FEYNN LABS INTERNSHIP

PROJECT 3

AI-Driven Energy Consumption Prediction in Machine Tool Production

Step 1: Prototype Selection

• PROBLEM STATEMENT

The machine industry faces significant challenges in managing and optimizing energy consumption, leading to increased operational costs and environmental impact. To address this issue, there is a critical need for a robust predictive energy consumption model that can analyze historical data, identify energy usage patterns, pinpoint inefficiencies, and provide actionable insights to facilitate optimal energy conservation strategies. This project aims to develop a sophisticated predictive analytics solution to empower machine industry companies in proactively managing their energy resources.

• INDUSTRY OVERVIEW:

The machine tool production industry involves the manufacturing of tools, machinery, and equipment used in various manufacturing processes. This sector is characterised by large-scale operations, high energy consumption, and a significant environmental impact. Companies in this industry are increasingly recognising the importance of reducing their carbon footprints to comply with regulations, meet customer expectations, and achieve long-term sustainability.

Business Challenges:

- **Carbon Emission Reduction Pressure:**
  - Stringent environmental regulations and global initiatives demand a substantial reduction in carbon emissions across industries.
  - Customers, investors, and regulatory bodies are scrutinizing businesses to adopt sustainable practices.

- **High Energy Costs:**
  - Energy expenses account for a substantial portion of operational costs in machine tool production.
  - Fluctuating energy prices and the need for energy-intensive manufacturing processes contribute to financial uncertainties.

- **Operational Inefficiencies:**
  - Lack of visibility into energy usage patterns and inefficiencies hinders the industry's ability to adopt targeted energy-saving strategies.
  - Traditional approaches to energy management may not capture dynamic operational changes and patterns.

Customer Needs:

- **Sustainability Goals:**
  - Companies in the machine tool production industry are actively seeking solutions to reduce their carbon footprints and align with global sustainability goals.
- **Cost Savings:**
  - Cost-effective solutions that optimize energy usage are highly desirable, providing companies with a competitive edge by reducing operational expenses.
- **Operational Efficiency:**
  - The industry requires insights that go beyond simple energy monitoring, focusing on identifying specific areas of inefficiency to implement targeted improvement strategies.

Step 2: Prototype Development

• INFORMATION AND DATA ANALYSIS

For Data analysis we have use below dataset from Kaggle

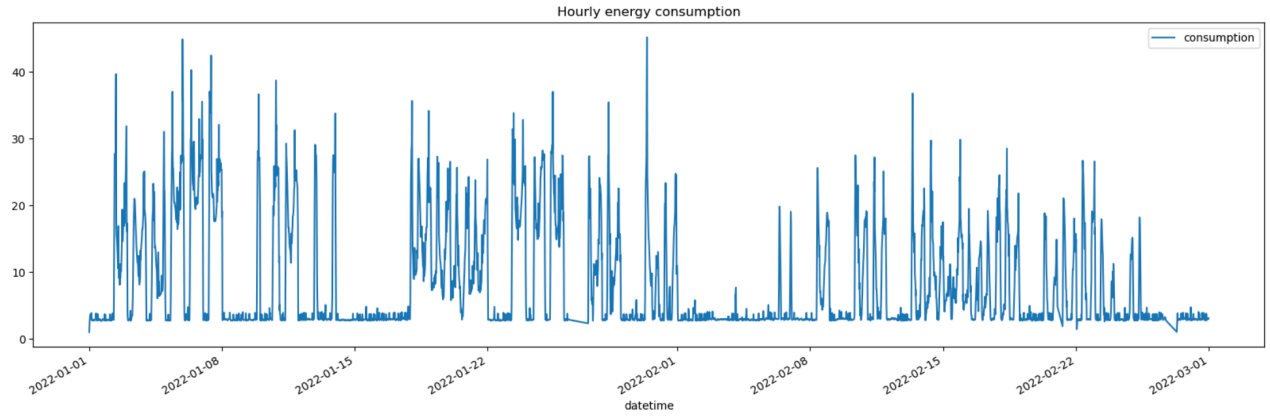
# srn	TxnDate Date of Energy Consumption	TxnTime Time of Energy consumption	# Consumption Consumption in KWh from previous time and current time stamp
 73.6k 98.0k	 2022-01-01 2022-01-20	 2022-11-27 2022-11-28	 0.84 27.1
76229	01 Jan 2022	16:55:52	1.01
76258	01 Jan 2022	21:45:29	0.908
76287	01 Jan 2022	12:24:52	0.926
76316	01 Jan 2022	04:07:36	0.928
76345	01 Jan 2022	06:52:25	0.916
76374	01 Jan 2022	10:20:09	0.972
76403	01 Jan 2022	15:32:01	0.878
76432	01 Jan 2022	19:23:47	1.902
76461	01 Jan 2022	11:19:47	0.9
76490	01 Jan 2022	14:52:01	0.928

This dataset featuring Consumption of Electrical Blower Machine with time-slots of around 10-15 min. this data is recorded with help of IoT device. Energy Consumption is Measured between Current and Previous time stamp.Null or less than 0.5 value of Energy Consumption means machine was of during respective time slot time . Above time series consumption is Stationary with time as KWH i.e Kilo Watt/Hour Capacity of Blower motor is fixed.

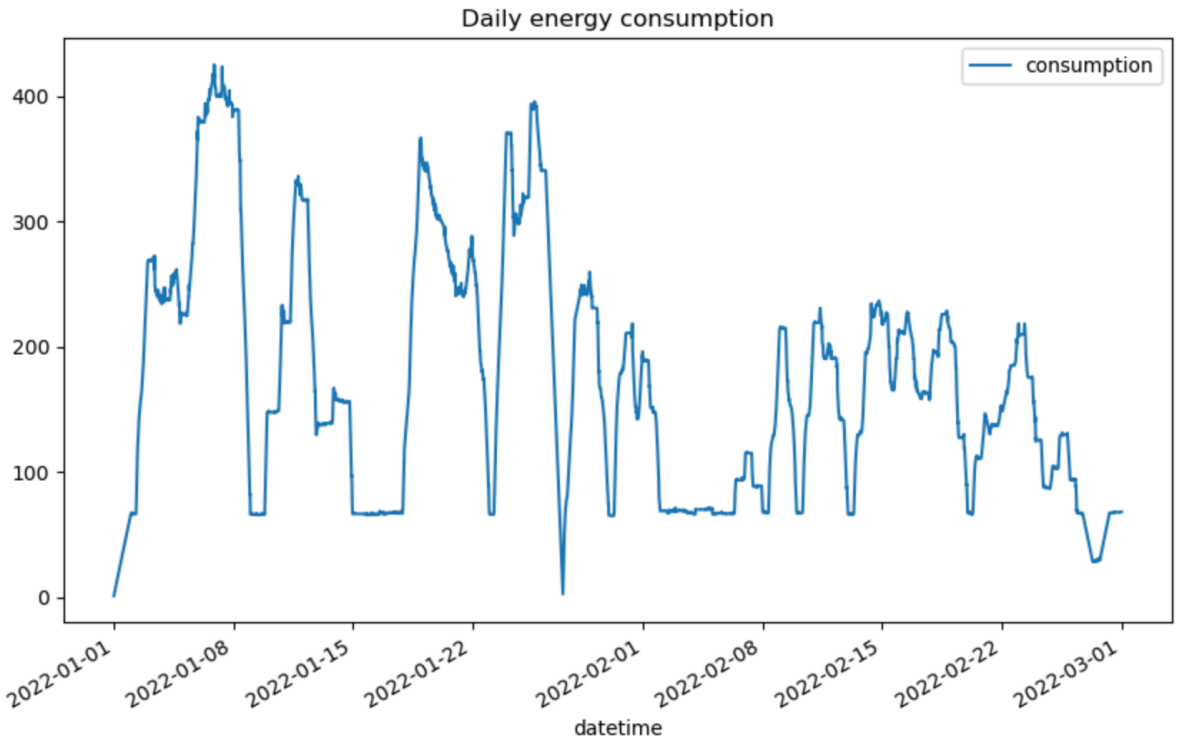
• DATA VISUALISATION OF ENERGY CONSUMPTION

Below visualisation depicts the hourly energy consumption of the machine across the period of 3 months.

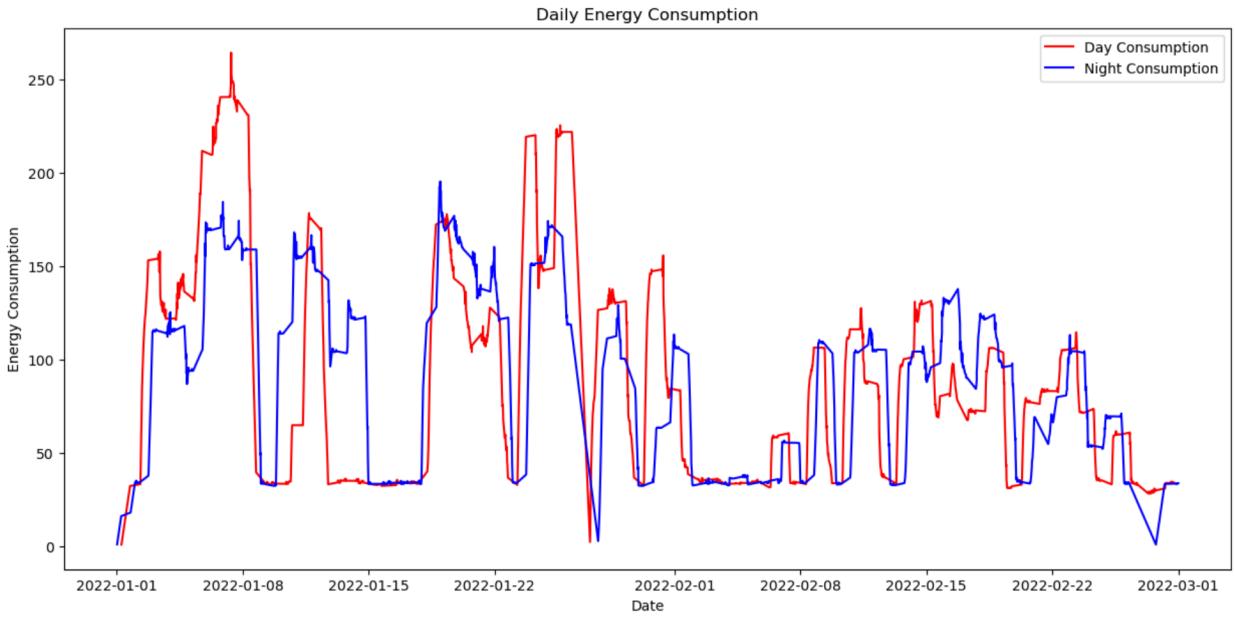
```
import matplotlib.pyplot as plt

# Sort the DataFrame by the 'datetime' column
df.sort_values('datetime', inplace=True)

# Apply the rolling operation
df.rolling('1H', on='datetime').sum().loc[df['consumption'] > 0.5].plot(x='datetime', y='consumption', title="Hourly

# Show the plot
plt.show()
```



Below visualisation depicts the Daily energy consumption of the machine across the period of 3 months.



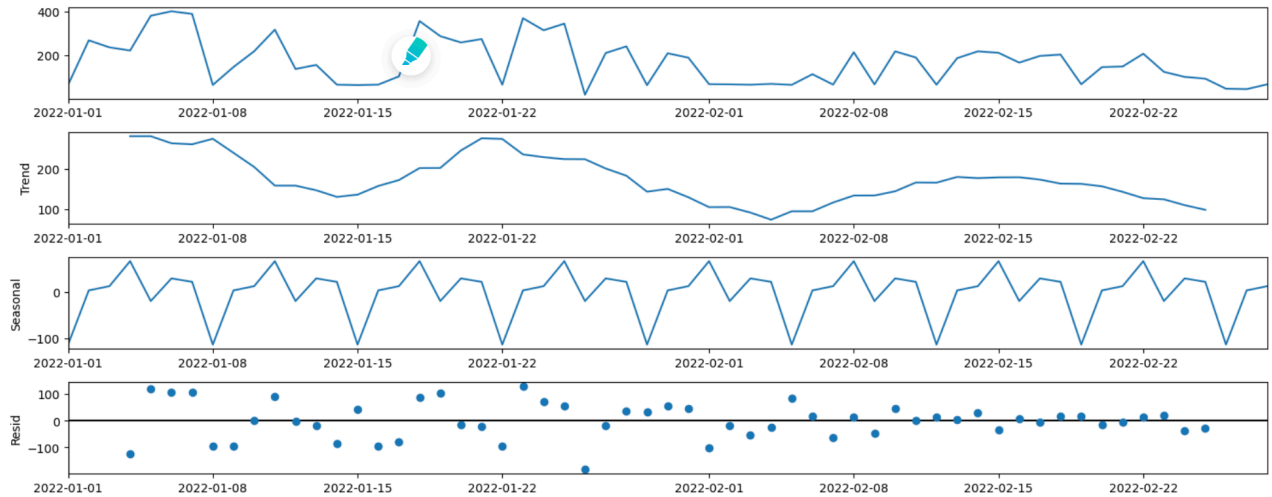
• Separating day and night consumption time



• TimeSeries Forecasting

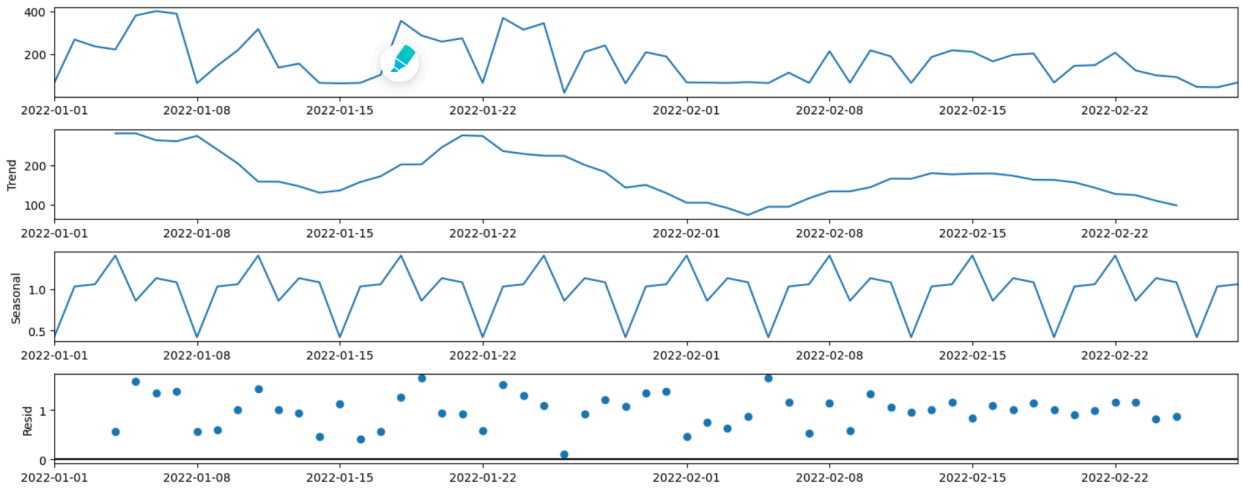
Additive Decompostion

```
#TimeSeries Additive Decomposition

from statsmodels.tsa.seasonal import seasonal_decompose

result = seasonal_decompose(df_copy,model='additive')
plt.rc("figure", figsize=(15,6))
result.plot()
plt.show()
```

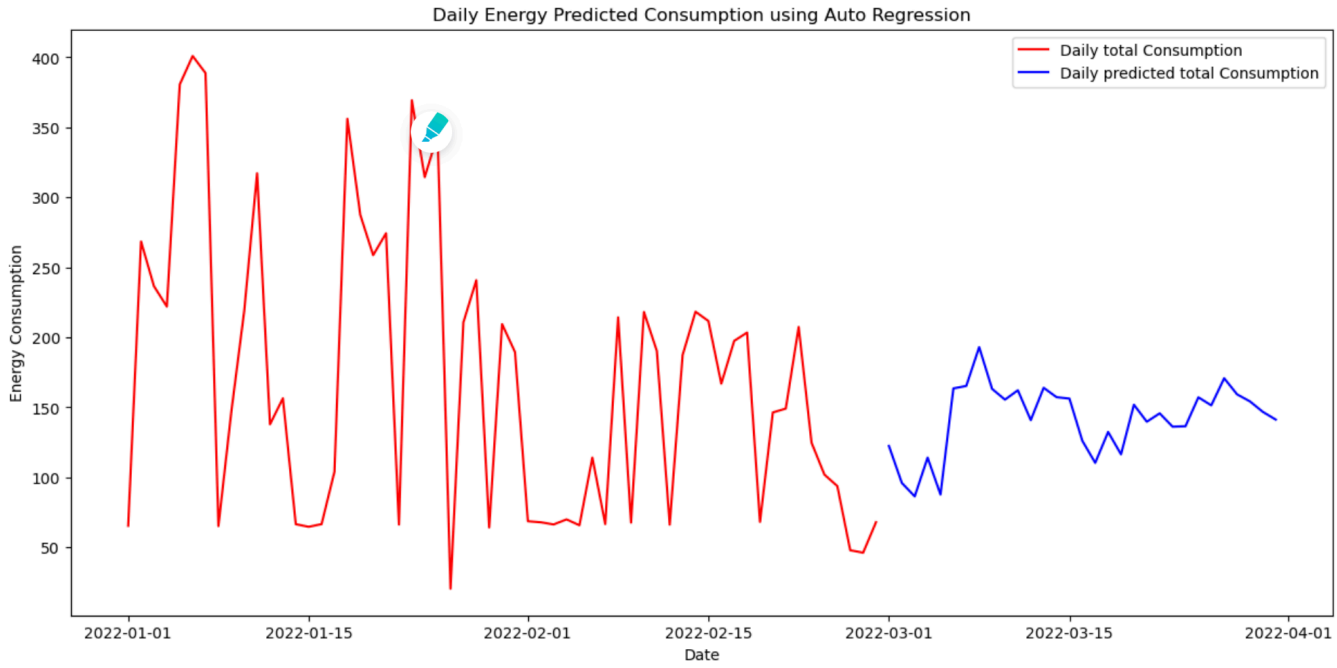


Multiplicative Decomposition

```
#TimeSeries Multiplitive Decomposition

from statsmodels.tsa.seasonal import seasonal_decompose

result = seasonal_decompose(df_copy,model='multiplicative')
plt.rc("figure", figsize=(15,6))
result.plot()
plt.show()
```



•Daily Energy Predicted Consumption using Auto Regression



Step 3: Business Modelling

PRACTICAL BUSINESS MODEL:

Monetization Strategy:

a. **Subscription Model**:

- ***Description****:* Implement a subscription-based revenue model where manufacturing plants pay a recurring monthly or yearly fee for access to the AI-based energy optimization platform.
- ***Features****:* Different subscription tiers can be designed to cater to various needs. Basic tiers may include real-time energy monitoring, while premium tiers could offer advanced features such as detailed reports, predictive analytics, and personalized energy-saving recommendations.

b. **Consultancy Services:**

- ***Description****:* Offer specialized consultancy services as an additional revenue stream. This can involve conducting in-depth energy audits, providing on-site visits, crafting custom energy solutions, and delivering ongoing support beyond the standard subscription services.
- ***Features****:* Customizable consultancy packages based on the specific needs of each manufacturing plant. Services may include personalized energy conservation plans, employee training, and continuous improvement strategies.

c. **Performance-Based Pricing:**

- ***Description****:* Introduce a performance-based pricing model, where clients pay a percentage of the actual energy cost savings achieved through the implementation of AI recommendations.

- ***Features**:* Clients benefit from the platform's efficiency improvements, and the pricing model aligns the success of the business with the tangible outcomes experienced by manufacturing plants.

- ***Advantages**:* Establishes a shared success model, fostering a strong partnership with clients. Encourages continuous improvement and optimization to maximize energy savings, creating a win-win situation for both parties.

Overall Monetization Strategy:

The combination of subscription-based revenue, consultancy services, and performance-based pricing creates a diversified income stream. This approach not only ensures a steady flow of revenue through subscription fees but also allows the business to provide additional value through specialized services and aligns its success with the actual energy efficiency improvements achieved by its clients. The flexibility in the monetization strategy caters to various client needs, positioning the business as a comprehensive solution provider in the energy optimization space.

Step 4: Financial Modelling

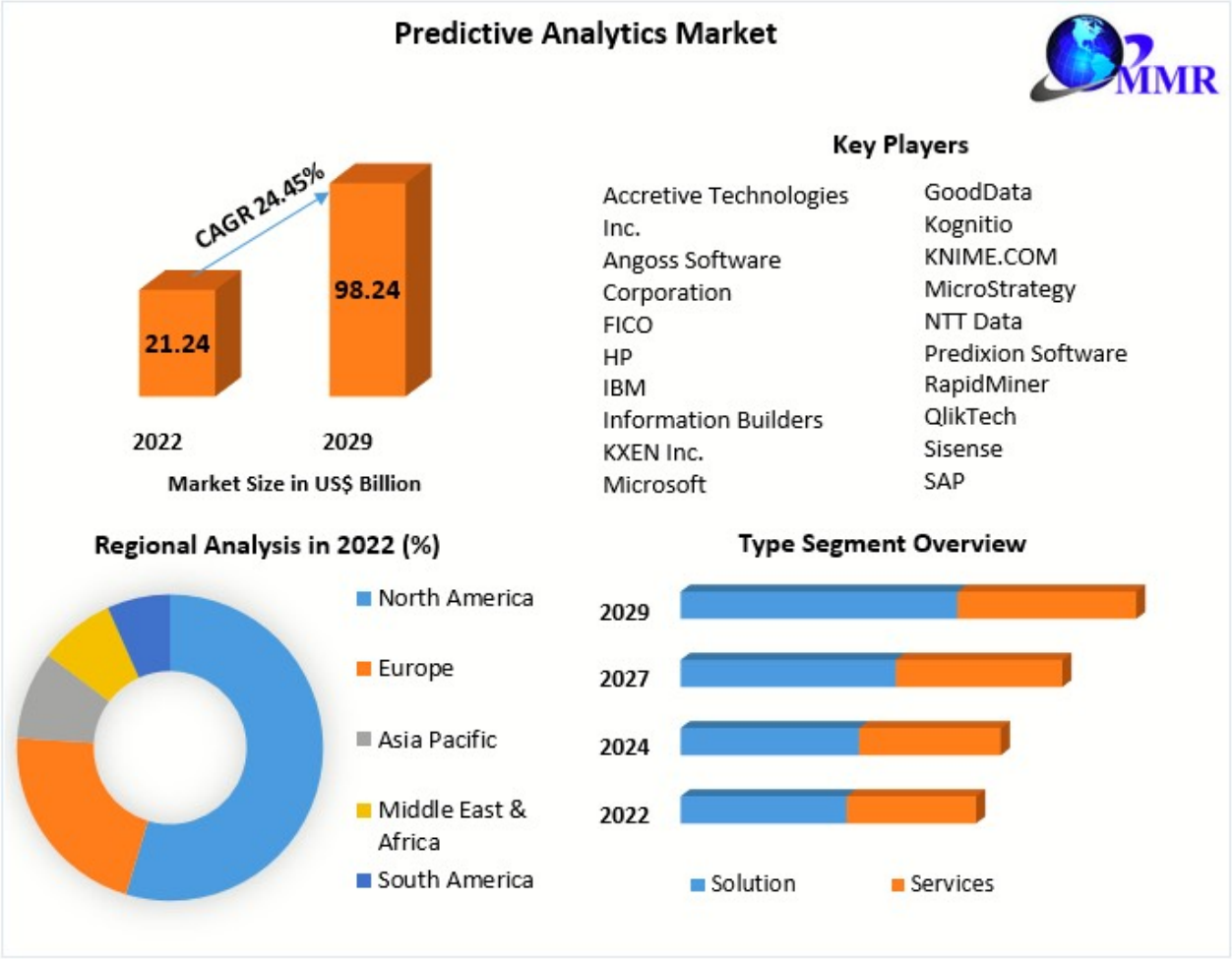
Launching a predictive energy consumption model for the machine industry requires a strategic approach encompassing market analysis, product development, and financial modeling. Here's a breakdown of key steps:

MARKET ANALYSIS:

- **Identified Target Markets:**
  - Focus on industries within the machine sector that heavily rely on energy, such as manufacturing, automation, and heavy machinery.

- **Competitive Landscape:**
  - There are existing solutions in the market but they have some gaps or weaknesses.

- **Regulatory Compliance:**
  - We ensure that the predictive analytics solution complies with industry standards and regulations related to energy management and conservation.



This depicts that predictive analytics market is growing market all across the globe. Huge data dependence and advanced technological implementations are projected to drive the predictive analytics market during the forecast period.

LAUNCH STRATEGY:

- **Pilot Programs:**
  - Collaborate with a few key industry players for pilot programs to validate the effectiveness of the predictive analytics solution.
  - Use feedback from pilot programs to refine and enhance the product.

- **Marketing and Outreach:**
  - Create a targeted marketing campaign emphasizing the cost savings and environmental benefits of the product.
  - Attend industry conferences, trade shows, and engage in digital marketing to raise awareness.

- **Partnerships:**
  - Explore strategic partnerships with machine manufacturers, energy efficiency consultants, and industry associations to broaden the product's reach.

FINANCIAL MODELLING EQUATION

It is crucial to design a financial model that encapsulates the relationship between various financial elements and the anticipated total profit. The proposed linear financial model can be expressed as:

$$y=mx(t)+c$$

Where:

- ***y*** represents the total profit derived from the operations of the machine industry.

- ***m*** denotes the pricing of the product, indicating the revenue generated per unit sold.

- ***x(t)*** signifies the total sales, treated as a function of time ***(t)*** emphasizing the dynamic nature of market demand over different time periods.

- ***C*** encapsulates production, maintenance, and other associated costs necessary for the operation of the industry.

• CONCLUSION

In conclusion, the development of a sophisticated predictive analytics solution for managing and optimizing energy consumption in the machine industry is a crucial initiative. The industry is currently facing significant challenges in terms of escalating operational costs and environmental impact due to inefficient energy usage. The proposed project aims to address these issues by leveraging historical data to create a robust predictive energy consumption model. This model will play a pivotal role in analyzing usage patterns, identifying inefficiencies, and offering actionable insights to empower machine industry companies in implementing proactive energy conservation strategies.

By implementing this solution, companies can expect to achieve not only cost savings but also a substantial reduction in their environmental footprint. The predictive analytics tool will enable businesses to make informed decisions, optimize energy resources, and enhance overall operational efficiency. This project is poised to contribute significantly to sustainable practices within the machine industry, fostering a more environmentally responsible and economically viable future. As industries continue to recognize the importance of energy conservation, the development and implementation of this predictive analytics solution will serve as a cornerstone for positive change in the sector.

Project Link : https://github.com/samruddhi-2709/Energy-consumption-prediction-using-machine-learning-