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An Energy Based Consumption Alarm Model for Improved Energy Utilization of Power Grids in Smart Cities

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Towards maximizing energy utilization in smart cities, there are number of methods being recommended by the researchers in literature. The scarcity of electricity requires proper utilization of energy and the methods consider the few activities of the consumer in producing alarms. However, the methods are not efficient in finding the overconsumption lines and produces poor performance in energy utilization. To solve this issue, an Energy based Consumption Alarm Model (ECAM) is presented in this paper. The model tracks the behaviors of electric power usage by different consumers and by monitoring their time line in using them, the method identifies the improper usage of electricity and produces alarm to the consumer. To perform this, the method categorizes the devices in consumer line and by analyzing the timeline of usage, the method estimates the Energy Utilization Factor (EUF) for the consumer line and devices. Based on the value of EUF, the method produces alarm to the consumer to restrict the usage of electricity. The proposed method improves the performance of energy utilization and improves the performance of smart grids.

Keywords: Smart Cities, Energy Utilization, ECAM, EUF, Smart Alarm.

1. Introduction

The human society utilizes the electricity for various works they perform every day. It has been identified as the essential source for the human life. However, the electric power is the highly scarcity one as the source to produce the electricity is limited. In general, the electric power has been produced from solar, thermal, atomic and wind sources. Whatever the source, the power generation organizations suffer to spend huge money on the production of electricity. They also spends huge amount in the installation of the units and for the environment. This increases the requirement of using the electricity for the highly needed one and the utilization of the electricity must be a perfect one.

As the human society spends much electric power for various works, it cannot be restricted from using the electricity but it must be a meaningful one. For example, there are situations where the consumer would consume electricity for unnecessary activities and there are cases where the electric device would be running anonymously. It produces waste of electricity and it must be avoided to improve the utilization. So that, the improper use of electricity should be reduced and avoided.

On the other side, the consumer would consume higher electricity units without knowing the consumption. As the electricity has been billed in various ranges, it is necessary for the consumer to know about the consumption. By providing enough information about the consumption of electricity, the user or the consumer would be aware of restricting the usage. By providing set of alarms and notifications, the consumer can be informed about the use of electricity which in turn would improve the performance of energy utilization[4]. With this consideration, an efficient an Energy based Consumption Alarm Model (ECAM) is presented in this paper. The model tracks the behaviors of electric power usage by different consumers and by monitoring their time line in using them, the method identifies the improper usage of electricity and produces alarm to the consumer. To perform this, the method categorizes the devices in consumer line and by analyzing the timeline of usage, the method estimates the Energy Utilization Factor (EUF) for the consumer line and devices [19]. Based on the value of EUF, the method produces alarm to the consumer to restrict the usage of electricity. The detailed working of the model has been sketched in the next section.

2. Related works:

Several ways have been developed to address the issue of consumer notification and alerts. The techniques are thoroughly examined in this section.[1] presents a comprehensive analysis of the progress made in building a robust power infrastructure in smart cities. The model examines multiple aspects of power distribution and proposes potential pathways for urban power grid networks. An in-depth analysis is conducted on the many approaches available to address the distinct power requirements of the urban sector. The paper [15] provides a comprehensive examination of the energy requirements, supply, distribution, and management of smart cities [25]. The author analyzed multiple elements related to energy demand, the availability of supply chains, and issues pertaining to management. Based on all of these aspects, the author suggested an effective distribution model to facilitate power regulation in smart cities[16]. In [3], a learning surrogate model (JCC-OPF) is introduced. This model transforms joint chance constraints into quantile-based representations. The approach employs a multi-layer perceptron network for power distribution. The network's neurons are responsible for implementing diverse limitations to monitor and quantify the power needs of a given area in order to facilitate efficient power distribution[27].The paper [4] introduces a control technique called Hydrogen Refueling Service Fee (HRSF) to assist in the selection of hydrogen refueling stations for Hydrogen Fuel Cell Electric Vehicles (HFCEVs). The choice of the station is determined based on certain parameters such as the remaining energy[13]. The paper [22] introduces a voltage control strategy that employs a multi-agent distributed approach. This system utilizes the proximal Jacobian alternating direction method of multipliers (PJ-ADMM) for power distribution. The agents are utilized to gather diverse info regarding the remaining energy in different units at hand, and based on that, the approach carries out power distribution and modifies the vehicle's heading[5].The paper [18] introduces a multi-agent reinforcement learning model aimed at optimizing electricity distribution in smart cities. The technique employs geographical and temporal characteristics in power distribution. The agents are utilized to gather diverse spatial and temporal data from several grid locations within the smart cities. This data is utilized to assess the needs of the city and facilitate efficient electricity distribution.The integration of cloud computing with a combination of Recurrent Neural Network (RNN) and Long Short-Term Memory (LSTM) is applied to address the problem of electricity distribution [7]. The LSTM model is employed to quantify the energy demand of urban areas[11]. The paper [20] presents the process of modifying a sensor network for power distribution. In [24], a service architecture based on containers is introduced. This design employs virtual dedicated agents, sometimes known as digital twins, for each smart meter on the user side. The purpose of this approach is to enhance power distribution efficiency. An efficient two-step approach for state estimation in multi-feeder radial distribution grids is provided in reference [10].In [21], a distributed self-triggered algorithmic solution is described for the regulation of frequency restoration and active power sharing in islanded microgrids. The self-trigger model analyzes the frequency and use of electricity and automatically activates to assist in power distribution. A hybrid model, called IMRFO-TS, is introduced in reference [24]. This model combines the Improved Manta Ray Foraging Optimization (IMRFO) with the Tabu Search (TS) method to address the UAV placement problem in a smart city. In [13], a Dirichlet process mixture model (DPMM) is introduced as a means to address the uncertainty associated with load patterns. All of the aforementioned methods struggle to reach optimal performance in energy usage and regulation[23].

3. Methodology:

Energy based Consumption Alarm Model (ECAM):

The proposed energy based consumption alarm model (ECAM) works based on the behavior of the consumer[9]. The model tracks the behaviors of electric power usage by different consumers and by monitoring their time line in using them, the method identifies the improper usage of electricity and produces alarm to the consumer. To perform this, the method categorizes the devices in consumer line and by analyzing the timeline of usage, the method estimates the Energy Utilization Factor (EUF) for the consumer line and devices[2]. Based on the value of EUF, the method produces alarm to the consumer to restrict the usage of electricity[24].

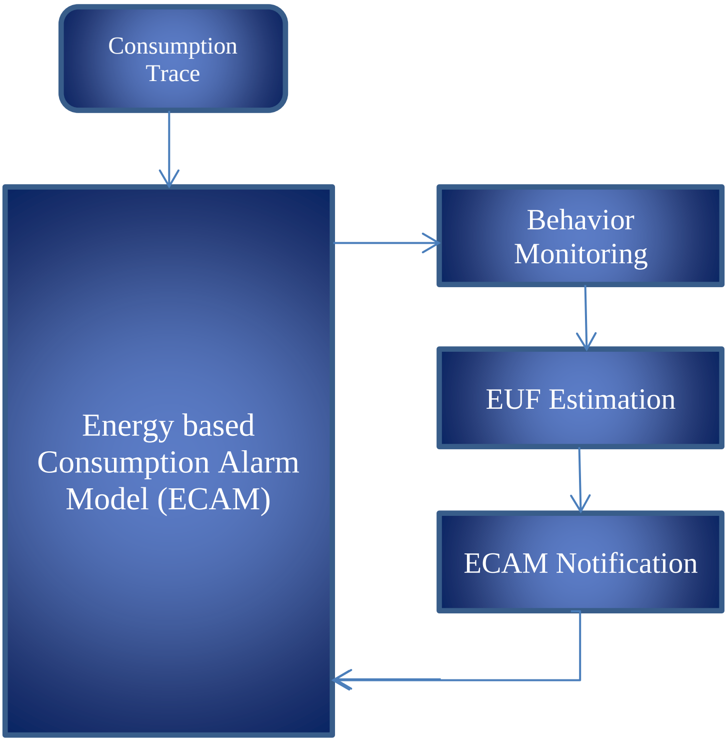

Figure 1: Architecture of ECAM Alarm Model

The architecture of proposed ECAM alarm model has been presented in Figure 1, and the functions of the model is presented in detail in this section.

Behavior Monitoring:

The proposed model monitors the individual connections of the power system. The consumer behavior in electricity consumption has been monitored throughout the day. The user connection has been monitored for the use of electricity. At each time stamp, the average electric usage is measured in terms of EUF (Electric Utilization Factor). According to the value of EUF, the method produces alarm with the ECAM Notification.

Algorithm:

Given: Behavior Trace BT, User Connection Uc

Obtain: Null

Start

Read BT and Uc.

Initialize Fvs.

While true

User Trace UT = $\left(\sum_{i=1}^{size(BT)} BT(i).ConnectionId == Uc\right)$

At each time stamp T

EUF = Perform EUF Estimation (UT)

If EUF>Th then

Perform ECAM Notification.

End

End

Stop

The behavior monitoring function collects the traces of user connection and at each time stamp, the method measure the EUF value and produces alarm accordingly.

EUF Estimation:

The electricity utilization factor is the measure which represents the usage of consumer in consuming the electricity. It has been measured based on the average usage of electricity in various time stamp and current usage value. Estimated EUF has been used to perform ECAM notification.

Algorithm:

Given: User Trace UT.

Obtain: EUF

Start

Read UT..

Compute EUF =

$$\frac{\sum_{i=1}^{size(Ts)} \left(\underset{j=1}{\overset{size(UT)}{Sum}}(UT(j).Consumption\ ?UT(j).Time==Ts(j)) \Big/ \underset{j=1}{\overset{size(UT)}{Count}}(UT(j).Time==Ts(j)) \right)}{\underset{j=1}{\overset{size(UT)}{Sum}}(UT(j).Consumption\ ?UT(j).Time==Current\ Time) \Big/ \underset{j=1}{\overset{size(UT)}{Count}}(UT(j).Time==Current\ time)}$$

Stop

The proposed approach measure the EUF value for any consumer connection according to the behavior of the user. Estimated value of EUF has been used to produce alarm to the user.

ECAM Notification:

The proposed model monitors the behavior of user in utilizing the electricity. At each time stamp T, the method computes the value of EUF for the user connection. According to the value of EUF, the method produces alarm to the user about the higher usage of electricity.

4. Results and Discussion:

The Energy based Consumption Alarm Model (ECAM) has been constructed and assessed to assess its efficacy under different restrictions[6]. The outcomes generated by the model have been compared to the outcomes of other methods.

Table 1: Experimental setup

Fact	Value
Tool Used	Matlab
No of connections	2000
Time	24 hours
Number of trace	1 million

The experimental setup considered for the performance evaluation of proposed method is presented in Table 1.

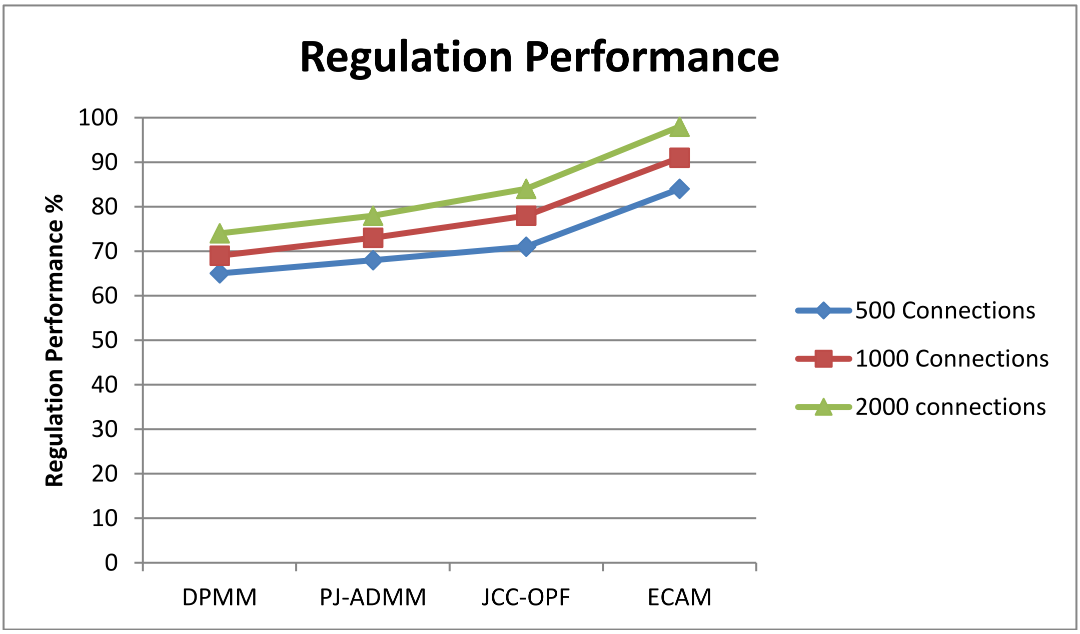

Figure 2: Regulation Performance

Figure 2 compares and measures the performance attained by different models in regulation. The proposed ECAM model outperforms existing models in terms of performance. The efficacy of energy regulation is assessed based on the quantity of connections. Without exception, the proposed ECAM model has consistently demonstrated superior performance compared to alternative models.

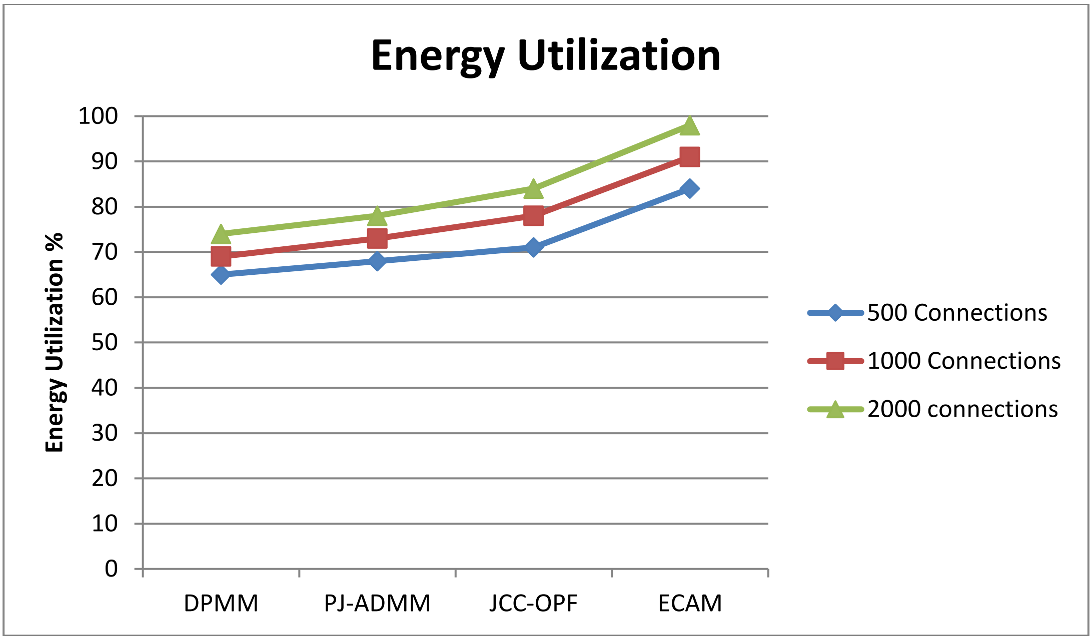

Figure 3: Energy Utilization Performance

The energy utilization performance has been quantified and displayed in Figure 3. The ECAM model proposed demonstrates superior energy usage compared to alternative approaches[12]. The energy efficiency of approaches is quantified based on the quantity of connections inside the network. The proposed ECAM model consistently outperformed alternative techniques in all circumstances.

5. Conclusion:

This paper presented a novel energy based consumption alarm model (ECAM) works based on the behavior of the consumer. The model tracks the behaviors of electric power usage by different consumers and by monitoring their time line in using them, the method identifies the improper usage of electricity and produces alarm to the consumer. To perform this, the method categorizes the devices in consumer line and by analyzing the timeline of usage, the method estimates the Energy Utilization Factor (EUF) for the consumer line and devices. Based on the value of EUF, the method produces alarm to the consumer to restrict the usage of electricity. The proposed method improves the performance of power regulation and energy utilization.

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