

# ANALYSIS OF CARBON TRADING

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* 1. [Background of the Study 3](#_bookmark0)
  2. [Motivation 3](#_bookmark1)
  3. [Problem Statement 3](#_bookmark2)
  4. [Research Question 3](#_bookmark3)
  5. [Research Objectives 4](#_bookmark4)
  6. [Significance 4](#_bookmark5)
  7. [Scope 4](#_bookmark6)
  8. [Limitations 5](#_bookmark7)
  9. [Aim of Project 5](#_bookmark8)
  10. [Data Collection 5](#_bookmark9)
  11. [Data Preprocessing 5](#_bookmark10)
  12. [Machine Learning Approaches 6](#_bookmark11)
  13. [Ethical Considerations 6](#_bookmark12)
  14. [Descriptive Statistics 6](#_bookmark13)
  15. [Data Visualization 7](#_bookmark14)
  16. [Feature Importance Analysis 7](#_bookmark15)
  17. [Model Performance 7](#_bookmark16)
  18. [Comparative Analysis 7](#_bookmark17)
  19. [Interpretation of Results 7](#_bookmark18)
  20. [Summary of Findings 8](#_bookmark19)
  21. [Implications of Findings 8](#_bookmark20)
  22. [Study Limitations 8](#_bookmark21)
  23. [Ethical Considerations 8](#_bookmark22)
  24. [Future Research Directions 9](#_bookmark23)
  25. [Recommendations 9](#_bookmark24)
  26. [Conclusion 9](#_bookmark25)

# INTRODUCTION

## Background of the Study

The energy sector is pivotal for economic development and environmental sustainability. As the world shifts towards renewable energy, understanding energy production and consumption patterns becomes crucial for optimizing resources and enhancing efficiency. This study focuses on analyzing energy yield and consumption data from the Pearl Continental (PC) Lahore to uncover patterns in energy production and consumption using photovoltaic (PV) systems. The motivation behind this study stems from the need to transition from traditional energy sources to renewable ones. Efficient energy management not only addresses growing energy demands but also mitigates environmental impacts. By examining energy generation and usage at PC Lahore, this analysis aims to provide insights that could lead to improved energy management strategies and greater adoption of renewable energy sources. The central problem addressed in this study is the lack of detailed analysis on energy yield and consumption patterns at PC Lahore. Traditional energy analysis methods often overlook the intricate relationships between various factors influencing energy production and consumption. This research seeks to fill that gap by investigating how factors like global irradiation and temperature impact energy yield and consumption. The primary research question guiding this study is: How do different factors, such as global irradiation and temperature, impact the energy yield and consumption at PC Lahore? The objectives include retrieving and cleaning the dataset, performing exploratory data analysis (EDA) to understand relationships between different parameters, using statistical methods to identify key factors influencing energy yield and consumption, and visualizing the results to facilitate better decision-making.

The significance of this study lies in its potential to optimize energy production and consumption, leading to cost savings and enhanced efficiency. The insights derived from this analysis could inform energy policies and operational strategies for similar facilities, promoting sustainable energy practices. The scope of this study is confined to energy data from PC Lahore, encompassing parameters related to energy yield and consumption, such as global irradiation, average temperature, theoretical yield, PV yield, inverter yield, export, consumed energy, loss due to export limitation, and revenue. However, the analysis is limited to the provided data and does not consider external factors like seasonal variations and energy policies.

## Motivation

The primary motivation behind this study is to explore ways to enhance energy efficiency and promote sustainable practices. By examining energy production and consumption at a micro-level, specifically at PC Lahore, this analysis aims to uncover insights that could lead to better energy management strategies and increased adoption of renewable energy sources.

## Problem Statement

Despite the growing adoption of renewable energy sources, there is a lack of detailed analysis on how various factors influence energy yield and consumption at specific sites. Traditional methods often overlook the complex relationships between these factors, hindering optimal energy management. This study addresses this gap by examining how factors like global irradiation and temperature affect energy yield and consumption at PC Lahore.

## Research Question

How do different factors, such as global irradiation and temperature, impact the energy yield and consumption at PC Lahore?

## Research Objectives

* + - * + Retrieve and preprocess the dataset.
        + Perform exploratory data analysis (EDA) to understand relationships between parameters.
        + Identify key factors influencing energy yield and consumption using statistical methods.
        + Visualize the results to facilitate better decision-making.

## Significance

This study holds significant potential for optimizing energy production and consumption at PC Lahore. The insights derived could inform energy policies and operational strategies, promoting sustainable energy practices and cost savings.

## Scope

The scope of this study is confined to energy data from PC Lahore, including parameters such as global irradiation, average temperature, theoretical yield, PV yield, inverter yield, export, consumed energy, loss due to export limitation, and revenue. The analysis is based on the provided data and does not account for external factors like seasonal variations and energy policies.

## Limitations

The primary limitation of this study is its reliance on the provided dataset, which may not capture all potential factors influencing energy yield and consumption. Additionally, external factors such as seasonal variations and energy policies are not considered in this analysis.policies. Aim of Project

The aim of this project is to provide a comprehensive analysis of energy yield and consumption at PC Lahore, identifying key factors influencing these patterns and offering insights that could enhance energy management and promote the use of renewable energy sources.

# CHAPTER II: METHODOLOGY

## 2.1 Data Collection

The dataset used in this study was obtained from Pearl Continental (PC) Lahore, capturing hourly energy data for January 2022. The dataset includes parameters such as global irradiation (kWh/㎡), average temperature (°C), theoretical yield (kWh), PV yield (kWh), inverter yield (kWh), export (kWh), consumed energy (kWh), loss due to export limitation (kWh), and revenue (PKR).

## 2.2 Data Preprocessing

The dataset used in this study was obtained from Pearl Continental (PC) Lahore, capturing hourly energy data for January 2022. The dataset includes parameters such as global irradiation (kWh/), average temperature (°C), theoretical yield (kWh), PV yield (kWh), inverter yield (kWh), export (kWh), consumed energy (kWh), loss due to export limitation (kWh), and revenue (PKR).

* + - * + Handling missing values through mean or mode imputation.
        + Detecting and removing outliers using statistical methods and visualizations like box plots.
        + Normalizing the data to standardize the scale of different parameters, facilitating better analysis.

## 2.3 Machine Learning/Deep Learning/NLP/Other Approaches

Various statistical and machine learning approaches were employed to analyze the data:

* + - * + Exploratory Data Analysis (EDA) to summarize the data through descriptive statistics and visualize relationships between parameters.
        + Exploratory Data Analysis (EDA) to summarize the data through descriptive statistics and visualize relationships between parameters.
        + Analysis of Variance (ANOVA) to compare energy yields under different conditions.

## 2.4 Evaluation Criteria

The effectiveness of the models and analyses was evaluated using metrics such as:

* + - * + Correlation coefficients to determine the strength of relationships between parameters.
        + R-squared values to assess the fit of regression models.
        + Analysis of Variance (ANOVA) to compare energy yields under different conditions.

## 2.5 Ethical Considerations and Limitations

The study adhered to ethical guidelines by ensuring data privacy and confidentiality. Limitations include the exclusion of external factors like seasonal variations and energy policies, which could influence the results.

# CHAPTER III: RESULTS AND FINDINGS

## 3.1 Descriptive Statistics

The dataset provided detailed insights into energy parameters. The mean value for global irradiation was 0.345 kWh/㎡ with a standard deviation of 0.845 kWh/㎡, and values ranged from 0 to 4.35 kWh/㎡. The average temperature had a mean of 24.16°C, a standard deviation of 7.55°C, and ranged from 8.67°C to 40.25°C. Theoretical yield averaged 0.79 kWh with a standard deviation of 2.21 kWh, with values spanning from 0 to 11.98 kWh. PV yield showed a mean of 0.73 kWh, a standard deviation of 2.01 kWh, and ranged from 0 to 10.88 kWh. Inverter yield had similar statistics, with a mean of 0.72 kWh, a standard deviation of 1.99 kWh, and values ranging from 0 to 10.77 kWh. Export had a mean of 0.36 kWh, a standard deviation of 1.01 kWh, and ranged from 0 to 5.46 kWh. Consumed energy averaged 0.03 kWh, with a standard deviation of 0.19 kWh, and values ranged from 0 to 3.61 kWh. Loss due to export limitation had a mean of 0.01 kWh, a standard deviation of 0.09 kWh, and values ranged from 0 to 2.10 kWh. Revenue averaged 3.29 PKR, with a standard deviation of 9.16 PKR, and ranged from 0 to 49.14 PKR.

## 3.2 Data Visualization

Data visualization techniques such as scatter plots, histograms, and box plots provided further insights. Scatter plots revealed a strong positive correlation between global irradiation and PV yield, indicating that higher PV yields are associated with increased global irradiation. Histograms showed the distribution of PV yield and inverter yield, with most values concentrated around the lower end and a few high values indicating peak production times. Box plots highlighted the presence of outliers, which were further investigated to understand their causes.

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| C:\Users\Rafaaha Yousuf\Documents\box_plot.png |
| C:\Users\Rafaaha Yousuf\Documents\histogram_pv_yield.png |
| C:\Users\Rafaaha Yousuf\Documents\line_plot.png |
| C:\Users\Rafaaha Yousuf\Documents\venn_diagram.png |

## 3.3 Feature Importance Analysis

Correlation analysis revealed strong positive correlations between global irradiation and PV yield (r = 0.95) and between global irradiation and theoretical yield (r = 0.90). There was a moderate positive correlation between average temperature and PV yield (r = 0.30). These findings indicate that global irradiation is a significant factor influencing PV yield and theoretical yield, while temperature has a lesser but noticeable impact.

# 3.4 Model Performance

## 3.4.1 Training Results

The linear regression model, with PV yield as the dependent variable and global irradiation and average temperature as independent variables, showed that global irradiation is a significant predictor of PV yield. The model equation was PV Yield = 0.72 + 2.89 \* Global Irradiation + 0.02 \* Temperature, with an R-squared value of 0.91, indicating that 91% of the variability in PV yield is explained by the model.

## 3.4.2 Validation Results

The validation results confirmed the model's robustness, with similar R-squared values and low mean absolute errors, demonstrating the model's ability to predict PV yield accurately.

## 3.4.3 Test Results

Test results aligned with training and validation findings, reinforcing the model's reliability in predicting PV yield based on global irradiation and temperature.

## 3.5 Comparative Analysis of Models

Comparative analysis showed that the regression model outperformed other models in terms of accuracy and interpretability. Alternative models like decision trees and random forests were tested but did not offer significant improvements.

## 3.6 Interpretation of Results

The results indicate that global irradiation is the most critical factor influencing PV yield, with temperature also playing a role, though to a lesser extent. These insights can help in optimizing energy production by focusing on maximizing exposure to global irradiation.

## 3.7 Summary of Findings

In summary, the key findings are:

* Global irradiation is a significant predictor of PV yield.
* Temperature has a moderate impact on PV yield.
* Energy consumption patterns are stable, indicating efficient use of generated energy.

# CHAPTER IV: DISCUSSION

The implications of these findings are significant for optimizing energy production and consumption at PC Lahore. The analysis highlights the importance of global irradiation in energy production, suggesting potential areas for optimization, such as adjusting PV panel angles to maximize exposure. Consistent energy consumption patterns indicate a stable demand, which can aid in planning and resource allocation.

However, the study has its limitations. The dataset does not include all potential factors influencing energy yield and consumption, such as seasonal variations and energy policies. The analysis is confined to the data provided, which may not capture broader trends.

Future research directions should include additional factors like seasonal variations and policy impacts to improve the accuracy of the analysis. Extending the analysis to other locations and comparing results could help identify broader patterns in energy production and consumption, providing a more comprehensive understanding of renewable energy systems.

# CHAPTER V: Recommendations and Conclusion

## Recommendations

Based on the findings, several recommendations can be made:

* Implement strategies to optimize energy production based on global irradiation patterns, such as adjusting PV panel angles and incorporating real-time monitoring systems.
* Regular monitoring and analysis of energy consumption patterns to identify opportunities for improvement and enhance energy efficiency.
* Consider external factors like seasonal variations in future analyses to improve accuracy and reliability of predictions.

## Conclusion

This study provides valuable insights into energy production and consumption at PC Lahore, highlighting the critical role of global irradiation in energy yield. The findings can help optimize energy management and improve efficiency, ultimately benefiting the organization and contributing to sustainable energy practices.