Title:

Promoting Real-Time Clean Energy Adoption Through Time-of-Day Optimization Tariffs Using Lightweight Neural Networks

Synopsis:

This research aims to develop a software-based energy management solution for small businesses and households under Time-of-Use (ToU) tariff systems. The project uses lightweight artificial neural networks (ANNs) to predict when low tariff is imposed due to clean energy production, and prompt usage of high energy appliances during this time.

The proposed system aims to:

1. Predict energy demand and pricing windows using simplified neural networks with minimal computational requirements.

2. Provide real-time notifications to users, prompting them to schedule high-energy appliances during low-tariff periods, thus ensuring clean energy usage

Features to Explore:

Lightweight ANN Architecture: Instead of deep or complex networks, use shallow models that are easy to train and deploy.

Historical Data Analysis: Implement basic data preprocessing and pattern detection using Python libraries like NumPy, pandas, and scikit-learn.

Real-Time Notifications: Use tools like Python Flask or Django to deliver alerts via mobile or web apps.

Behavioural Insights: Include basic analytics to track user responses and adjust future recommendations.

Relevant Research Papers

1. "Analysis of Variability in Electric Power Consumption: A Methodology for Setting Time-Differentiated Tariffs"

This paper explores methodologies for identifying time intervals suitable for implementing ToU tariffs. It uses k-means clustering and other data analysis techniques. The authors acknowledge that user-specific consumption behavior is not fully explored, which could make predictive systems less personalized. Potential improvement: Include advanced predictive analytics for user-specific recommendations.

Source: https://www.mdpi.com/1996-1073/17/4/842

2. "Time-of-Use Tariff Design Under Uncertainty in Price-Elasticities of Electricity Demand"

This paper focuses on using stochastic optimization to design ToU tariffs. A limitation is its reliance on static price-elasticity models, which may not accurately reflect real-time user behavior or integrate adaptive learning. Potential improvement: Incorporate real-time feedback systems with adaptive machine learning to dynamically refine elasticity models.

Source: https://ieeexplore.ieee.org/document/6509446

3. "Energy Forecasting: A Review and Outlook"

This comprehensive review highlights various energy forecasting models and emphasizes the difficulty of integrating prediction accuracy with usability. The paper suggests further exploration into hybrid models combining machine learning with traditional statistical techniques. Potential improvement: Develop lightweight hybrid forecasting models to enhance real-time decision-making in ToU applications.

Source: https://ieeexplore.ieee.org/document/9218967

Peer-review:

**1. "A Review of Research on Building Energy Consumption Prediction Models Based on Artificial Neural Networks"**

**Key Points: This paper discusses the use of artificial neural networks (ANNs) to predict energy consumption patterns. It emphasizes the effectiveness of ANNs but highlights challenges in model parameter optimization, high computational demand, and large data requirements.**

**Limitation: Existing models are often complex, making them unsuitable for small-scale applications like households.**

**Our Project's Contribution: Develop a lightweight ANN model that reduces computational requirements and focuses on real-time ToU optimization for household energy management.**

**2. "Energy Demand Forecasting Models for Optimizing ToU Tariffs"**

**Key Points: The study applies machine learning for energy demand forecasting and recommends ToU tariff schedules. However, the model relies heavily on large, clean datasets.**

**Limitation: Dependency on extensive data collection makes implementation in smaller setups or regions without advanced infrastructure impractical.**

**Our Project's Contribution: Use smaller, publicly available datasets to train a simplified predictive model that performs well in resource-constrained environments.**

**3. "Real-Time Energy Consumption Feedback for User Behavior Optimization"**

**Key Points: This paper explores feedback systems to influence user behavior toward energy-saving practices. Real-time feedback improves energy efficiency but does not integrate predictive analytics.**

**Limitation: Lack of predictive analysis limits the system's ability to inform users in advance, reducing its effectiveness for ToU planning.**

**Our Project's Contribution: Integrate predictive analytics to inform users ahead of time, allowing them to plan energy-intensive tasks during low-tariff periods.**

**4. "Integration of Demand Response and Renewable Energy in Smart Grids"**

**Key Points: Examines the challenges of integrating renewable energy with demand response systems. Predictive modeling is used to balance demand and supply but requires real-time updates and constant fine-tuning.**

**Limitation: Over-reliance on hardware and grid-level infrastructure, which is not viable for household-level applications.**

**Our Project's Contribution: Focus solely on software-based, user-level energy management without requiring hardware integration, making it more accessible.**