DVA Capstone Project

Intelligent Abnormal Electricity Usage

Sector: **ENERGY AND POWER**

Team Members

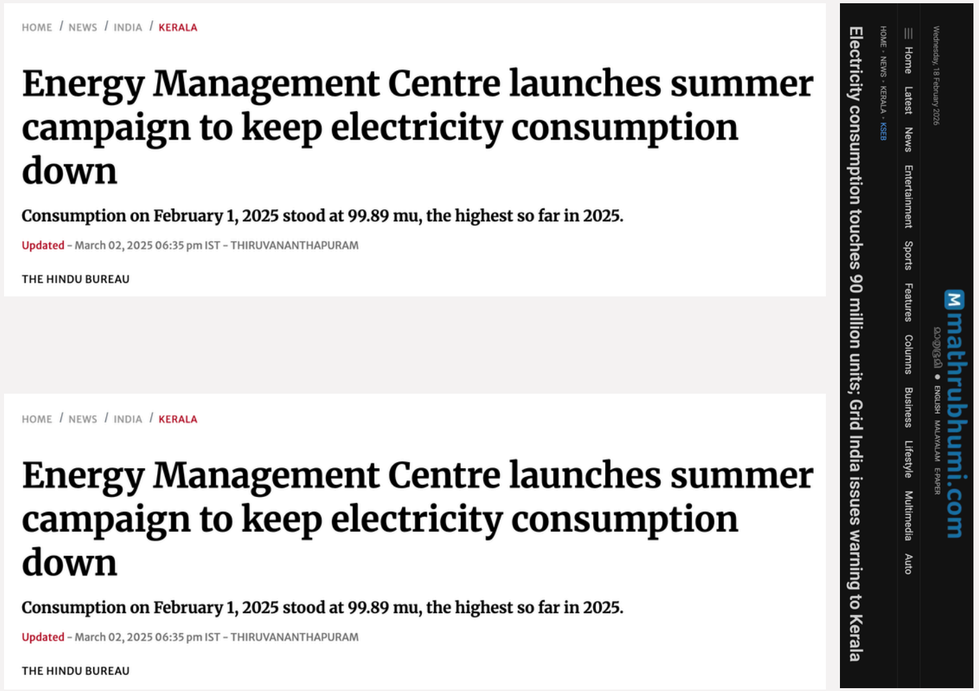
Palwai Tejaswini - 2401010314
Kashika Agarwal - 2401010215
Utkarsh Jain - 2401020072
Lokendra singh - 2401010254
Anwesha Adhikari - 2401010091
Sankalp M Tellur - 2401010416

Mentor

Archit Raj

Sector Context

Kerala’s electricity distribution sector operates in a high-demand, climate-sensitive environment where efficient load management and loss reduction are critical. Rapid urbanization and rising residential consumption require stronger, data-driven monitoring to ensure grid stability and operational efficiency.



HOME / NEWS / INDIA / KERALA

Energy Management Centre launches summer campaign to keep electricity consumption down

Consumption on February 1, 2025 stood at 99.89 mu, the highest so far in 2025.

Updated - March 02, 2025 06:35 pm IST - THIRUVANANTHAPURAM

THE HINDU BUREAU

HOME / NEWS / INDIA / KERALA

Energy Management Centre launches summer campaign to keep electricity consumption down

Consumption on February 1, 2025 stood at 99.89 mu, the highest so far in 2025.

Updated - March 02, 2025 06:35 pm IST - THIRUVANANTHAPURAM

THE HINDU BUREAU

Problem Statement

Electricity distribution companies lack an intelligent, data-driven system to proactively detect abnormal residential electricity consumption patterns, resulting in:

- Revenue losses
- Grid inefficiencies
- Delayed corrective actions

Objective

This project aims to support decision-makers by:

- Identifying abnormal residential electricity usage patterns
- Measuring deviation between expected and actual consumption
- Detecting high-consumption clusters

Source

Dataset Name: Intelligent abnormal electricity usage
Source: Deep Data Lake (dataset_id = 112) [Link]
Size: 10,800 rows × 21 columns
Time Period: January 2023
Coverage: Selected districts of Kerala

Cleaning

Missing Values Handled: Null values in key energy fields were cleaned to ensure accurate KPI calculation.
Data Formatting Issues Fixed: Date fields were standardised and meter ID prefixes were removed for simplified analysis.
Outliers & Deviations Reviewed: Extreme usage deviations were validated to ensure realistic abnormal usage detection.

Dictionary

Meter_Id	Unique smart meter identifier
Cleaned_Date	Date of record
Cleaned_Expected_Energy	Estimated consumption
Cleaned_Actual_Energy	Actual consumption
Usage_Deviation(%)	Difference between expected and actual
Abnormal_Usage	Difference between expected and actual
Cluster_Avg_Energy(kWh)	Cluster-based consumption benchmark
Appliance_Score	Appliance intensity indicator

What Are We Measuring?

- Average Usage Deviation (%) - Overall abnormal consumption trend
- Maximum Usage Deviation (%) - Extreme anomaly detection
- Abnormal vs Normal Energy Comparison - Behavioural difference analysis
- Highest Risk Region - Geographic abnormal concentration
- Load vs Energy Correlation - Relationship between capacity and usage

Why These KPIs?

These KPIs directly support the core problem of detecting abnormal residential electricity usage by:

- Identifying overall deviation patterns
- Detecting extreme abnormal cases early
- Understanding factors driving abnormal behavior (load, area, region)
- Supporting data-driven monitoring decisions

Key Insights (EDA)

Consumption Is Operationally Stable
Average weekly usage ~16.7 kWh; no major seasonal fluctuation.

Ernakulam Is the Highest Risk District
Highest abnormal cases (1930); primary monitoring focus.

Actual Consumption Consistently Exceeds Expected Levels
Consistent positive deviation across districts.

Independent Houses Drive Higher Deviations
Standalone residences indicate greater irregular usage risk.

Consumption Is Usage-Driven, Not Infrastructure-Driven
Abnormal usage linked more to consumer behavior than infrastructure limits.

Advanced Analysis

Segmentation

High usage in Load Category 3 and 4–6 occupant households
Ernakulam is the highest abnormal segment
Clear high-risk consumer identification

Root Causes

Driven by high load intensity
Higher occupancy
Temperature above 30°C

Risk Assessment

4,739 abnormal cases detected
Load category and temperature increase deviation risk
Requires proactive monitoring

Key Understanding

Identified who, where, and why of abnormal usage
Shifted to risk-based, actionable insights

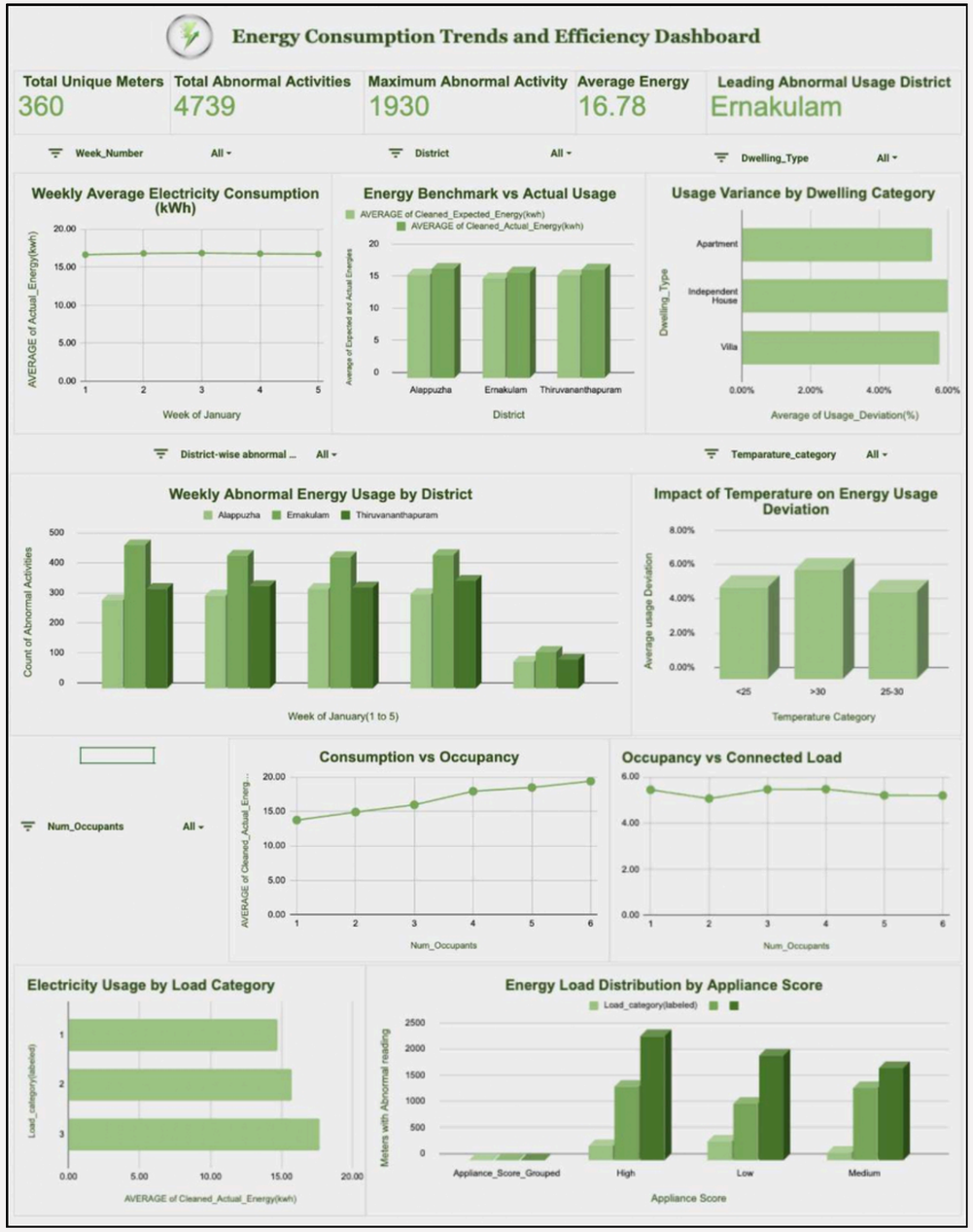
Forecasting Insights

Weekly demand stable (~16.7 kWh)
Higher occupants, load, and temperature increase consumption and deviation

Dashboard Walkthrough

Operational View (Detailed Drill-Down)

District-wise abnormal usage comparison
Dwelling type and load category impact analysis
Temperature and occupancy-based deviation patterns
Interactive filters for region, dwelling type, and number of occupants



Executive View (High-Level Summary)

Displays total Unique Meters (360) and Total Abnormal Activities (4,739)
Shows Average Energy Consumption (16.78 kWh)
Highlights Highest Risk District – Ernakulam
Provides a quick snapshot of overall deviation trends and risk concentration

Recommendations

1. **Implement Targeted Monitoring in High-Risk Districts**

Linked Insight: Ernakulam shows highest abnormal concentration.

- Deploy district-level alert systems for high-deviation meters.
- Prioritise inspections in Ernakulam and other high-risk zones.
- Introduce risk scoring for consumers based on abnormal frequency

2. **Launch Seasonal Energy Monitoring (Temperature-Based Alerts)**

Linked Insight: High temperature (>30°C) increases energy deviation.

- Activate summer-specific anomaly thresholds.
- Send advisory notifications during peak heat periods.
- Encourage optimised AC usage and load balancing.

3. **Focus on Independent Houses with High Deviation**

Linked Insight: Independent houses show highest usage deviation.

- Offer energy audits for high-deviation households.
- Promote smart meters and load optimisation devices.
- Provide targeted awareness campaigns for independent dwellings.

4. **High Load Category Consumer Monitoring**

Linked Insight: Higher load category consumers use more energy.

- Create tier-based monitoring dashboards.
- Implement differential tariff or incentive programs for efficient usage.
- Conduct appliance efficiency assessments.

5. **Occupancy-Based Energy Optimisation Programs**

Linked Insight: Higher occupancy drives higher consumption.

- Develop consumption benchmarks based on household size.
- Offer behavioral nudges via monthly deviation reports.
- Encourage staggered appliance usage.

Impact & Value

The “So What?” — Business Impact

Direct Cost Recovery Opportunity

- 4,739 abnormal cases detected in one month
- Even if only 15% are bill-correction opportunities
- Avg correction: ₹400 per case

Improved Service Quality & Consumer Trust

- Faster identification of billing inconsistencies
- Reduced consumer disputes
- Transparent benchmarking

Why Should Stakeholders Approve This?

- Immediate measurable financial impact
- Scalable monitoring framework
- Data-driven decision support
- Reduced operational burden
- Long-term sustainability improvement

Limitations & Next Steps

Limitations

- Analysis is based on limited time-period data (no long-term seasonal validation)
- Abnormality is deviation-based, not confirmed theft or fraud
- No real-time smart meter data used
- Limited external factors (income, appliance-level usage, billing history)

Next Steps

- Extend analysis to 6–12 months seasonal data
- Build predictive risk scoring model for early detection
- Add transformer/feeder-level monitoring for grid-level control
- Develop automated alert system for high-risk consumers