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ENERGY AUDITING ANALYSIS OF ELECTRICAL LOAD

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ABSTRACT

The in creasing demand for electrical energy in Karnataka necessitates efficient monitoring and optimization of energy usage. This paper presents a comprehensive energy auditing study based on electrical load consumption data obtained from Karnataka Power Transmission Corporation Limited (KPTCL). The study focuses on comparative load curve analysis for January 2024 and January 2025. The analysis identifies variations in peak load, base load, and daily consumption trends. Results indicate that peak demand occurs during daytime operational hours, while minimum demand is observed during late-night hours. The study also highlights differences between weekday and weekend consumption patterns. The findings provide insights for demand-side management, loss reduction, and efficient grid operation. Recommendations such as load shifting, smart grid adoption, and renewable energy integration are proposed to enhance overall system efficiency.

KEYWORDS: Energy Audit, Load Curve Analysis, Peak Load, Demand-Side Management, Smart Grid

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1. INTRODUCTION

Energy auditing plays a crucial role in ensuring efficient utilization of electrical energy, especially in large transmission systems. Karnataka Power Transmission Corporation Limited (KPTCL) is responsible for transmitting electricity across the state through an extensive network of substations and transmission lines. Energy auditing involves systematic monitoring, analysis, and optimization of energy consumption. It helps identify inefficiencies, reduce losses, and improve system performance. Load curve analysis is a key component of energy auditing, as it provides insights into demand variation over time. With rising energy demand, it is essential to analyze consumption patterns and optimize resource utilization for sustainable development.

2. LITERATURE REVIEW

Several studies highlight the importance of energy auditing in power systems:

Energy audits in electrical utilities have shown that transformer inefficiencies and poor reactive power management contribute significantly to losses.

Substation-level audits indicate that proper load scheduling and efficient equipment usage can reduce internal consumption.

Transmission loss reduction studies suggest that SCADA systems and high-efficiency transformers can minimize losses by up to 10%.

Implementation of structured energy auditing improves operational efficiency by 8–15% in power utilities [1-6].

These findings support the need for detailed load analysis in large-scale transmission networks like KPTCL.

Research Paper

3. Objectives

The main objectives of this study are:

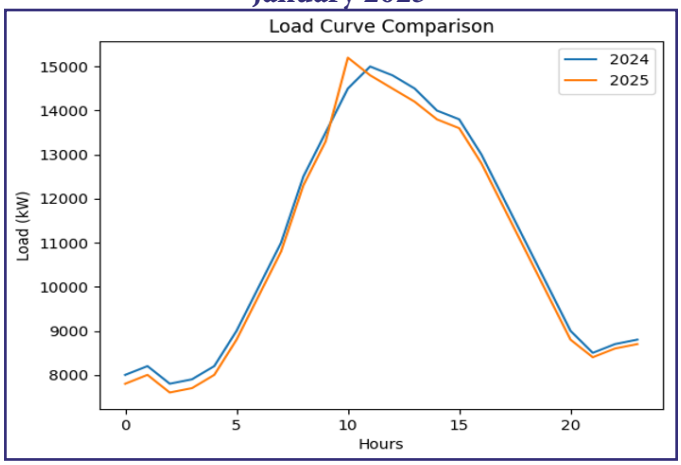
a. To analyze energy consumption patterns in Karnataka
b. To identify peak and off-peak load conditions
c. To detect energy wastage and inefficiencies
d. To recommend energy-saving measures
e. To promote sustainable and efficient energy utilization

4. METHODOLOGY

4.1 Data Collection

Load curve data for January 2024 and January 2025 was collected from the KPTCL official portal [7].

Fig. 1: Load curve data for January 2024 and January 2025



4.2 Data Analysis

From the load curve data the hourly load data (00:00–24:00) was analyzed and identified maximum and minimum load values. Weekly and monthly comparisons were performed based on the collected data.

Fig. 2: One Week Power Output Analysis (Jan 2024)

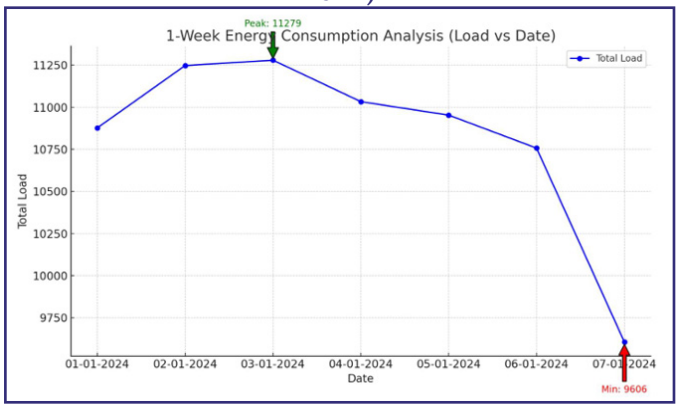


Table 1: Load Curve Data for January 2024

01-01-2024	02-01-2024	03-01-2024	04-01-2024	05-01-2024	06-01-2024	07-01-2024
8371	8654	8984	9104	8444	8613	8467
8466	8913	9247	9390	8566	8601	8480
8100	**8422**	**8765**	8755	8142	8210	7834
8251	8503	8776	**8705**	**8123**	**8210**	**7914**
8412	8787	9166	8969	8416	8357	7960
8616	9302	9299	9313	8831	8733	8101
9368	9462	9719	9745	9218	9199	8144
10697	11276	11577	11169	11280	10859	8910
12354	12892	12786	12591	12555	12245	9777
13876	13038	13353	13188	12900	12971	11277
14515	**14666**	**15019**	14401	**14479**	**14291**	12296
14456	15005	14961	**14478**	14235	14116	12402
14652	14901	14977	14481	14352	14273	**12556**
14309	14451	14582	13852	14470	13902	12265
13725	14316	13832	13301	13637	13520	12325
13827	14303	13908	13128	13606	13320	11688
13131	14017	13628	13124	13483	13130	11424
12125	12792	12164	11867	12349	11932	10250
10829	11466	10948	11238	11027	10737	9135
9200	9812	9522	9692	9969	9449	8626
8683	8719	8953	8878	9033	8429	7815
8146	8486	8542	8375	8585	8254	7505
8478	8900	8914	8501	8607	8350	7545
8470	8850	9060	8542	8563	8464	7852
10877	11247	**11279**	11033	10953	10757	9606

Energy Analysis made for one week i.e. (01–07 Jan 2024) it is observed that Peak Day (Highest Total Energy) on 03-01-2024 Total Load consumption is 11,279 units. This day had the highest recorded total consumption. Minimum Consumption on 07-01-2024 recorded Load is 9,606 units. Represents a notable drop in energy usage compared to previous days.

Fig. 3: Typical Peak Load Curve

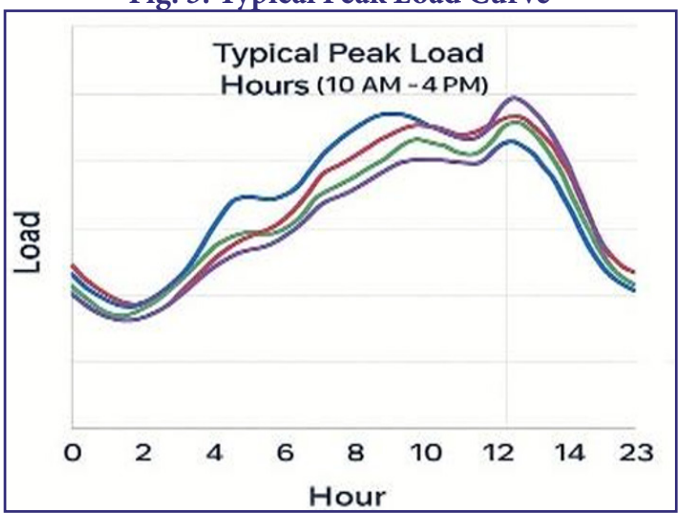


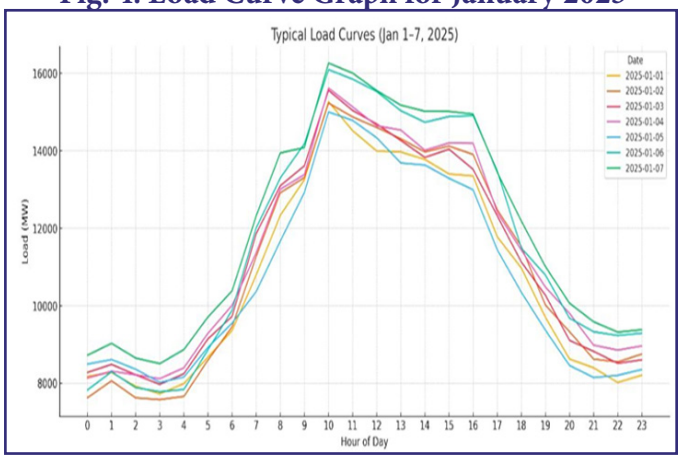
Figure 3 depicts that the Peak demand consistently occurs between 10:00 AM and 2:00 PM. Minimum Load during early morning hours (midnight to 5:00 AM)

RECOMMENDATIONS

Encourage shifting non-essential loads to early morning or late evening hours. Implement demand-side management strategies during peak hours (10 AM–2 PM).

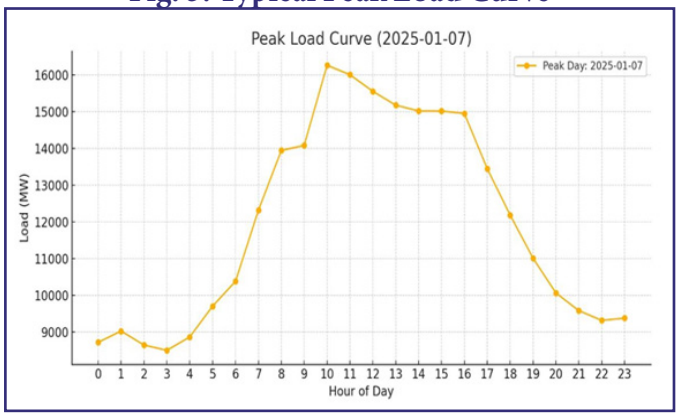
Load Curve Graph for January 2025

Fig. 4: Load Curve Graph for January 2025



Energy Analysis (01-07 Jan 2025) from the data peak Load observed on January 7, 2025 with a load of 16,267 MW. This was the highest recorded load in the week, indicating a surge in demand. Minimum Consumption observed on January 5, 2025 (Sunday) Total Energy Consumption was 267,919 kWh Likely lower due to reduced activity on the weekend. Average Daily Energy Consumption was 280,622 kWh. The load steadily increases during weekdays and drops slightly on the weekend. This trend is typical for urban and industrial grids. Observation for the month (Jan 2025) Load is lowest during midnight to early morning (0–5 hours). Load is highest from 11 AM to 5 PM. Peak loads gradually increase day by day in January. Load decreases again in the evening after 6 PM.

Fig. 5: Typical Peak Load Curve

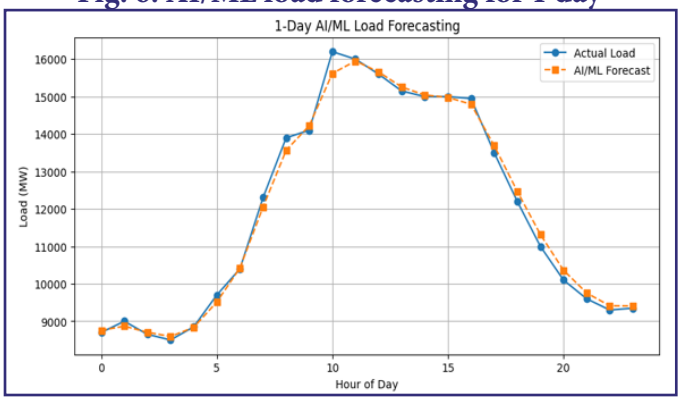


From the fig Peak load noticed from 10:00 AM – 2:00 PM (highest demand) and Lowest load: 3:00 AM – 5:00 AM (early morning dip).

5. RESULTS & DISCUSSION

Load Pattern Analysis for Jan 2024 and Jan 2025 was compared and developed a load forecasting model for one day (for 24 hours).

Fig. 6: AI/ML load forecasting for 1 day



The Random Forest regression method was used to create the predictive model for 1-day. The load curves of January 2024 and 2025 indicate a dynamic load profile during peak and off-peak periods. From fig. 6 it is observed that the variations in load highlight the importance of accurate load forecasting.

CONCLUSIONS

The study demonstrates that energy auditing through load curve analysis provides valuable insights into consumption patterns and system efficiency. Peak demand occurs during working hours, while minimum demand is observed during early morning hours.

The comparison between 2024 and 2025 indicates consistent trends with slight improvements in load management. Effective implementation of energy-saving strategies can significantly reduce losses and improve grid performance.

Energy auditing is thus an important parameter for proper energy management and future planning in power system.

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