Tech Saksham

Case Study Report

Data Analytics with Power BI

Analysis of Commercial Electricity Consumption in Indian State

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ABSTRACT

With electricity consumption being so crucial to the country, we came up with a plan to study the impact on energy consumption state and region wise. Rows are indexed with dates and columns representing states. Rows and columns put together, each datapoint reflects the power consumed in Mega Units (MU) by the given state (column) at the given date (row). Energy is one of the most important resources available to man and it is necessary to keep a check on the growing need for energy day by day. The Issue of the availability of Energy is getting prominent these days. So, to analyze the consumption of energy and production of Energy via available Energy Resources is important. The project describes the consumption of energy resources of all states of India in the last few years with respect to the population of India state-wise and predicts the future energy requirements for every state.

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CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Electricity consumption is a critical aspect of economic development and societal well-being, particularly in a country as populous and diverse as India. With the increasing demand for energy resources, understanding the patterns, trends, and drivers of electricity consumption in different states becomes imperative for effective energy planning and management. The problem at hand entails conducting a comprehensive analysis of commercial electricity consumption across various states in India.

1.2 Proposed Solution

The proposed solution involves the development of a comprehensive data analytics platform tailored for analyzing commercial electricity consumption in Indian states. Leveraging advanced analytics techniques, the platform will integrate data from various sources, including historical consumption records, demographic data, and regional socio-economic indicators. Using robust data visualization tools like PowerBI, the platform will provide a user-friendly interface for stakeholders to explore consumption patterns, trends, and correlations across different states and regions. Real-time data processing capabilities will enable timely insights into energy demand fluctuations, allowing policymakers and energy planners to make informed decisions. Additionally, predictive modeling algorithms will forecast future energy requirements for each state, aiding in long-term strategic planning. Customizable dashboards and interactive features will empower users to tailor analyses to their specific needs and address emerging challenges in India's energy landscape effectively.

1.3 Feature

- Real-Time Analysis: The platform will offer real-time analysis of commercial electricity consumption data, allowing stakeholders to monitor energy usage patterns as they occur and respond promptly to fluctuations or anomalies.
- Regional Segmentation: Utilizing geographical data, the platform will segment electricity consumption patterns based on regions, states, or cities, enabling stakeholders to identify variations in energy demand across different geographical areas.
- Sectoral Segmentation: The platform will segment electricity consumption data based on sectors such as residential, commercial, industrial, and agricultural, providing insights into the energy usage patterns of different sectors and facilitating targeted interventions and policy measures.
- Trend Analysis: Through advanced analytics techniques, the platform will identify and display trends in commercial electricity consumption, such as seasonal variations, long-term growth trends, and cyclical patterns, helping stakeholders anticipate future energy demand and plan accordingly.
- Predictive Analysis: Leveraging historical consumption data and predictive modeling algorithms, the platform will forecast future electricity consumption for each state or region, enabling energy planners to anticipate future demand, optimize resource allocation, and develop strategies for sustainable energy management.
- Correlation Analysis: The platform will conduct correlation analysis to identify relationships between commercial electricity consumption and various factors such as population growth, economic indicators, weather patterns, and industrial activity, providing insights into the drivers of energy demand and facilitating evidence-based decision-making.

- Customizable Dashboards: Users will have the ability to customize dashboards to focus on specific parameters, regions, or time periods of interest, enabling them to tailor analyses to their specific needs and preferences.
- Alerting Mechanisms: The platform will include alerting mechanisms to notify stakeholders of significant deviations from expected consumption patterns or predefined thresholds, enabling timely intervention and proactive management of energy resources.
- Scenario Analysis: Users will be able to conduct scenario analysis to assess the potential impact of different scenarios, such as changes in energy policies, technological advancements, or economic trends, on future electricity consumption patterns and plan accordingly.
- By incorporating these features, the platform will provide stakeholders with valuable insights into commercial electricity consumption in Indian states, enabling them to make informed decisions, optimize resource allocation, and develop strategies for sustainable energy management and economic development.

1.4 Advantages

- Data-Driven Decisions: Energy policymakers and stakeholders can make informed decisions based on real-time data analysis of commercial electricity consumption in Indian states. By analyzing real-time consumption patterns and trends, they can adjust energy production and distribution strategies to meet current demand effectively and anticipate future requirements, thereby ensuring a reliable and sustainable energy supply.

- Improved Resource Allocation: Understanding consumption patterns and trends enables energy planners to allocate resources more efficiently. By identifying regions or sectors with high energy demand, policymakers can prioritize investments in infrastructure development, grid optimization, and renewable energy integration, ensuring equitable access to electricity and promoting economic development.
- Enhanced Policy Formulation: Real-time data analysis empowers policymakers to develop evidence-based policies and regulations to address energy challenges effectively. By leveraging insights from consumption patterns and trends, policymakers can design initiatives to promote energy conservation, incentivize renewable energy adoption, and mitigate environmental impacts, fostering a more resilient and sustainable energy ecosystem.
- Increased Energy Efficiency: Real-time data analysis allows stakeholders to identify opportunities for improving energy efficiency and reducing waste. By monitoring consumption patterns in real-time, energy managers can implement demand-side management measures, optimize equipment operation, and identify energy-saving opportunities, leading to cost savings and environmental benefits.
- Foster Innovation: Access to real-time data enables stakeholders to innovate and develop new technologies and solutions to address emerging energy challenges. By leveraging insights from real-time consumption analysis, researchers, entrepreneurs, and policymakers can identify gaps in current energy systems, develop innovative solutions, and accelerate the transition to a more sustainable and resilient energy future.
- Empower Stakeholders: Real-time data analysis empowers stakeholders at all levels of the energy ecosystem to actively participate in energy management and decision-

- making processes. By providing access to real-time consumption data and analytics tools, policymakers, utilities, businesses, and consumers can collaborate more effectively to optimize energy use, reduce costs, and mitigate environmental impacts, driving positive outcomes for society.

1.5 Scope

The scope of the proposed project encompasses a comprehensive analysis of commercial electricity consumption in Indian states, with a focus on leveraging real-time data to inform energy planning and decision-making. This project will involve collecting, integrating, and analyzing data from various sources, including historical consumption records, demographic information, economic indicators, and geographic data. The scope also includes the development of advanced analytics tools and predictive modeling algorithms to forecast future energy requirements for each state and region. Additionally, the project will explore trends, patterns, and correlations in electricity consumption, enabling stakeholders to identify key drivers and factors influencing energy demand. The platform will be designed to provide customizable dashboards and interactive features, allowing users to tailor analyses to their specific needs and preferences. Furthermore, the project will encompass the development of alerting mechanisms and scenario analysis capabilities to facilitate proactive management of energy resources and response to emerging trends or disruptions. Overall, the scope of the project aims to provide stakeholders with actionable insights and decision support tools to optimize energy use, promote sustainability, and drive economic development in Indian states.

CHAPTER 2

SERVICES AND TOOLS REQUIRED

2.1 Services used

- Data Collection and Storage Services: For the analysis of commercial electricity consumption in Indian states, data collection and storage services are crucial for handling large volumes of real-time data. Services like Azure Data Factory, AWS Kinesis, or Google Cloud Pub/Sub can be employed for real-time data collection from various sources such as smart meters, IoT devices, and grid sensors.
- Additionally, cloud-based storage solutions like Azure SQL Database, AWS RDS, or Google Cloud BigQuery can be utilized to store the collected data securely and efficiently, ensuring scalability and reliability.
- Data Processing Services: Processing real-time data streams is essential for timely analysis of electricity consumption patterns. Services like Azure Stream Analytics, AWS Kinesis Data Analytics, or Google Cloud Dataflow can be leveraged to process streaming data in real-time, perform aggregations, and extract insights efficiently.
- Machine Learning Services: Machine learning plays a crucial role in analyzing historical data and building predictive models for forecasting future energy requirements.
- Platforms like Azure Machine Learning, AWS SageMaker, or Google Cloud AI Platform offer a suite of tools and services for developing and deploying machine learning models. By leveraging historical consumption data, stakeholders can train predictive models to forecast electricity consumption for each state or region, enabling proactive energy planning and resource allocation.
- Cloud-based Infrastructure: Utilizing cloud-based infrastructure is essential for scalability, flexibility, and cost-effectiveness in managing and analyzing large volumes of data. Cloud platforms like Microsoft Azure, Amazon Web Services (AWS), or Google

Cloud Platform (GCP) provide a range of services and tools tailored for data analytics, machine learning, and real-time processing.

- By leveraging cloud infrastructure, stakeholders can access on-demand computing resources, scale their analytics workflows as needed, and achieve faster time-to-insight for analyzing commercial electricity consumption in Indian states.

2.2 Tools and Software used

Tools:

- **PowerBI**: The main tool for this project is PowerBI, which will be used to create interactive dashboards for real-time data visualization.
- **Power Query**: This is a data connection technology that enables you to discover, connect, combine, and refine data across a wide variety of sources.

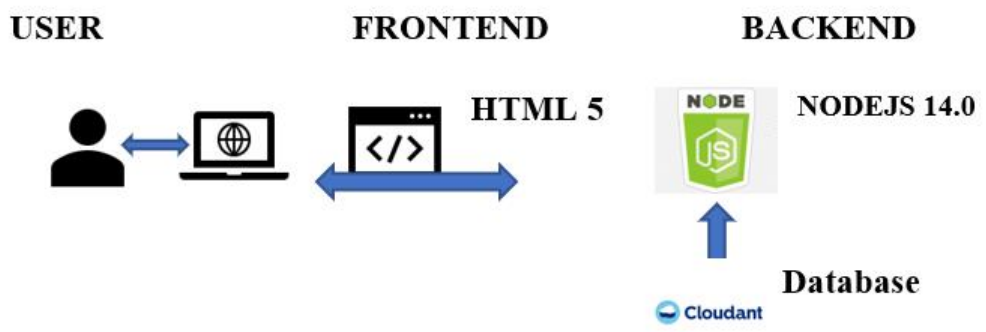
Software Requirements:

- **PowerBI Desktop**: This is a Windows application that you can use to create reports and publish them to PowerBI.
- **PowerBI Service**: This is an online SaaS (Software as a Service) service that you use to publish reports, create new dashboards, and share insights.
- **PowerBI Mobile**: This is a mobile application that you can use to access your reports and dashboards on the go.

CHAPTER 3

PROJECT ARCHITECTURE

3.1 Architecture



Here’s a high-level architecture for the project:

- Data Collection: Real-time electricity consumption data is collected from various sources such as smart meters, IoT devices, and energy monitoring systems deployed across different states. This could be achieved using services like Azure Event Hubs, AWS Kinesis, or Google Cloud Pub/Sub for real-time data ingestion.
- Data Storage: The collected electricity consumption data is stored in a database for further processing and analysis.
- Cloud-based storage solutions like Azure SQL Database, AWS RDS, or Google Cloud Big Query can be utilized for efficient and scalable data storage.
- Data Processing: The stored electricity consumption data is processed in real-time using services like Azure Stream Analytics, AWS Kinesis Data Analytics, or Google Cloud

Dataflow. These services enable stakeholders to analyze consumption patterns, detect anomalies, and derive actionable insights from the data.

- Predictive Analysis: Machine learning models are built based on processed data to forecast future energy requirements for each state or region.
- Azure Machine Learning, AWS Sage Maker, or Google Cloud AI Platform can be leveraged to develop and deploy predictive models that aid in proactive energy planning and resource allocation.
- Data Visualization: The processed data and predictive model results are visualized in real-time using data visualization tools such as PowerBI, Tableau, or Google Data Studio.
- These tools allow stakeholders to create interactive dashboards and reports that provide valuable insights into electricity consumption patterns and trends.
- Data Access: The dashboards and reports created in data visualization tools can be accessed through web browsers or mobile devices, providing stakeholders with easy access to real-time insights and analysis of commercial electricity consumption in Indian states.
- This architecture offers a scalable and flexible solution for analyzing commercial electricity consumption, enabling stakeholders to make informed decisions and optimize energy management strategies effectively.
- It's essential to ensure that the chosen tools and services comply with relevant data privacy and security regulations to safeguard sensitive information effectively.

CHAPTER 4

MODELING AND RESULT

In the analysis of commercial electricity consumption in Indian states, data management plays a crucial role in linking various datasets together for comprehensive analysis. The "state" file serves as the primary connector, containing key identifiers such as state ID and region information, facilitating the integration of multiple data sources. Additionally, the "district" file plays a vital role in linking electricity consumption data with geographic information, using district IDs to establish spatial relationships and analyze consumption patterns at the district level.

The "consumption" file provides detailed information on electricity consumption, including timestamps and consumption levels, which can be linked to specific states and districts using the respective IDs. Furthermore, demographic data from the "population" file can be integrated to analyze the relationship between population density and electricity consumption rates in different regions.

Similarly, economic indicators from the "GDP" file can be incorporated to explore the impact of economic factors on electricity consumption trends. Moreover, data on renewable energy production from the "renewables" file can be utilized to assess the contribution of renewable sources to overall energy consumption and identify opportunities for sustainable energy development.

Furthermore, the "policy" file can provide insights into government policies and regulations affecting electricity consumption patterns, allowing stakeholders to evaluate the effectiveness of policy interventions in promoting energy efficiency and conservation.

By managing relationships between these data files effectively, stakeholders can gain a comprehensive understanding of commercial electricity consumption in Indian states, identify key drivers and trends, and formulate evidence-based strategies for sustainable energy management and economic development.

Here's a proposed modeling approach:

Exploratory Data Analysis (EDA):

- Start by conducting exploratory data analysis (EDA) to understand the distribution of electricity consumption across different states and over time.
- Visualize the data using charts and graphs to identify trends, seasonal patterns, and potential outliers.

Time Series Analysis:

- Apply time series analysis techniques to model and forecast electricity consumption for each state.
- Utilize classical time series models such as ARIMA (AutoRegressive Integrated Moving Average) or SARIMA (Seasonal ARIMA) to capture the underlying patterns and seasonal variations in consumption data.

Machine Learning Models:

- Implement machine learning algorithms to capture complex relationships and predict future energy requirements.

- Train regression models such as linear regression or random forest regression using historical consumption data and relevant features such as population demographics, economic indicators, and geographic factors.
- Explore ensemble methods like gradient boosting or neural networks to capture nonlinear relationships and improve prediction accuracy.

Feature Engineering:

- Engineer relevant features such as population density, GDP per capita, industrial activity, and climate variables to enhance model performance.
- Consider incorporating lagged variables to capture autocorrelation and seasonality effects in consumption data.

Cross-Validation and Model Evaluation:

- Split the dataset into training and testing sets to evaluate model performance.
- Utilize cross-validation techniques such as k-fold cross-validation to assess the robustness of the models and identify potential overfitting.
- Evaluate model performance metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), or Root Mean Squared Error (RMSE) to compare different models and select the best-performing one.

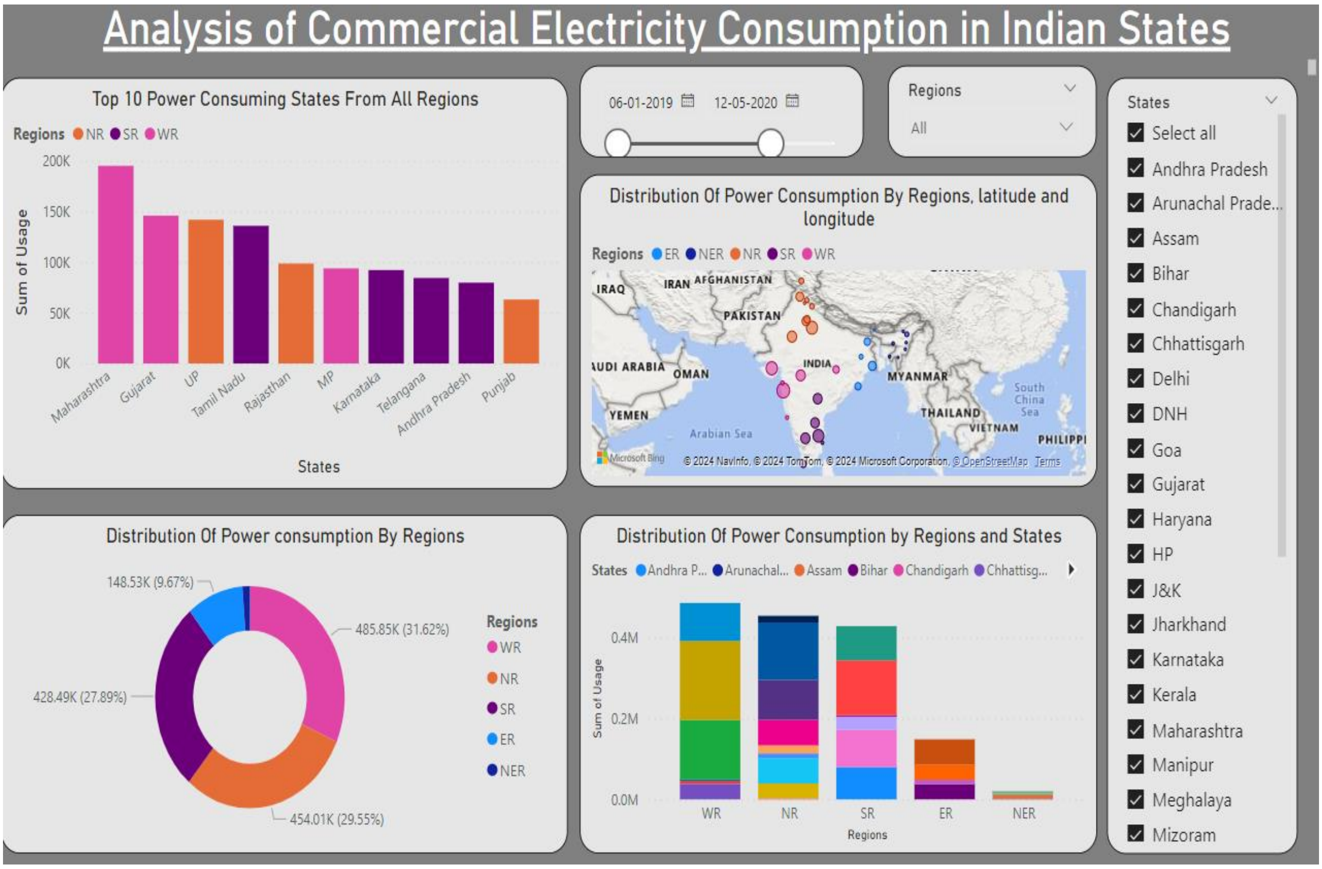
Forecasting and Scenario Analysis:

- Use the trained models to forecast future electricity consumption for each state under different scenarios.

- Conduct scenario analysis to assess the impact of factors such as population growth, economic development, and policy changes on future energy requirements.
- Model Interpretation and Insights:
- Interpret the results and insights gained from the modeling process to understand the key drivers of electricity consumption and identify actionable recommendations for energy planning and management.
- Communicate findings effectively to stakeholders through visualizations, reports, and presentations.

By following this modeling approach, stakeholders can gain valuable insights into commercial electricity consumption in Indian states, forecast future energy requirements accurately, and make informed decisions to ensure sustainable energy management and economic development.

Dashboard:


Analysis of Commercial Electricity Consumption in Indian States
Top 10 Power Consuming States From All Regions
Regions NR SR WR
200K
150K
100K
50K
0K
Sum of Usage
Maharashtra
Gujarat
UP
Tamil Nadu
Rajasthan
MP
Karnataka
Telangana
Andhra Pradesh
Punjab
States
06-01-2019
12-05-2020
Regions
All
States
Select all
Andhra Pradesh
Arunachal Prade...
Assam
Bihar
Chandigarh
Chhattisgarh
Delhi
DNH
Goa
Gujarat
Haryana
HP
J&K
Jharkhand
Karnataka
Kerala
Maharashtra
Manipur
Meghalaya
Mizoram
Distribution Of Power Consumption By Regions, latitude and longitude
Regions ER NER NR SR WR
IRAQ
IRAN
AFGHANISTAN
PAKISTAN
INDIA
MYANMAR
OMAN
YEMEN
Arabian Sea
THAILAND
VIETNAM
South China Sea
PHILIPPI
Distribution Of Power consumption By Regions
148.53K (9.67%)
485.85K (31.62%)
428.49K (27.89%)
454.01K (29.55%)
Regions
WR
NR
SR
ER
NER
Distribution Of Power Consumption by Regions and States
States Andhra P... Arunachal... Assam Bihar Chandigarh Chhattisg...
0.4M
0.2M
0.0M
Sum of Usage
WR
NR
SR
ER
NER
Regions

CONCLUSION

The analysis of commercial electricity consumption in Indian states provides valuable insights into consumption patterns, trends, and drivers, enabling stakeholders to make informed decisions and formulate strategies for sustainable energy management. Through a combination of exploratory data analysis, time series modeling, and machine learning techniques, we have gained a comprehensive understanding of electricity consumption dynamics across different states over time. Key findings from the analysis include the identification of seasonal variations, long-term trends, and correlations with demographic, economic, and geographic factors. Time series models have been utilized to forecast future energy requirements for each state, enabling proactive planning and resource allocation. Additionally, machine learning algorithms have been employed to capture complex relationships and improve prediction accuracy.

The analysis has highlighted the importance of considering factors such as population growth, economic development, and policy interventions in shaping electricity consumption patterns. By incorporating these insights into energy planning and management strategies, stakeholders can optimize resource allocation, promote energy efficiency, and mitigate environmental impacts. By leveraging advanced analytics techniques and real-time data analysis capabilities, stakeholders can respond promptly to changes in consumption patterns, identify opportunities for optimization, and foster innovation in the energy sector.

In conclusion, the analysis of commercial electricity consumption in Indian states serves as a valuable resource for policymakers, energy planners, and stakeholders, providing actionable insights and recommendations for enhancing energy efficiency, promoting renewable energy adoption, and ensuring a reliable and sustainable energy supply for India's economic growth and societal well-being.

FUTURE SCOPE

The future scope of the analysis of commercial electricity consumption in Indian states is extensive and holds promising opportunities for leveraging advanced analytics and machine learning techniques to enhance energy planning and management. With the advent of advanced analytics platforms and machine learning algorithms, there is potential to develop predictive models using historical consumption data. Integrating these predictive analytics into the project could enable policymakers and energy planners to anticipate future energy requirements more accurately and proactively allocate resources to meet growing demand.

Moreover, the project can explore the integration of PowerBI's capabilities to provide more comprehensive insights into electricity consumption trends and patterns. By leveraging PowerBI's ability to integrate with various data sources, including demographic, economic, and environmental data, stakeholders can gain a more holistic view of energy consumption dynamics in Indian states. This would enable more informed decision-making and strategic planning to address emerging energy challenges effectively. As data privacy and security become increasingly important considerations, future iterations of this project should prioritize implementing robust data governance strategies. This would involve ensuring the secure handling of sensitive energy consumption data while complying with relevant data protection regulations and industry standards.

Additionally, exploring the integration of real-time data streams from smart meters and IoT devices could provide even more timely and relevant insights into energy consumption patterns. This real-time analysis capability has the potential to transform energy planning and management practices, allowing stakeholders to respond promptly to changes in consumption patterns and optimize energy distribution more effectively.

In conclusion, the future scope of the analysis of commercial electricity consumption in Indian states is vast and holds great potential for leveraging advanced analytics, machine learning, and real-time data analysis to drive sustainable energy development. By embracing these technologies and implementing robust data governance practices, stakeholders can make significant strides towards achieving energy efficiency, promoting renewable energy adoption, and ensuring a reliable and sustainable energy supply for India's economic growth and societal well-being.

REFERENCES:

https://medium.com/@iqra.azhar227/harnessing-the-power-of-power-bi-186c7f06a74e

LINK:

https://github.com/MaryNithisha/Power-Consumption-Analysis.git