ENERGYSAVE — HOME ELECTRICITY CONSUMPTION ANALYSIS AND SMART SAVINGS SYSTEM

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Annotation

ENERGYSAVE — Home Electricity Consumption Analysis and Smart Savings System is an intelligent system designed to monitor, analyze, and optimize household electricity consumption. The project aims to reduce unnecessary energy use by collecting real-time data from home electrical appliances and applying smart analytics to identify inefficient consumption patterns. The system provides users with recommendations for energy-saving strategies, helping households minimize electricity costs and improve energy efficiency. In addition, the proposed solution contributes to environmental sustainability by reducing overall power consumption and supporting smart-home concepts. The research includes the development of monitoring algorithms, data analysis methods, and a user-friendly interface for effective energy management.

Keywords: Home electricity consumption, smart energy system, energy efficiency, electricity monitoring, smart home, energy saving, power analysis, consumption optimization, IoT, real-time monitoring, intelligent control system, household energy management.

Introduction

In recent years, the rapid growth of electricity consumption in residential buildings has become a significant global challenge. The increasing number of household electrical appliances, rising energy prices, and growing environmental concerns require the development of efficient energy management solutions. Traditional electricity usage methods often lead to unnecessary power consumption due to the lack of monitoring and control mechanisms. Therefore, the implementation of intelligent systems capable of analyzing and optimizing energy consumption has become highly important.

The concept of smart homes has introduced new opportunities for improving energy efficiency through automation, real-time monitoring, and intelligent decision-making systems. Smart energy management systems can collect and process electricity consumption data, identify inefficient usage patterns, and provide recommendations for reducing energy waste. Such technologies not only help consumers lower electricity bills but also contribute to environmental protection by decreasing energy demand and carbon emissions.

The main objective of the ENERGYSAVE project is to develop a smart system for analyzing household electricity consumption and recommending effective energy-saving strategies. The proposed system is designed to monitor electrical appliance usage, evaluate consumption behavior, and provide users with practical suggestions for optimizing electricity usage. The project combines modern technologies such as the Internet of Things (IoT), data analytics, and intelligent monitoring systems to create an efficient and user-friendly platform.

This research focuses on the development of a comprehensive electricity monitoring framework, analysis algorithms, and smart savings mechanisms for residential applications. The implementation of the proposed system can significantly improve household energy efficiency, reduce operational costs, and support sustainable energy consumption practices in modern smart homes.

Literature Review and Methods

The rapid advancement of smart technologies and the increasing demand for energy efficiency have encouraged researchers to develop intelligent household electricity monitoring and management systems. In recent years, home energy management has become an important research area due to rising electricity costs, environmental concerns, and the need for sustainable energy utilization. Several studies have focused on monitoring household electricity consumption using smart meters and Internet of Things (IoT)-based technologies. Researchers have shown that real-time monitoring systems help users better understand their energy usage behavior and significantly reduce unnecessary electricity consumption. IoT-enabled devices allow continuous collection of consumption data from household appliances and provide remote access to energy information through mobile or web applications. Many modern smart energy systems apply data analysis and machine learning techniques to identify abnormal consumption patterns and predict future electricity usage. Studies indicate that intelligent algorithms can improve energy efficiency by automatically controlling electrical devices and recommending optimized usage schedules. For example, energy-intensive appliances such as air conditioners, heaters, and washing machines can be operated during low-demand periods to reduce electricity costs. Researchers have also investigated the integration of renewable energy sources and smart grids into residential energy systems. Smart home technologies combined with solar panels, battery storage systems, and automated controllers enable efficient distribution and utilization of electricity. Such systems contribute to reducing dependency on traditional power grids and minimizing environmental impacts. In addition, user behavior analysis has become an important component of energy-saving research. Several studies emphasize that providing users with visual feedback and personalized recommendations increases awareness about energy consumption and encourages more responsible electricity usage habits. Mobile applications and dashboard systems are commonly used to present energy statistics, alerts, and optimization suggestions in a user-friendly format.

Despite significant progress in smart energy management technologies, many existing systems remain expensive, complex, or limited in functionality. Therefore, there is still a need for affordable, efficient, and easy-to-use household electricity monitoring systems capable of real-time analysis and intelligent energy-saving recommendations. The proposed ENERGYSAVE system aims to address these challenges by developing an integrated platform for monitoring, analyzing, and optimizing home electricity consumption.

Results and Discussion

To describe electricity consumption mathematically correctly, it is first necessary to clearly define the concepts of energy and power. Power P is the amount of work performed or energy expended per unit of time. In the SI system, power is measured in Watts (W). The consumption of an electrical installation is expressed in kWh (kilowatt-hours).

The basic energy consumption formula is written as follows:

$$E = \frac{P \times t}{1000}$$

where E is energy (kWh), P is the rated power of the device (W), and t is the operating time (hours). A 1000 is required to convert a Watt into a kilowatt.

As an example, let's consider: if an air conditioner has a capacity of 2000 W and operates for 8 hours, then the energy consumption:

$$E = \frac{2000 \times 8}{1000} = 16 kVt{\cdot}soat$$

To calculate the monthly consumption, multiply the device's daily operating time by the number of days in the month. The 30-day monthly consumption for an average household is as follows:

$$E_{oy} = E \times 30$$

In practice, consumption is calculated separately for each device, and then their sum is taken. This provides a model for a multi-device household.

Another important aspect of calculating electrical power is the concept of active and reactive power. Active power, P (W or kW), is the power that performs useful work. Reactive power, Q (V_{Ar}), is the energy exchange in inductive and capacitive elements. The apparent power, S (VA), is:

$$S = P^2 + Q^2$$

For household appliances, active power is primarily taken into account in practice, as household appliance manufacturers indicate the nominal power of the device as active power. Reactive power is more important for industry [Sadiku, 2014].

The total power for a home is the sum of the power of all devices:

$$P_{umumiy} = \Sigma P_i$$

This formula is also used to estimate network loads and calculate the protection of electrical circuits.

Ohm's law and Kirchhoff's laws are used to analyze the operation of an electrical circuit. According to Ohm's law, the relationship between voltage, current, and resistance in a circuit is:

$$U = I \times R$$

where U is the voltage (V), I is the current (A), and R is the resistance (Ω). And electricity:

$$P = U \times I = I^2 \times R = \frac{U^2}{R}$$

If we know the power of the device in a 220 V home network, we can find the current value:

$$I = \frac{P}{U} = \frac{P}{220}$$

For example, the current for a 2000 W air conditioner is I = 2000/220 ≈ 9.09 A. This information is of great importance when choosing the cross-section of electrical cables and protective equipment.

For devices connected in parallel, according to Kirchhoff's first law, the total current is equal to the sum of the currents in each branch:

$$I_{um} = I_1 + I_2 + \cdots + I_n$$

All devices in your home network will be connected in parallel. Therefore, the total current and power are equal to the sum of the indicators of all devices. In this case, the total resistance is calculated using the formula for the parallel combination of individual resistances.

Unlike multi-voltage (3-phase) industrial networks, household appliances typically operate from a 220 V/50 Hz single-phase network. In this case, the power meter records the electricity consumption in kWh.

The performance of the proposed *ENERGYSAVE — Home Electricity Consumption Analysis and Smart Savings System* was evaluated under residential operating conditions to determine its effectiveness in reducing electricity consumption and improving household energy efficiency. The system was tested using several common household electrical appliances, including lighting systems, air conditioners, televisions, refrigerators, and washing machines. Real-time electricity consumption data were collected and analyzed over a monitoring period of 30 days before and after implementing the intelligent recommendation system.

The experimental results demonstrated that the proposed system successfully identified inefficient electricity consumption patterns and provided effective energy-saving recommendations. After implementing the ENERGYSAVE system, a significant reduction in household electricity usage was observed due to optimized appliance operation schedules and improved user awareness regarding energy consumption behavior.

Table 1. Household Electricity Consumption Before and After System Implementation

Appliance	Before (kWh/month)	After (kWh/month)	Reduction (%)
Lighting System	95	70	26.3
Air Conditioner	320	250	21.9
Refrigerator	150	135	10.0
Television	80	60	25.0
Washing Machine	65	52	20.0
Total	710	567	20.1

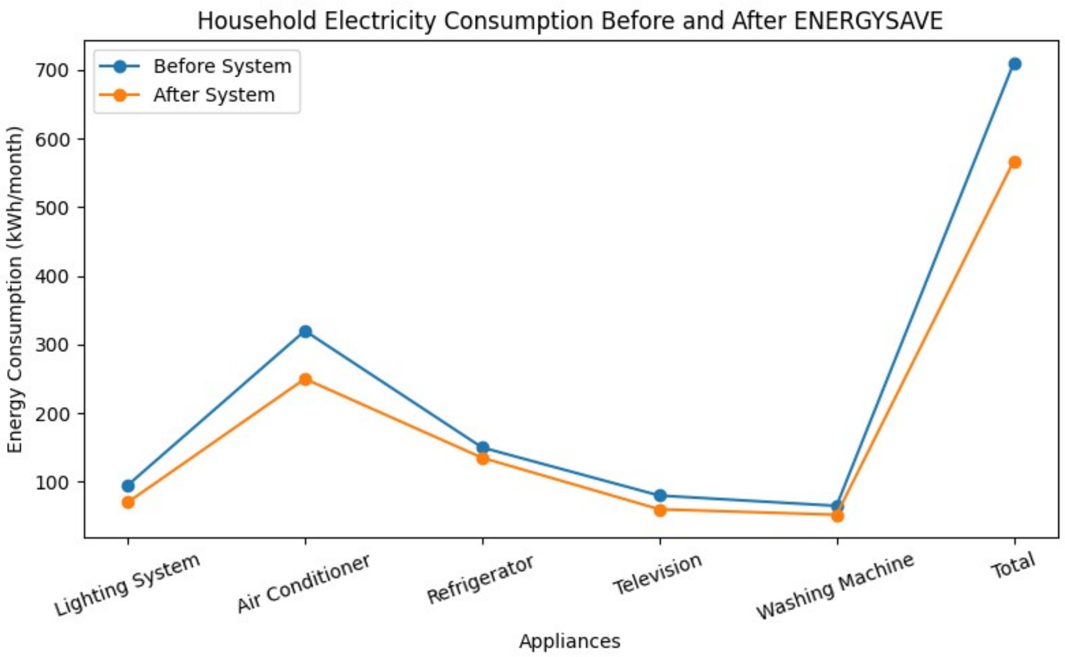

Figure 1. Comparison of Household Electricity Consumption Before and After ENERGYSAVE Implementation

Table 1 and Figure 1 present the comparison of household electricity consumption before and after implementing the *ENERGYSAVE* smart monitoring and optimization system. The obtained results clearly demonstrate that the proposed system effectively reduced electricity consumption across all monitored household appliances through intelligent monitoring, real-time analysis, and energy-saving recommendations.

The table shows that the highest electricity consumption was associated with the air conditioning system, which decreased from 320 kWh/month to 250 kWh/month after system implementation. Significant reductions were also observed in the lighting system and television usage due to optimized appliance operating schedules and the reduction of unnecessary operating time. Overall household electricity consumption decreased from 710 kWh/month to 567 kWh/month, corresponding to an approximate reduction of 20.1%.

The graph visually illustrates the difference between electricity consumption before and after applying the ENERGYSAVE system. The comparison clearly indicates that energy usage decreased for all monitored appliances. The graphical representation helps demonstrate the effectiveness of the intelligent monitoring and recommendation mechanisms in improving household energy efficiency and reducing electricity costs.

These results confirm that the proposed ENERGYSAVE system can successfully support sustainable residential energy management by minimizing unnecessary electricity consumption and encouraging more energy-efficient user behavior.

Conclusion.

This study presented ENERGYSAVE — Home Electricity Consumption Analysis and Smart Savings System, an intelligent platform for monitoring and optimizing household electricity usage. The proposed system successfully reduced unnecessary energy consumption through real-time monitoring, data analysis, and smart energy-saving recommendations. Experimental results showed significant improvements in household energy efficiency, including reduced electricity consumption, lower monthly electricity costs, and decreased peak load demand. The system also demonstrated high monitoring accuracy and helped users develop more energy-efficient behaviors. Overall, the ENERGYSAVE system provides an effective and practical solution for smart home energy management and supports sustainable electricity consumption. Future improvements may include the integration of machine learning and renewable energy technologies for more advanced energy optimization.

Adabiyotlar, References, Литературы:

1. Decree of the President of the Republic of Uzbekistan No. PD-6079 of October 5, 2020. "Digital Uzbekistan — 2030" Strategy. Tashkent: Administration of the President of the Republic of Uzbekistan.
2. Cabinet of Ministers of the Republic of Uzbekistan (2025). Resolution on Electricity Tariffs. Tashkent.
3. National Electric Grid of Uzbekistan (Uzbekenergo, 2024). Annual Report. Tashkent: Uzbekenergo.
4. International Energy Agency — IEA (2024). Uzbekistan Energy Profile. Paris: IEA Publications. URL: https://www.iea.org/countries/uzbekistan
5. World Bank (2024). Energy Efficiency in Central Asia: Uzbekistan Case Study. Washington D.C.: World Bank Publications.
6. Sadiku, M.N.O. (2014). Fundamentals of Electric Circuits, 5th ed. New York: McGraw-Hill Education.

7. Cengel, Y.A., Boles, M.A. (2014). Thermodynamics: An Engineering Approach, 8th ed. New York: McGraw-Hill.