Electricity Consumption Analysis Report

1. Executive Summary

This report presents a comprehensive analysis of electricity consumption data from various meters, focusing on understanding consumption patterns and behavior over time. Key insights were drawn from time series decomposition, clustering analysis, and statistical summaries. The goal is to provide actionable recommendations to optimize electricity usage and improve energy management.

Key Insights:

- **Clear seasonal patterns** observed in consumption data, indicating predictable peak and low usage times.
- **Distinct consumption clusters** identified, allowing targeted strategies for different user groups.
- Time series decomposition of **Meter-1 – r1** revealed strong daily trends and seasonality, while **R4** displayed more variable patterns.
- Identified outliers and anomalies suggest opportunities for improving demand forecasting and energy efficiency.

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2. Data Analysis

2.1 Data Overview

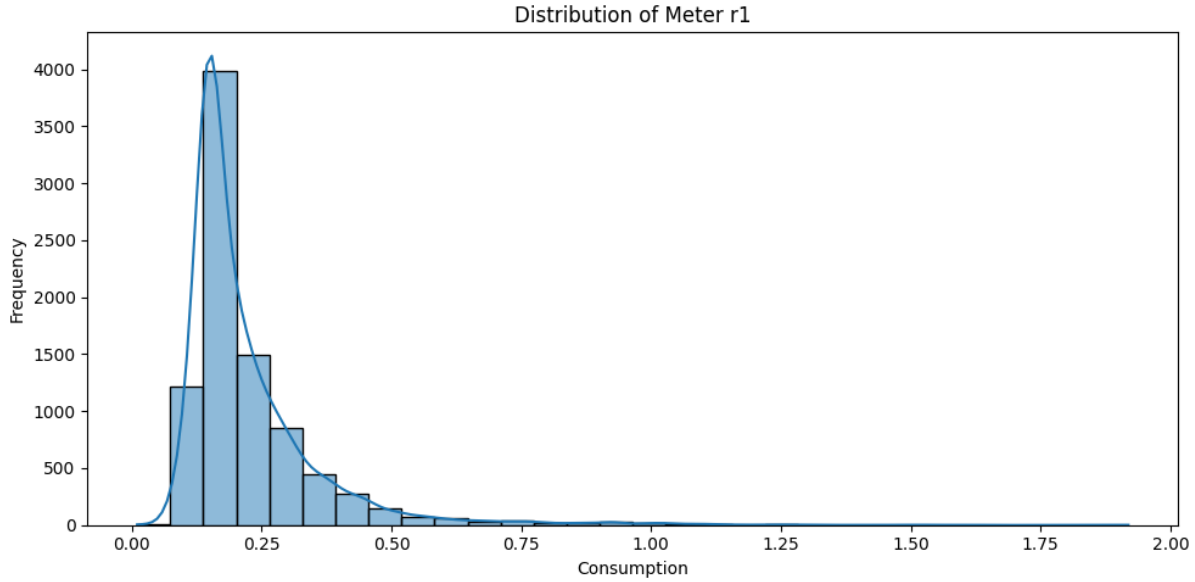
- Dataset includes electricity consumption readings from multiple meters over a defined period.
- Meter readings recorded at regular intervals (e.g., hourly or daily).
- Initial data cleaning addressed missing values and inconsistencies.

2.2 Meter Clustering Analysis

- Clustering based on consumption profiles segmented meters into groups with similar usage patterns.
- Clusters enable customized interventions for different consumer groups.

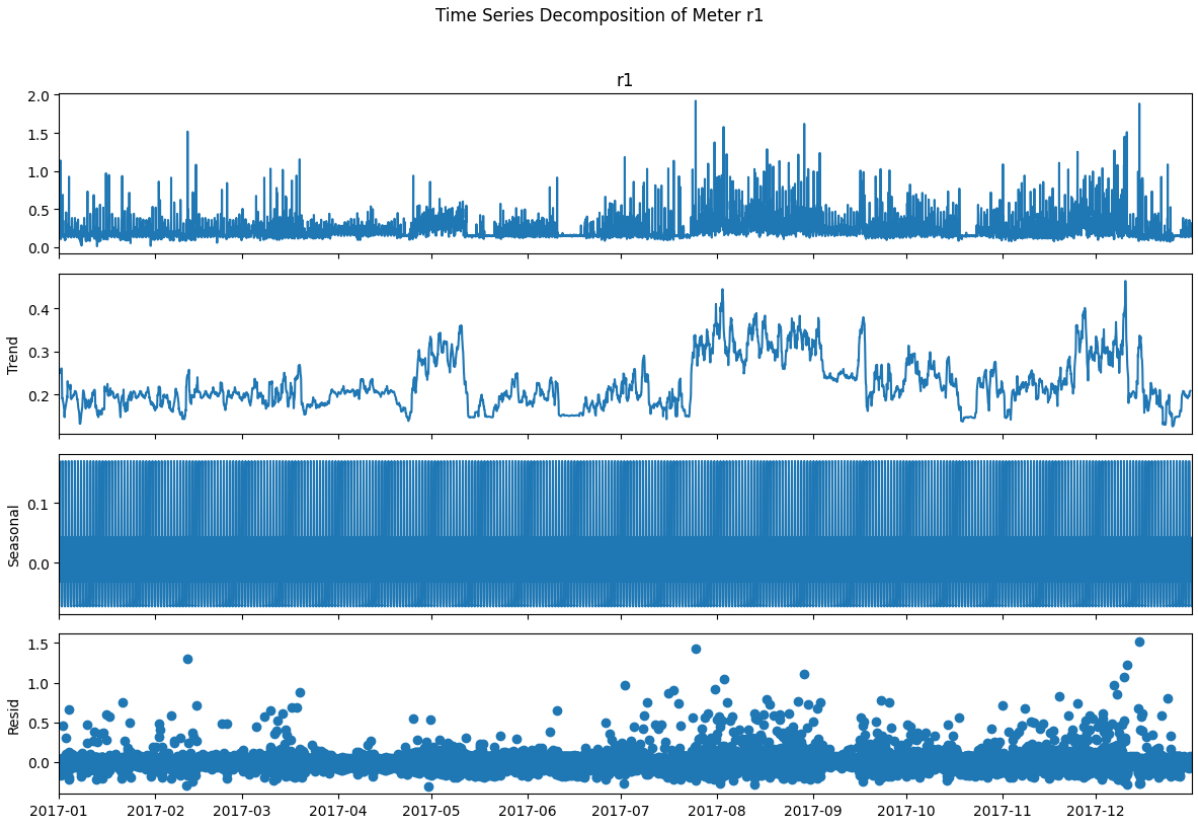
2.3 Time Series Decomposition

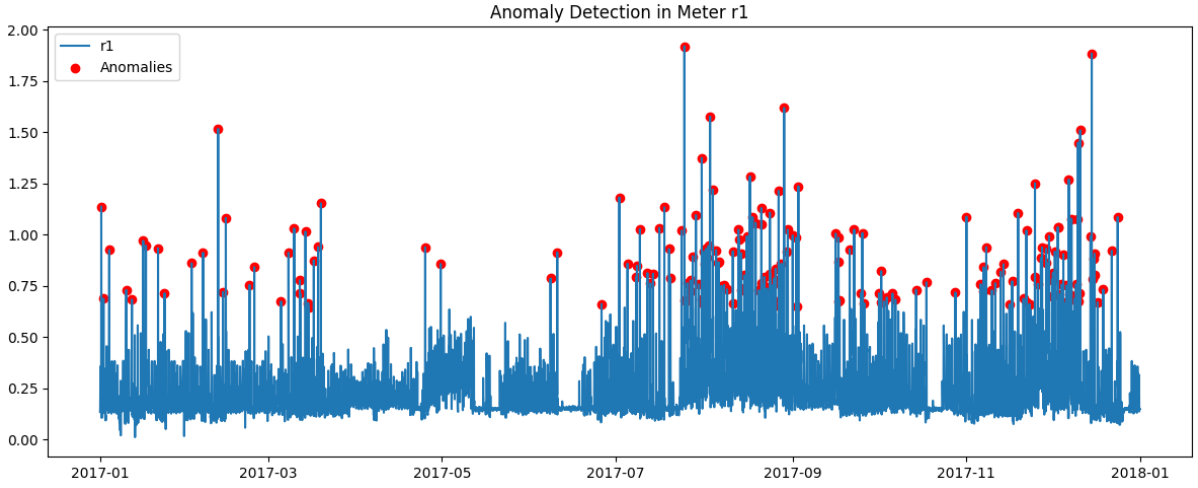
- Performed decomposition on **Meter-1- r1** and **R4** to isolate trend, seasonal, and residual components.
- **Meter-1:** Exhibited a clear upward trend with strong daily and weekly seasonality, indicating predictable consumption peaks (e.g., mornings and evenings).
- **R4:** Showed less stable consumption patterns with irregular fluctuations and weaker seasonality, suggesting varying user behavior or external factors.

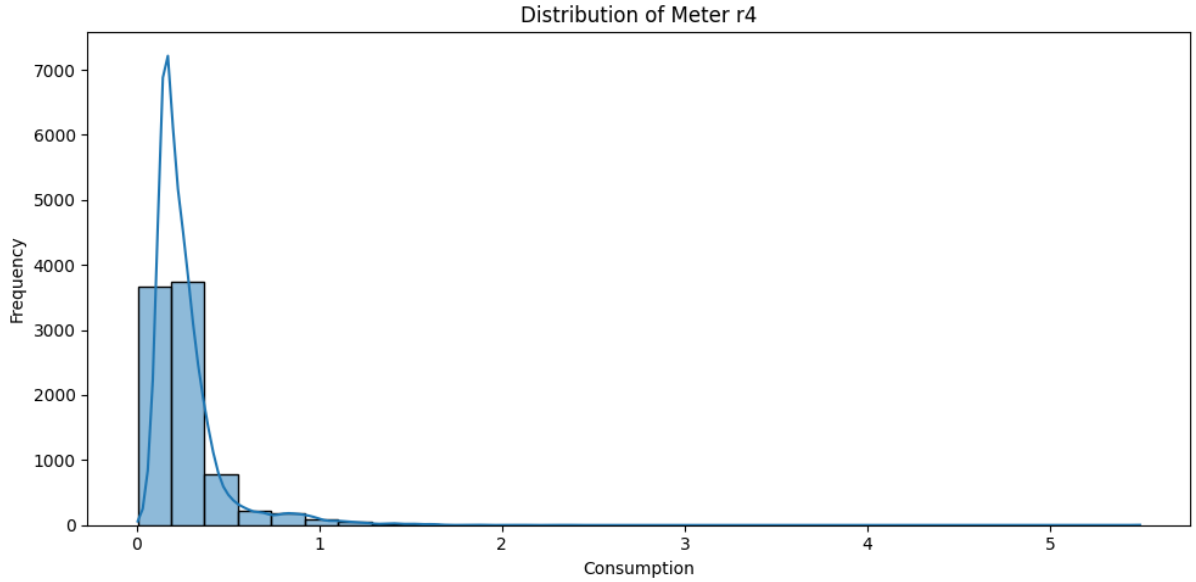


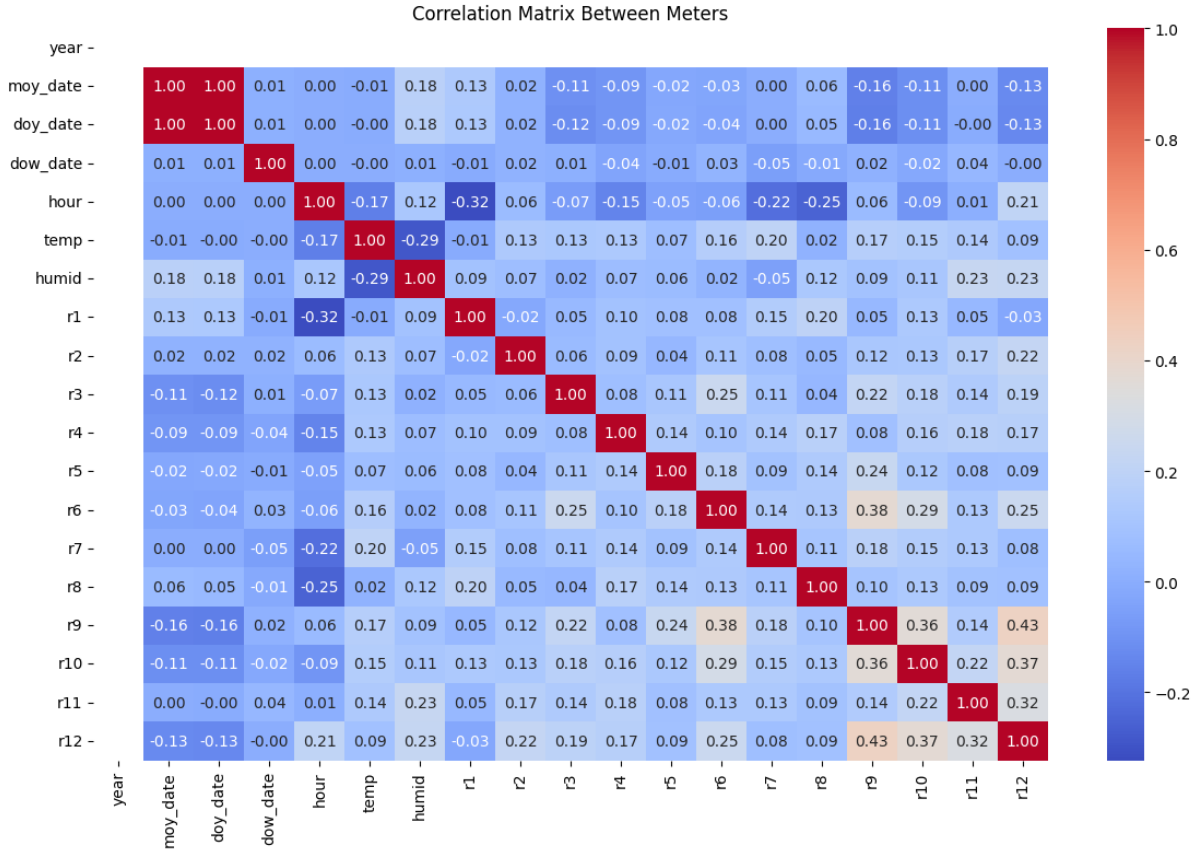
Correlation Matrix Between Meters

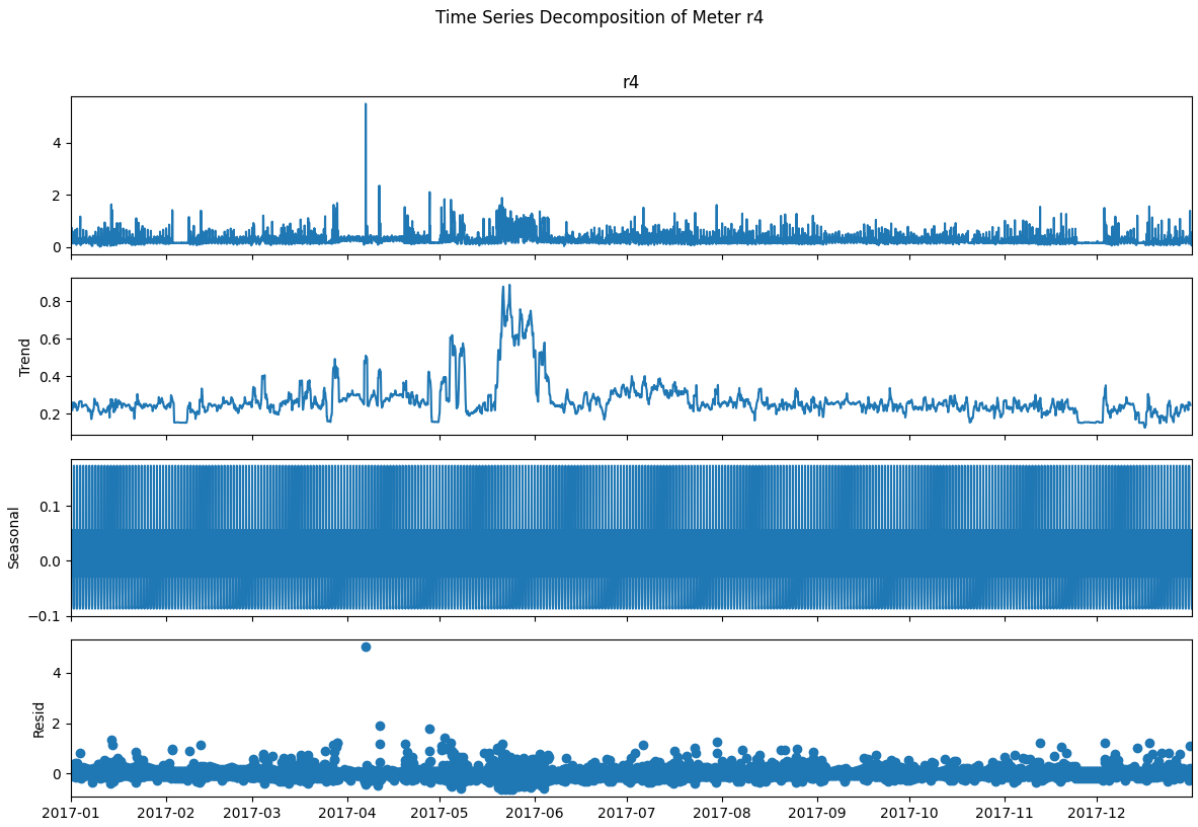
	year	moy_date	doy_date	dow_date	hour	temp	humid	r1	r2	r3	r4	r5	r6	r7	r8	r9	r10	r11	r12
year		1.00	1.00	0.01	0.00	-0.01	0.18	0.13	0.02	-0.11	-0.09	-0.02	-0.03	0.00	0.06	-0.16	-0.11	0.00	-0.13
moy_date	1.00	1.00	1.00	0.01	0.00	-0.00	0.18	0.13	0.02	-0.12	-0.09	-0.02	-0.04	0.00	0.05	-0.16	-0.11	-0.00	-0.13
doy_date	1.00	1.00	1.00	0.01	0.00	-0.00	0.18	0.13	0.02	-0.12	-0.09	-0.02	-0.04	0.00	0.05	-0.16	-0.11	-0.00	-0.13
dow_date	0.01	0.01	0.01	1.00	0.00	-0.00	0.01	-0.01	0.02	0.01	-0.04	-0.01	0.03	-0.05	-0.01	0.02	-0.02	0.04	-0.00
hour	0.00	0.00	0.00	0.00	1.00	-0.17	0.12	-0.32	0.06	-0.07	-0.15	-0.05	-0.06	-0.22	-0.25	0.06	-0.09	0.01	0.21
temp	-0.01	-0.00	-0.00	-0.00	-0.17	1.00	-0.29	-0.01	0.13	0.13	0.13	0.07	0.16	0.20	0.02	0.17	0.15	0.14	0.09
humid	0.18	0.18	0.18	0.01	0.12	-0.29	1.00	0.09	0.07	0.02	0.07	0.06	0.02	-0.05	0.12	0.09	0.11	0.23	0.23
r1	0.13	0.13	0.13	-0.01	-0.32	-0.01	0.09	1.00	-0.02	0.05	0.10	0.08	0.08	0.15	0.20	0.05	0.13	0.05	-0.03
r2	0.02	0.02	0.02	0.02	0.06	0.13	0.07	-0.02	1.00	0.06	0.09	0.04	0.11	0.08	0.05	0.12	0.13	0.17	0.22
r3	-0.11	-0.12	-0.12	0.01	-0.07	0.13	0.02	0.05	0.06	1.00	0.08	0.11	0.25	0.11	0.04	0.22	0.18	0.14	0.19
r4	-0.09	-0.09	-0.09	-0.04	-0.15	0.13	0.07	0.10	0.09	0.08	1.00	0.14	0.10	0.14	0.17	0.08	0.16	0.18	0.17
r5	-0.02	-0.02	-0.02	-0.01	-0.05	0.07	0.06	0.08	0.04	0.11	0.14	1.00	0.18	0.09	0.14	0.24	0.12	0.08	0.09
r6	-0.03	-0.04	-0.04	0.03	-0.06	0.16	0.02	0.08	0.11	0.25	0.10	0.18	1.00	0.14	0.13	0.38	0.29	0.13	0.25
r7	0.00	0.00	0.00	-0.05	-0.22	0.20	-0.05	0.15	0.08	0.11	0.14	0.09	0.14	1.00	0.11	0.18	0.15	0.13	0.08
r8	0.06	0.05	0.05	-0.01	-0.25	0.02	0.12	0.20	0.05	0.04	0.17	0.14	0.13	0.11	1.00	0.10	0.13	0.09	0.09
r9	-0.16	-0.16	-0.16	0.02	0.06	0.17	0.09	0.05	0.12	0.22	0.08	0.24	0.38	0.18	0.10	1.00	0.36	0.14	0.43
r10	-0.11	-0.11	-0.11	-0.02	-0.09	0.15	0.11	0.13	0.13	0.18	0.16	0.12	0.29	0.15	0.13	0.36	1.00	0.22	0.37
r11	0.00	-0.00	-0.00	0.04	0.01	0.14	0.23	0.05	0.17	0.14	0.18	0.08	0.13	0.13	0.09	0.14	0.22	1.00	0.32
r12	-0.13	-0.13	-0.13	-0.00	0.21	0.09	0.23	-0.03	0.22	0.19	0.17	0.09	0.25	0.08	0.09	0.43	0.37	0.32	1.00


Time Series Decomposition of Meter r1
r1
Trend
Seasonal
Resid
2017-01
2017-02
2017-03
2017-04
2017-05
2017-06
2017-07
2017-08
2017-09
2017-10
2017-11
2017-12


Anomaly Detection in Meter r1
r1
Anomalies
2017-01
2017-03
2017-05
2017-07
2017-09
2017-11
2018-01


Distribution of Meter r4
Frequency
Consumption
0
1000
2000
3000
4000
5000
6000
7000
0
1
2
3
4
5


Correlation Matrix Between Meters
year
moy_date
doy_date
dow_date
hour
temp
humid
r1
r2
r3
r4
r5
r6
r7
r8
r9
r10
r11
r12
1.0
0.8
0.6
0.4
0.2
0.0
−0.2



3. Conclusions

- Electricity consumption exhibits strong and predictable seasonal patterns for many meters, which can be leveraged for better demand management.
- Clustering reveals heterogeneity among consumers, suggesting the need for tailored energy-saving programs.
- Anomalies and residual fluctuations in the data point to potential areas for further investigation, such as technical faults or unusual consumption.

4. Recommendations

- **Demand Response Programs:** Utilize identified seasonal trends to schedule energy-saving initiatives during peak usage times.
- **Targeted Customer Engagement:** Develop customized communication and incentives for each cluster group to promote efficient consumption.
- **Anomaly Detection:** Implement continuous monitoring systems to detect irregular consumption patterns early and investigate causes.
- **Data-Driven Forecasting:** Leverage time series decomposition insights to improve short- and long-term load forecasting accuracy.

5. Next Steps

- Extend time series analysis to other meters and clusters for a broader view.
- Integrate weather and event data to better understand external influences.
- Explore advanced machine learning models for forecasting and anomaly detection.