International Journal of Future Generation Communication and Networking
Vol. 13, No. 4, (2020), pp. 1472–1480

Implementation of IOT Based Smart Energy Management System in College Campus

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Abstract

This paper deals with an implementation of an intelligent energy management system in college campuses. This system has a simple way to perform supervision processes anywhere in college. This method operates on real-time monitoring parameters such as current, voltage, power and power factor by recognizing energy use at every moment of time and generates daily consumption reports displayed on the web portal page and an SMS alert. The proposed program observes the values that are continuously stored in the cloud and controlled through cell phones or computers in real time. This intended method recommends replacing conventional electrical devices with energy-saving devices in order to fulfil the electricity consumption and optimum system execution. The implied system's achievement is confined via the Thingspeak server. The suggested smart devices reduce energy consumption by around 46.64%, reduce expenditure by 30.6% and increase system power factor by about 10 % to 20%.

Keywords: *IoT, Arduino, Energy audit, Energy conservation, Thingspeak server, College campus.*

1. Introduction

Electricity is a prominent significance to a country's economy and directly associated per capita energy consumption. The day-to-day growing population and extension of industries succeed in increasing energy requirements [1]. Energy audit and energy conservation measures can reduce energy demand or per capita energy consumption. [2] - [4]. An energy audit is interpreted from evaluation, examination, and review of energy flow in any system to diminish the amount of energy without disturbing the output. This process requires a wide estimation exercise such as data collection, data investigation, and the association of the energy-saving potential of the system [5].

Energy inspection is a critical process for enhancing the organization's energy efficiency and modern facilities [6]. Such inspection processes therefore make time-consuming and costly [7] - [8]. Energy saving is attained by the detection of wasted energy, the recognition of unwanted resources and inadequate system ratings. The overall aim of energy-saving is to reduce power consumption but not alter output quantity and efficiency [9] - [10]. Intelligent energy-saving tools have been the right approach for reducing the difference between energy spending and producing electricity [11]. It reduces advantages in electricity usage, fuel shortage, saves fuel supplies, the ability to overcome environmental pollution, and changes are effective security [12]. There is a growing need for autonomy in digital technologies, and the smart machine operates with less human interference and better technology for decision making [13]. This study consequently designed a smart energy monitoring and control system

ISSN: 2233-7857 IJFGCN

based on IoT for the campus. This device has an important impact on cutting energy costs to manage the office and industries conveniently.

2. Proposed System Description

The central power supply connects or otherwise unlocks it via the relay. The controller has been conFigureured with multiple sensors for monitoring and measuring parameters like current, voltage, electricity, and device temperature. Such data will be stored in the cloud and smartphones will be connected to the Arduino controller to send a text message employing a max of 232 devices and GSM. At any moment, the Atmega controller senses the energy usage of several types of equipment inside the network into the cloud through the Wi-Fi module.

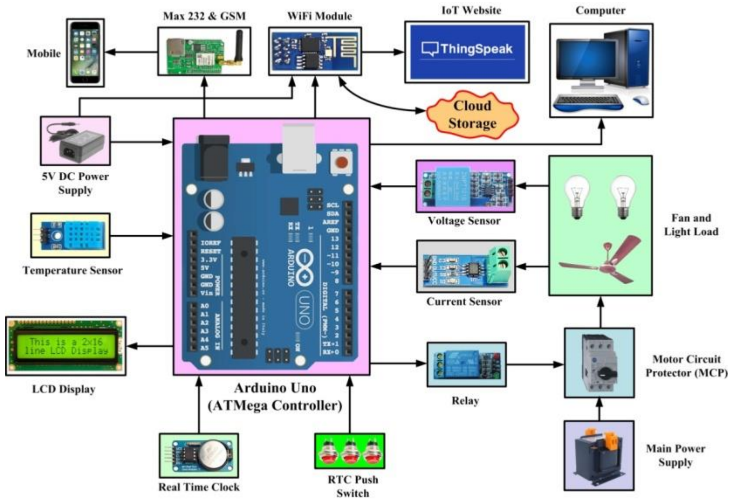

Figure 1: IoT based Smart Energy Management System

The examination continues on the computer using the web information collected. The system for smart energy management used many parts that are shown in Figure. 1. Several instruments such as temperature sensors, current sensors and step-down transformers were used in the process to calculate parameters of temperature, load-current and load-voltage. This structure represents the overall daily energy consumption summarized for the recommendations for the online portal and the text message. This report will additionally estimate the overall monthly energy expenditure.

Automatic ON and OFF functions of light and fans are established more at the control center. This includes a high timing / energy-based approach using the system of automated supply management by the user feedback. The control scheme for the synchronization of connected structures inside of the controller is shown in Table 1. The real-time clock of the Arduino Uno controller is used as time control. The RTC push switch regulates the user schedule. The connected systems are routinely monitored by relays, appropriate programming needs. The systems are controlled using smartphones throughout the campus.

Table 1: Scheduled control of the devices

Turn ON Time	Turn OFF Time
8.45 am - 10.45 am	10.46 am -11.00 am
11.00 am - 01.00 pm	01.01 pm - 01.59 pm
02.00 pm – 05.00 pm	05.51 pm - 8.44 pm

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3. Analysis of Devices in College Campus

The power ratings of the devices vary from 5W to 3000W based on requirements. The lamp and fan load are employed in each department as tabulated in Table 2. The several electrical devices are operated on the college campus as stipulated in Table 3.

Table 2: Light and fan loads in each department

Department	No. of lamps in Each Floor			No. of Fans in Each Floor		
Floor	Ground	First	Second	Ground	First	Second
Main Block	120	112	90	110	98	82
Computer Science	61	8	10	16	4	11
Mechanical	45	11	177	38	9	119
Electrical	48	53	71	33	34	60
Civil	85	35	-	81	42	-
Electronics	102	-	-	68	-	-
Science & Humanities	140	80	152	32	30	68

Table 3: Devices used in each department

Device	**Minimum Rating (W)**	**Maximum Rating (W)**
LED	7	10
CFL	15	30
Ceiling fan	25	75
Desktop computer	80	200
Projector	200	350
Inverter AC	1200	1800
Centralized AC	2000	5000
UPS	400	500
Printer	80	100
Scanner	10	20
Laptop	20	75
Lift	800	1200
Water doctor	100	300
Television	120	150
Lab components	5	3000

4. Detailed Analysis of Energy Audit

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Energy consumption plus the measurement of the required rate structure is based mostly on electricity bills received for the campus from December 2018 through December 2019. It involves a thorough investigation only with operators further providing quite a better assessment of the changes in daily and annual energy costs and needs.

Tamil Nadu's electricity has set a 292 kVA, and Table 4 indicates the value of energy spending.

Table 4: Energy consumption ratings

Consumption Parameters	Energy consumption rate (Rs. per unit)
Industrial	6.35
Peak hour	1.27
Night hour (5% rebate)	0.3175
Commercial	8.05
Demand charges	350 per kVA
Power factor	0.96 to 0.98

4.1. Analysis of Energy Auditing

Eighty percent of the electrical components used on campuses are primarily lamps and fans of different department. The energy-saving system helps the traditional equipment to save money and replace the required fans and lights in cost-efficient ways. Using a single lamp and fan energy the total energy consumption of all the lights and fans connected to the device has been measured.

4.2. Analysis of Utility Bill for Lamp

The power rating of the lamp = 40 Watts

Energy consumed by the lamp/hour = 40 W × 1 hr × 0.88= 35.2 Whr

Energy consumed by the lamp/day = 40 W × 7 hr × 0.88= 246.4 Whr

Total number of lamps in college = 1541

Total no. of lamp consumed energy/hour = 1541× 35.2 = 54243.2 Whr

Total no. of lamp consumed energy/day = 54243.2 × 7 = 379702.4 Whr

Total no. of lamp consumed energy/day = 379702 / 1000 = 379.7 units

4.3. Calculation of Energy and Money for Main Block Lamps

Total no. of the lamp in the main block = 322

Total watts consumed = 322×34 = 10948 W

Total usage timing/day =10 hours

Total usage time annually = 10×140 = 1400 hours

Total watts annually = 10948×1400 = 15.327MWhr (15327 units)

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Total cost annually = 15327×8 = Rs. 122616

Replacing the conventional CFL lamp by LED lamps

Saved units of power = 15327-8114 = 7213 units

Saved money = 122616 - 64912 = Rs. 57,704

4.4. Payback Period for Lamp

Cost of 1 LED (18 W) = Rs. 570

Cost of 322 LEDs = 322×570 = Rs. 1,83,540

Labour charge = Rs. 10,000

Recover period = 1,93,540 / 57,704 = 3.35 years

4.5. Analysis of Utility Bill for Fan

The power rating of the fan = 75 Watts

Energy consumed by the fan/hour = 75 W×1 hr = 75 Whr

Energy consumed by the fan/day = 75 W×7 hr = 525 Whr

Total number of fans in college = 860

Total no. of fans consumed energy/hour = 860×75 = 64500 Whr

Total no. of fans consumed energy/day = 64500 ×7 = 451500 Whr

Total no. of fans consumed energy/day in units = 4,51,500 / 1000 = 451.5 units

The total amount of units consumed by the lights and fans/day = 831.2 units.

4.6. Calculation of Energy and Money for Main Block Fans

Total no. of fan in main block = 291

Total watts consumed = 291×75 = 21825 W

Total usage of timing/day = 10 hours

Total usage of time annually = 10×140 = 1400 hours

Total watts annually = 21835×1400 = 30.569 MWhr

Total units consumed annually = 30569 units

Total cost annually = 30569×8 = Rs. 244552

Saved units of power = 30569 – 14259 = 16,310 units

Saved money = 244552 – 114072 = Rs. 1,30,480

4.7. Payback Period for Fan

Cost of a fan (35W) = Rs. 3,570

Cost of 291 fans = 291×3,570 = Rs. 10,38,870

Labour charge = Rs. 14,550

Recover period = 10,53,420 / 1,30,480 = 8 years

Saved units of power = 15327-8114 = 7213 units

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Saved money = 122616 - 64912 = Rs. 57,704

The complete unit and money saved from lamps are Rs. 7,213, Rs. 57,704 and the playback or recovery period of the lamps around 3.35 years. The total unit and money saved from lamps are Rs. 16,310, Rs. 1,30,480 and the payback period of the fan around eight years. The prescribed light and fans help to reduce energy consumption and also the cost of the system resulting from the analysis component.

5. Suggestion and Recommendations

Even after fifty-thousand hours, the Led lighting can retain seventy percent of its light, and the CFL is dim after eight-thousand to ten-thousand hours. Hence, instead of CFL to LED light has been suggested. In addition to an efficiency factor needed to produce the intensity of the light, both CFL and Led lamp output is nearly identical. The comparative analysis of illumination of LED and CFL lamp is shown here in Table 5.

Table 5: Brightness comparison of LED and CFL lamp

Lumens (Brightness)	LED (Watts)	CFL (Watts)
400 – 500	6 – 7	8 – 12
650 – 850	7 – 10	13 – 18
1000 – 1400	12 – 13	18 – 22
1450-1700	14 – 20	23 – 30
Above 2700	25 – 28	30 – 55

Brushless DC motor mounted super fans can replace AC motor in ceiling fans, such fans are 40-50 percent lower rated power but it can provide comparable ventilation. The 30W super fans are about equal to the traditional fan's 75W power consumption. The analysis of the conventional and super fan regulator role as shown in Table 6 results in a substantial amount of power-saving. Table 7 describes the recommended practice for reducing energy expenditure and costs.

Table 6: Ceiling fan versus super fan

Regulator position	Super fan (Watts)	Ceiling fan (Watts)
1	6	16
2	10	27
3	14	45
4	19	55
5	28	75

Table 7: Recommendation for energy-saving devices

S.No.	Conventional device	Recommended device
1.	Induction Ceiling fans	Supers fans

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2.	Conventional ballast	Electronic ballast
3.	Incandescent and fluorescent lamps	CFL and LED lamps
4.	Geysers	Solar water heating system
5.	CRT monitor	LCD monitor
6.	CRT based television	LED/LCD television
7.	Induction motors	Energy-efficient motors
8.	Improper rating of the device	Exact rating of the device
9.	Resistance based iron box	Steam iron box

6. Hardware Description

The design of the proposed structure is shown in the Figure 2 (a) for monitoring devices tied directly to the IoT on-campus platform. The configuration is installed either with a single or a three-phase supply. The processor is linked to the parameter recording and observing Thinkspeak server. The elements of the current scheme have been included in Figure 2 (b) and the structures are being controlled either by hand or wirelessly.

Figure 2: (a) Prototype model (b) Components of the proposed system

7. Result and Discussion

The present, voltage, power, power factor, and temperature parameters can be periodically monitored. These data will be stored in a server that can be analyzed on Thingspeak server as shown in Figure 3.

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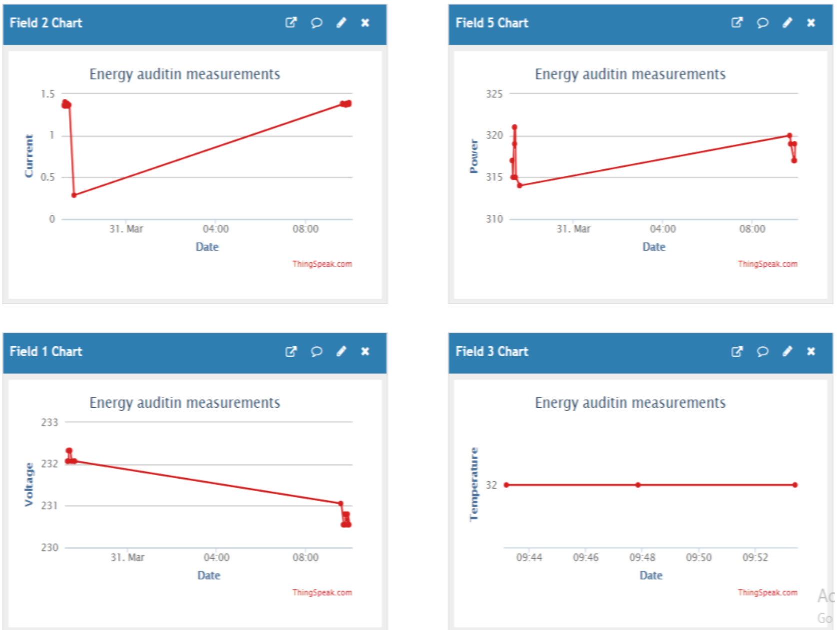

Figure 3: Measurement of voltage, current, power, and temperature

The consumption of energy and cost from December 2018 to December 2019 is shown in Figure 4(a). It is observed that period of February to April the energy consumption is high due to workshops and fests conducted in various departments and cultural activities. Similarly, energy consumption is very high during September month due to inauguration functions. The suggested method increases the power factor shown in Figure 4(b) almost 10 to 20 percent.

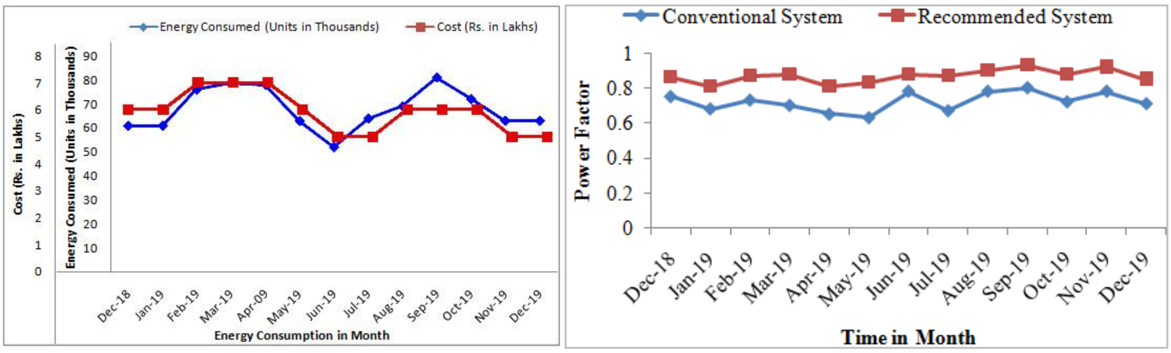

Figure 4: (a) Energy consumption in a year (b) Power factor of the recommended devices

8. Conclusion

Energy audits have been performed on to the campus through different departments. From each instant, the data were collected within cloud and decided the energy consumption. The method has been routinely observed with different tools and suggestions for reducing energy consumption and prices have been suggested. The analysis inferred that the LED lights and super-fans became a smarter method for decreasing energy consumption. The connected devices have been automatically controlled and can be controlled either inside or outside the campus using mobile phones. Hence, the need for more intellectual resources was reduced. The suggested system presents a strong indication of energy expenditure, although on the campus energy crisis. The recommended devices provided an energy reduction of approximately 46.64 percent, cost reduction of 30.6 percent, and enhanced the system power factor by 10 to 20 per cent.

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References

[1] A. Kluczek and P. Olszewski, "Energy audits in industrial processes", *Journal of cleaner production*, Vol. 142, pp.3437-3453, 2017.

[2] D.Chiaroni, V.Chiesa, S.Franzo, F.Frattini, and V.M.Latilla, "Overcoming internal barriers to industrial energy efficiency through energy audit: a case study of a large manufacturing company in the home appliances industry", *Clean Technologies and Environmental Policy*, Vol.19, No. 4, pp.1031-1046, 2017.

[3] A.Chakraborty, D.Dey, and P.Das, "Investigation of Energy Consumption and Reservation Scheme using Energy Auditing Techniques", in *IEEE International Conference on Smart Systems and Inventive Technology*, pp. 34-38, 2018.

[4] R.P.Zanardo, J.C.M.Siluk, F.de Souza Savian, and P.S.Schneider, "Energy audit model based on a performance evaluation system", *Energy*, Vol.154, pp.544-552, 2018.

[5] S.S.Chandel, A.Sharma, and B.M.Marwaha, "Review of energy efficiency initiatives and regulations for residential buildings in India", *Renewable and Sustainable Energy Reviews*, Vol.54, pp.1443-1458, 2016.

[6] Getu, B.N. and Attia, H.A, "Electricity audit and reduction of consumption: campus case study", *International Journal of Applied Engineering Research*, Vol. 11, No.6, pp.4423-4427, 2016.

[7] D.Lee, and C.C.Cheng, "Energy savings by energy management systems: A review", *Renewable and Sustainable Energy Reviews*, Vol.56, pp.760-777, 2016.

[8] N.Beniwal, A.E.Lyngwa, and M.P.Mohan, "Energy Conservation and Management Practises", 2017.

[9] S.O.Oyedepo, J.O.Dirisu, O.S.I. Fayomi, E.E.Essien, and U.K.Efemwenkiekie, "Energy evaluation and conservation strategies for a Nigerian private college facilities: Case analysis of energy audit of Covenant University", in *AIP Conference Proceedings*, Vol. 2190, No. 1, pp.020080, 2019.

[10] A.Mathur, and S.A.Muthukumaraswamy, "On the enhancement of building energy conservation using energy auditing", in *IEEE International Conference on Intelligent Sustainable Systems*, pp. 720-724, 2017.

[11] A.Arya, P.Arunachalam, L.Ramesh, V.Ganesan, and H.Egbert, "Energy usage analysis of industries with ETAP case study", in *IEEE International Conference on Circuit, Power and Computing Technologies*, pp. 1-7, 2017.

[12] M.Prathik, K.Anitha, and V.Anitha," Smart Energy Meter Surveillance Using IoT", in *IEEE International Conference on Power, Energy, Control and Transmission Systems*, pp. 186-189, 2018.

[13] S.Karthikeyan, and P.T.V.Bhuvaneswari, "IoT based real-time residential energy meter monitoring system", in *IEEE Trends in Industrial Measurement and Automation*, pp. 1-5, 2017.

[14] M.O.Agyeman, Z.Al-Waisi, and I.Hoxha, "Design and Implementation of an IoT-Based Energy Monitoring System for Managing Smart Homes", in *IEEE International Conference on Fog and Mobile Edge Computing*, pp. 253-258, 2019.

ISSN: 2233-7857 IJFGCN