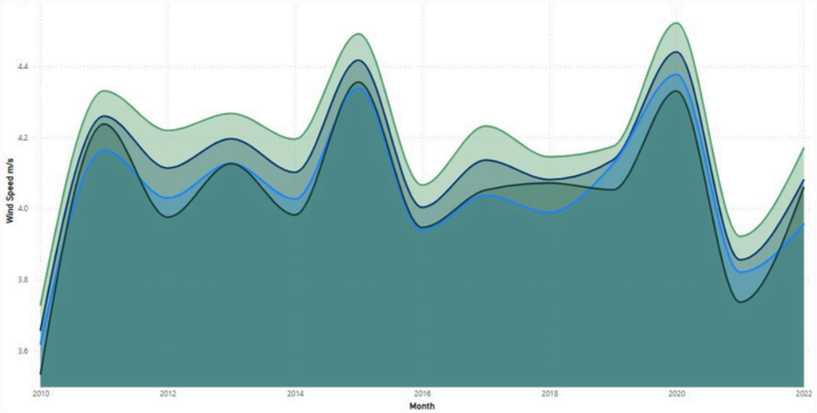


02 Regional Information Enhancement

Strategy: Gather in-depth information about the targeted regions for the wind farms, considering not only wind speeds but also logistical feasibility, community impact, and environmental considerations.

Action Plan:

- Perform an on-the-ground assessment to collect local data. This should include infrastructure analysis, environmental impact assessments, and community consultations to ensure the project's viability and social license to operate.



Future goals

So where do we go from here?

03 Risk Management and Contingency Planning

Strategy: Anticipate potential challenges and develop contingency plans.

Action Plan:

- Identify key risks such as fluctuating wind speeds, regulatory changes, or funding delays. Establish risk mitigation strategies and a contingency fund to address these risks as needed.

04 Addressing Model Limitations

Strategy: Enhance the predictive model by integrating diverse datasets to mitigate the risk of overfitting and improve the model's robustness.

Action Plan:

- Acquire additional datasets as identified in the limitations slide. This may include more granular regional energy consumption data, economic indicators, and demographic statistics. Update the model with this new information to refine forecasts and validate the chosen wind farm locations.

Geospatial data helps position wind farms optimally, balancing prime wind resources with environmental and societal considerations.

Data on **energy storage solutions** and **grid integration technologies** can help determine how effectively wind energy can be stored and distributed.

Analyzing **population growth patterns** informs forecasts of rising energy demand, guiding energy distribution strategy.

Future goals

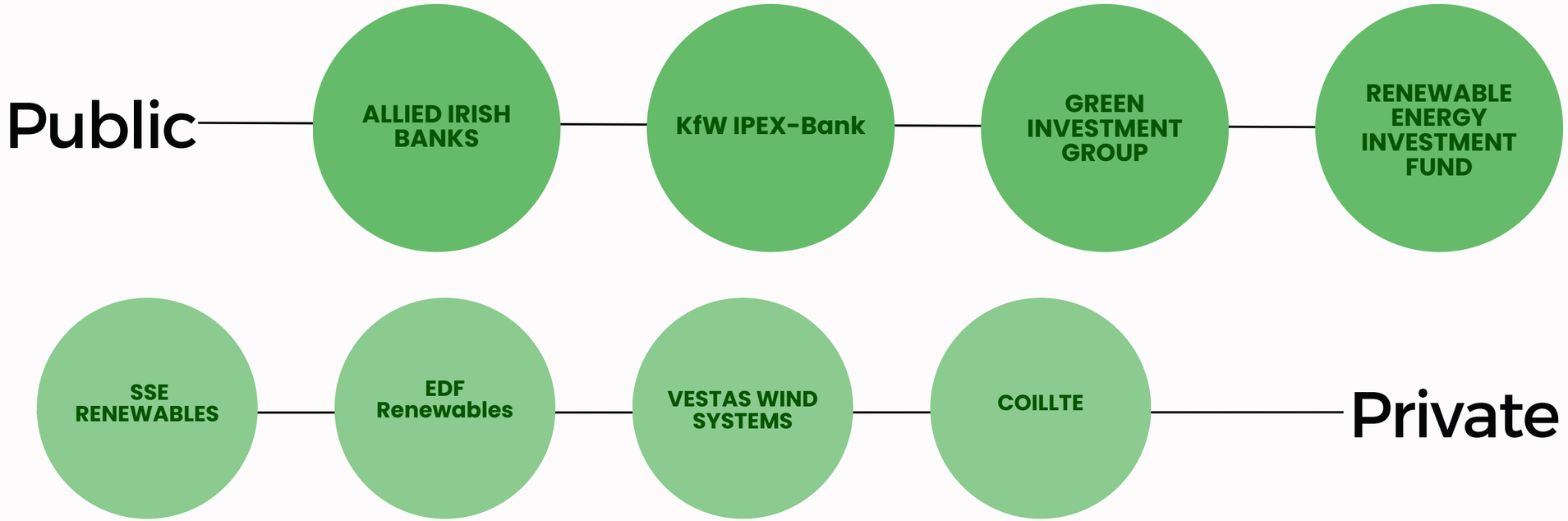
So where do we go from here?

05 Funding and Investment Mobilization

Strategy: Engage with investors who are committed to renewable energy initiatives, showcasing the potential return on investment and environmental impact of the wind farm project.

A**ction Plan**:

- Prepare a compelling investment pitch that includes data-driven projections of energy production, expected return on investment, and contribution to carbon footprint reduction. Highlight how the project aligns with the investors' sustainability goals.



Recommendation

We recommend that Ireland increases its investment in wind energy due to favorable geographical conditions. Wind farms are already a significant contributor to electricity generation, and further investment can accelerate the transition to sustainable energy. Our forecasts, generated using the Prospect model, indicate the potential for growth in wind energy consumption, though improved data sources could enhance accuracy. Investing in wind energy aligns with climate goals, offers economic benefits, and enhances energy security. Therefore, prioritizing wind energy investment can pave the way for a sustainable and prosperous energy future for Ireland.

THANK YOU!

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