Instrux Sensor Electricity Data Analysis Dashboard — Power BI

Raw Sensor Data Cleaning, Time-Series Analysis & Interactive Energy Monitoring

Data Analytics & Business Intelligence Project

Muhammad Anas

Abstract

This project focuses on analyzing electricity sensor data using Python and Power BI. The raw dataset contained 58,809 time-series records collected from an Instrux electricity monitoring system between January 1 and January 23, 2025. The data was first cleaned and preprocessed using Python (Pandas) by removing empty and constant columns, converting datetime fields, and preparing the dataset for analysis.

After preprocessing, the cleaned data was imported into Power BI to develop an interactive dashboard. The dashboard visualizes voltage, current, power factor, real power, and energy consumption trends over time. The analysis helps in identifying usage patterns, monitoring system stability, and detecting irregular behavior. This project demonstrates how data cleaning and visualization tools can transform raw sensor data into meaningful insights for energy monitoring and decision-making.

1. Dataset Description

The dataset used in this project contains electricity sensor readings collected from an Instrux smart meter system. The data represents time-series measurements recorded continuously between **1 January 2025 and 23 January 2025**.

The raw dataset originally contained **58,809 rows and 346 columns**. Many columns were empty or contained constant values, which were removed during preprocessing. After cleaning, the final dataset contained **13 important features** relevant to electricity monitoring.

Key Features Used in Analysis:

- **Datetime** – Timestamp of each reading
- **Frequency (Hz)** – Electrical system frequency
- **VoltagePhaseR (V)** – Voltage value of Phase R
- **CurrentPhaseR (A)** – Current value of Phase R
- **RealPowerPhaseR (W)** – Real power consumption
- **TotalRealPower (W)** – Total real power usage
- **EnergyValue (kWh)** – Accumulated energy consumption
- **PowerFactorPhaseR** – Power efficiency indicator
- **TotalLineCurrent (A)** – Total current flow

The dataset is structured as time-indexed data, making it suitable for trend analysis and performance monitoring.

2. Data Cleaning & Preprocessing

The raw Instrux electricity dataset contained unnecessary, empty, and constant columns that were not useful for analysis. Therefore, data preprocessing was performed using Python and the Pandas library.

Cleaning Steps Performed:

1. The CSV file was loaded using Pandas with error handling to skip corrupted rows.
2. The dataset shape was checked to understand the number of rows and columns.
3. Empty columns (all null values) were removed.
4. Constant columns (columns containing only one unique value) were identified and dropped.
5. The datetime column was converted into proper datetime format.

6. The datetime column was set as the index to enable time-series analysis.
7. The unnecessary datetime_server column was removed.
8. The cleaned dataset was exported as a new CSV file for Power BI.

After preprocessing, the dataset was reduced to 13 meaningful features with 58,809 valid records.

3. Data Modeling in Power BI

After cleaning the dataset in Python, the processed CSV file was imported into Power BI for visualization and analysis.

Steps Performed in Power BI:

1. The cleaned dataset (clean.csv) was loaded into Power BI Desktop.
2. The datetime column was verified as Date/Time data type.
3. Additional time-based columns such as Date and Hour were created for better analysis.
4. Necessary measures were created using DAX for:
    - Total Energy Consumption
    - Average Voltage
    - Average Current
    - Total Real Power
    - Average Power Factor
5. Data consistency and formatting were checked before dashboard creation.

The dataset was structured as time-series data, allowing trend analysis and performance monitoring over hours and days.

Data View

kNPLVW

File | Home | Transform | Add Column | View | Tools | Help

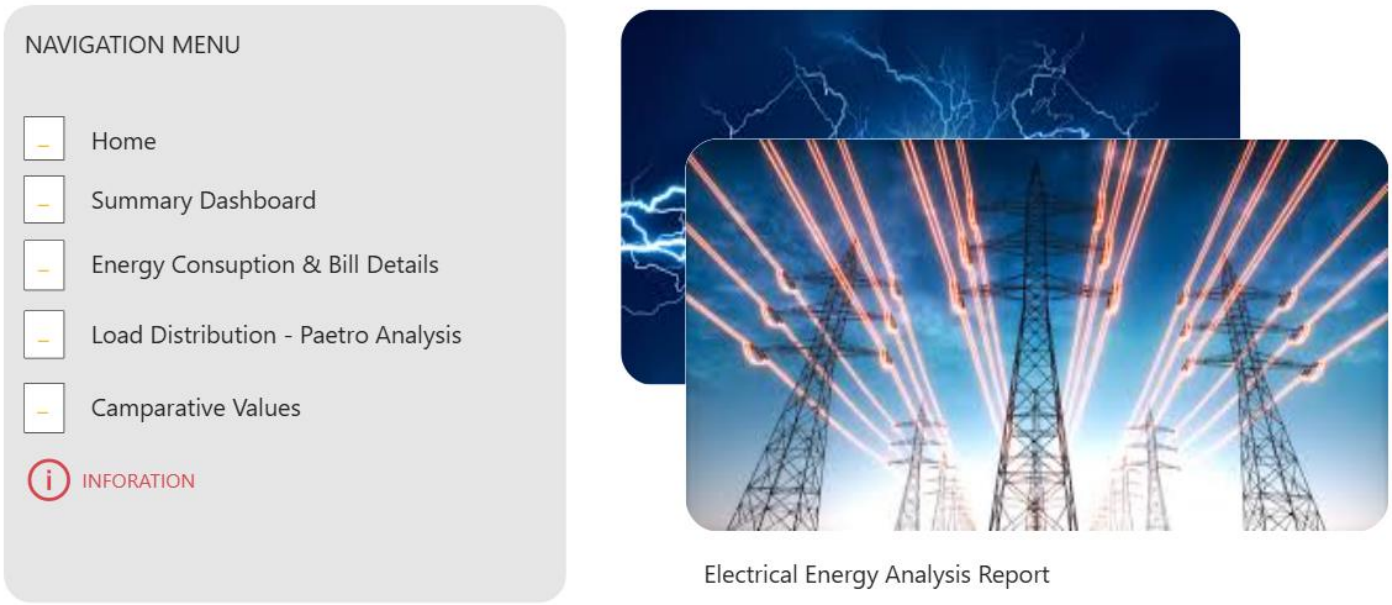
```
= Table.Sort(#"Changed Type1",{{"datetime", Order.Ascending}, {"Date", Order.Ascending}})
```

Queries

	datetime	timestamp	frequency(Hz)	voltagePhaseR(v)	currentPhaseR(A)	powerfactorPhaseR	realPowerPhaseR(W)	averageLin
1	1/1/2025 5:00:29 AM	1735689629	50	236.3	0.41	0.5	56	
2	1/1/2025 5:00:59 AM	1735689659	50	235.5	0.41	0.52	56	
3	1/1/2025 5:01:29 AM	1735689689	50	234.3	0.41	0.55	54	
4	1/1/2025 5:01:59 AM	1735689719	50	236.3	0.44	0.54	56	
5	1/1/2025 5:02:29 AM	1735689749	50	236.5	0.41	0.5	55	
6	1/1/2025 5:02:59 AM	1735689779	50	237.5	0.47	0.53	57	
7	1/1/2025 5:03:29 AM	1735689809	50	238.6	0.45	0.58	58	
8	1/1/2025 5:03:59 AM	1735689839	50	239.3	0.43	0.57	56	
9	1/1/2025 5:04:29 AM	1735689869	50	240.1	0.44	0.61	56	
10	1/1/2025 5:04:59 AM	1735689899	51	240.3	0.54	0.54	60	
11	1/1/2025 5:05:29 AM	1735689929	51	240.6	0.46	0.62	58	
12	1/1/2025 5:05:59 AM	1735689959	51	240.5	0.48	0.61	57	
13	1/1/2025 5:06:29 AM	1735689989	51	240.3	0.45	0.55	57	
14	1/1/2025 5:06:59 AM	1735690019	50	239.9	0.47	0.53	58	
15	1/1/2025 5:07:29 AM	1735690049	50	239.8	0.47	0.54	58	
16	1/1/2025 5:07:59 AM	1735690079	50	239.4	0.43	0.55	56	
17	1/1/2025 5:08:29 AM	1735690109	50	239.2	0.42	0.54	55	
18	1/1/2025 5:08:59 AM	1735690139	50	238.4	0.42	0.54	56	
19	1/1/2025 5:09:29 AM	1735690169	50	237.8	0.42	0.54	54	
20	1/1/2025 5:09:59 AM	1735690199	50	237.4	0.44	0.54	57	
21	1/1/2025 5:10:29 AM	1735690229	50	237.2	0.43	0.55	56	
22	1/1/2025 5:10:59 AM	1735690259	50	237.2	0.44	0.54	55	
23	1/1/2025 5:11:29 AM	1735690289	50	237.2	0.42	0.55	57	
24	1/1/2025 5:11:59 AM	1735690319	50	237.7	0.42	0.55	55	
25	1/1/2025 5:12:29 AM	1735690349	50	238.3	0.44	0.54	56	

16 COLUMNS, 999+ ROWS Column profiling based on top 1000 rows PREVIEW DOWNLOADED AT 7:29 PM

Home Page



4.1 Page 1 – Electricity Overview Dashboard

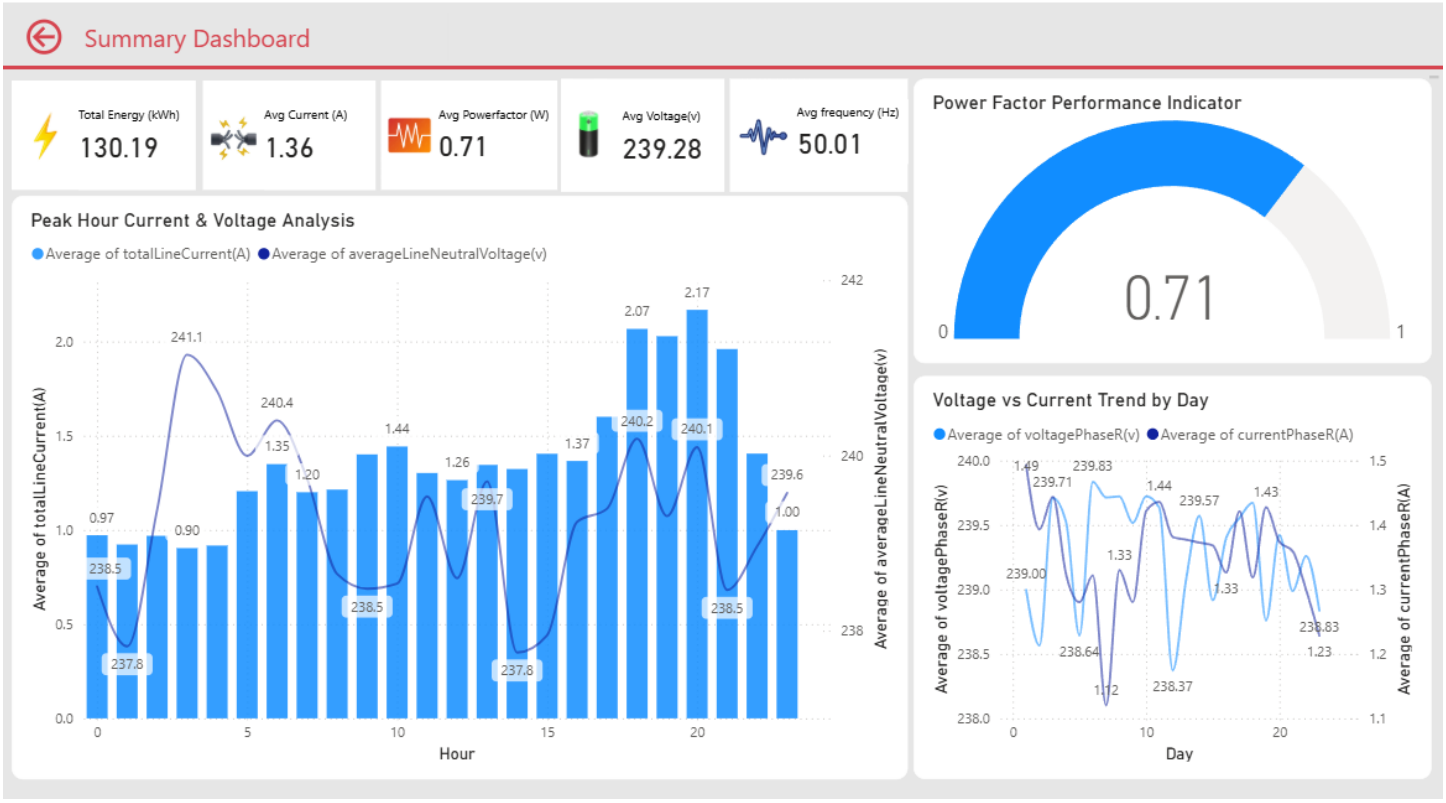
This page provides a high-level summary of the electricity monitoring system.

Main Components:

- KPI Cards displaying:
  - Total Energy Value
  - Average Voltage
  - Average Current
  - Total Real Power
  - Average Power Factor
- Time-series line charts showing:
  - Voltage trend over time
  - Current variation
  - Real power fluctuation
- Date slicer for interactive filtering

Purpose:

This page allows quick monitoring of overall system performance and detection of abnormal fluctuations.



4.2 Page 2 – Power & Energy Trend Analysis

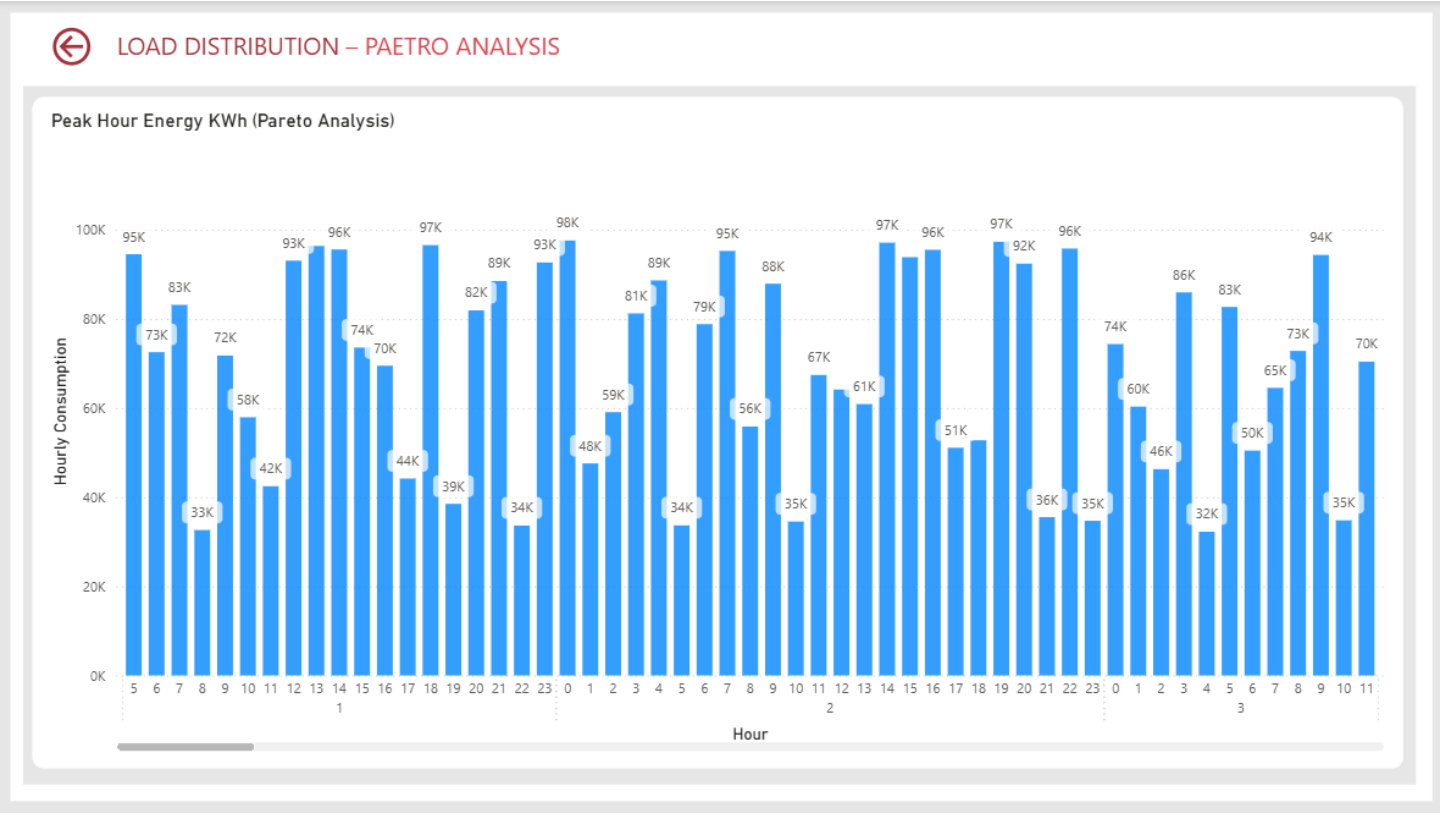
This page focuses on analyzing how energy and power change over time.

Visuals Included:

- Energy Value over time (Line Chart)
- Total Real Power trend
- Hourly consumption pattern
- Time-based slicers

Purpose:

To identify peak consumption periods and understand load behavior across different hours and days.



4.3 Page 3 – Voltage & Current Monitoring

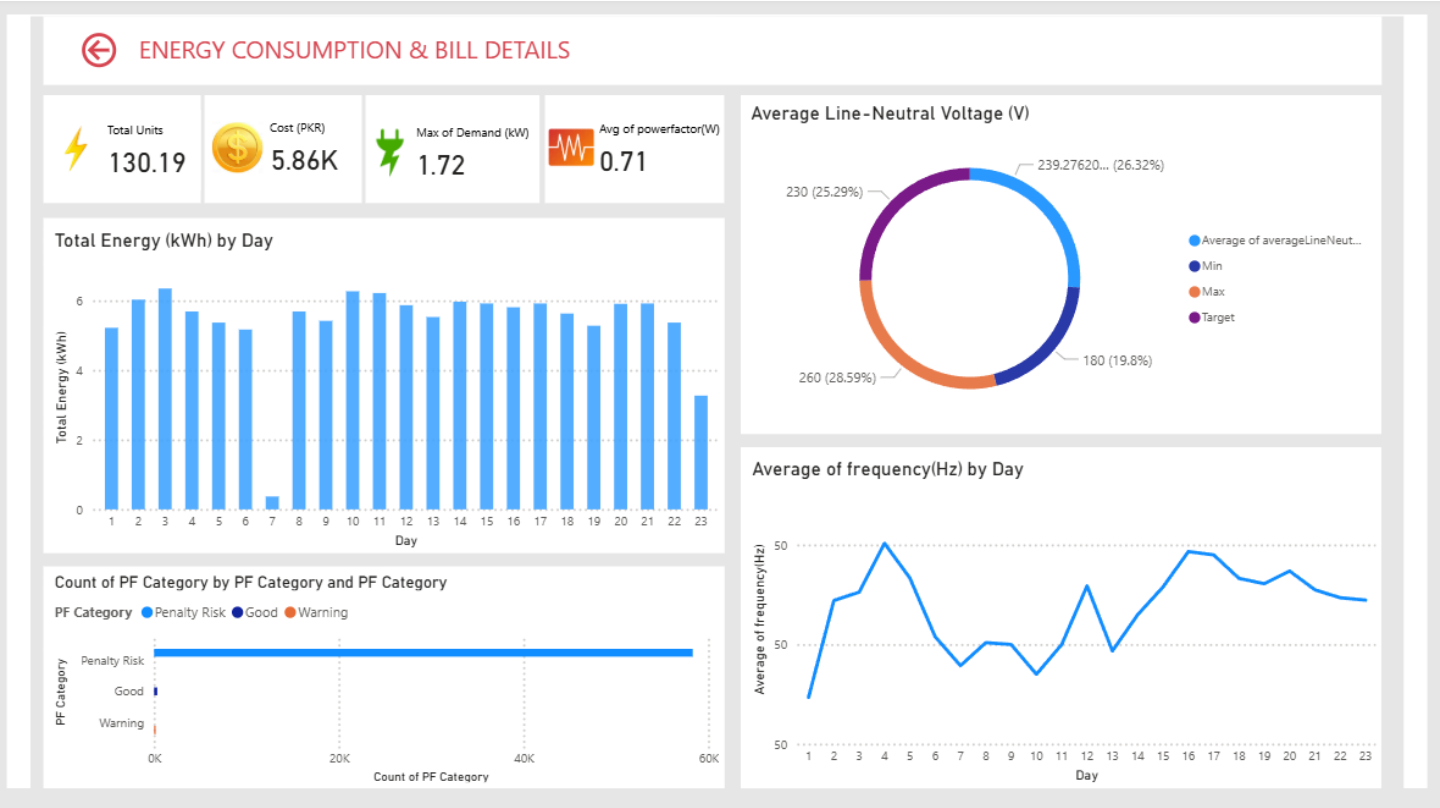
This page analyzes electrical stability.

Visuals Included:

- VoltagePhaseR trend analysis
- CurrentPhaseR monitoring
- Total Line Current tracking
- Comparative visual between voltage and current

Purpose:

To evaluate system stability and detect irregular electrical behavior.



4.4 Page 4 – Power Factor & Frequency Analysis

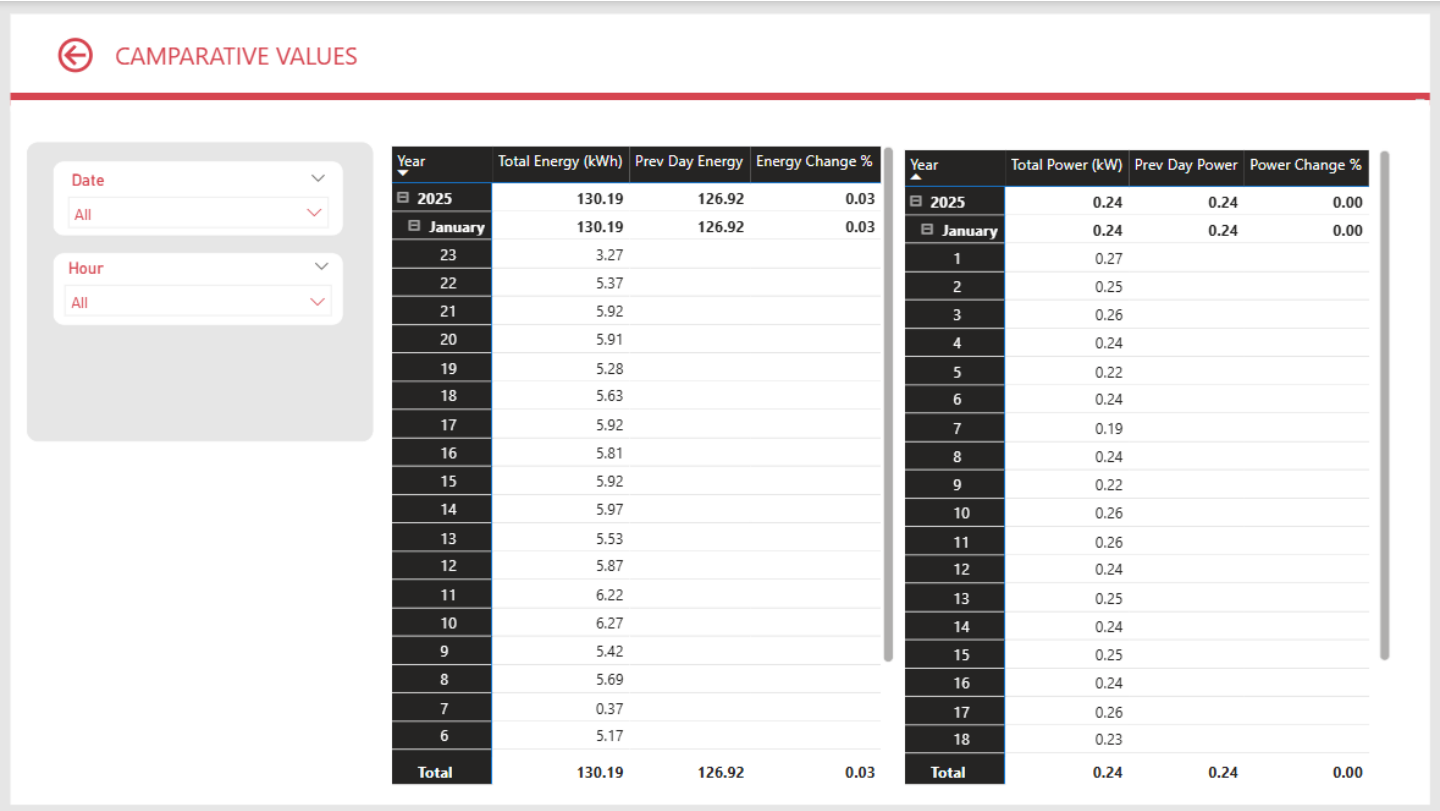
This page evaluates electrical efficiency.

Visuals Included:

- Power Factor trend
- Frequency stability graph
- Real Power vs Power Factor relationship

Purpose:

To monitor efficiency and ensure system frequency remains within acceptable operational limits.



Year	Total Energy (kWh)	Prev Day Energy	Energy Change %
2025	130.19	126.92	0.03
January	130.19	126.92	0.03
23	3.27		
22	5.37		
21	5.92		
20	5.91		
19	5.28		
18	5.63		
17	5.92		
16	5.81		
15	5.92		
14	5.97		
13	5.53		
12	5.87		
11	6.22		
10	6.27		
9	5.42		
8	5.69		
7	0.37		
6	5.17		
Total	130.19	126.92	0.03

Year	Total Power (kW)	Prev Day Power	Power Change %
2025	0.24	0.24	0.00
January	0.24	0.24	0.00
1	0.27		
2	0.25		
3	0.26		
4	0.24		
5	0.22		
6	0.24		
7	0.19		
8	0.24		
9	0.22		
10	0.26		
11	0.26		
12	0.24		
13	0.25		
14	0.24		
15	0.25		
16	0.24		
17	0.26		
18	0.23		
Total	0.24	0.24	0.00

5. Key Insights and Findings

Based on the analysis of 58,809 time-series electricity records, the following key observations were identified:

1. Voltage Stability: The voltage values remained relatively stable throughout the observed period with minor fluctuations. No extreme voltage drops or spikes were observed, indicating a stable power supply system.

2. Load Variation Patterns: Current and total real power showed noticeable fluctuations during different hours of the day. Peak load periods were observed during high-usage hours, indicating varying electricity demand.

3. Energy Consumption Trend: EnergyValue displayed a continuous upward trend, as expected from cumulative energy measurement. Higher growth rates during certain time windows indicate increased consumption activity.

4. Power Factor Efficiency: The power factor remained close to 1 for most of the time period, suggesting efficient energy utilization and minimal reactive power losses.

5. Frequency Stability: The system frequency remained within normal operational limits, showing no major instability events.

6. Correlation Between Current and Power: An increase in total line current corresponded directly with higher total real power, confirming expected electrical behavior.

6. Conclusion

This project successfully transformed raw Instrux electricity sensor data into meaningful analytical insights using Python and Power BI. The preprocessing phase removed unnecessary and constant features, structured the dataset into a time-series format, and prepared it for visualization.

The Power BI dashboard enabled interactive monitoring of voltage, current, real power, energy consumption, power factor, and frequency trends. The analysis confirmed system stability, identified peak load periods, and demonstrated efficient energy utilization.

Overall, this project highlights the importance of data cleaning, structured modeling, and visual analytics in converting raw electrical sensor readings into actionable insights for monitoring and decision-making.