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Energy Conservation through Smart Building and Smart Lighting System

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----------ABSTRACT----------

Energy conservation is an extensive topic due to the propagation of electricity demand and challenges globally and is regarded as one of the most significant issues affects the power system quality, global environment and consumers. Smart building is a technology that can connect everything to networks or systems to monitor and control them in various areas such as offices, energy-consuming devices especially in laboratories, security devices etc. Nevertheless, people's perception about using smart technology for energy saving is still in the mind's eye. This means that people discuss about environmental awareness readily. Due to the availability of electricity and its elemental role, regulating consumers' behaviours towards power savings can be a challenge. Remarkably, the gap in today's smart technology design in smart buildings is the compassionate of consumers' attitudes and the merging of this perspective into the smart technology. Implementation of PLC based controlling system is a convenient method to save the power and energy strategy for whole building. Furthermore, prepare a lighting scheme can results a rapid response in energy conservation. Consequently, PLC Automatic system removes the human intervention which makes the process smart and energy reduction will gives benefits to the consumers in terms of reducing the cost of electricity bills. Nonetheless, contemporary buildings' energy conservation has been significant solution to cope with the rising electricity necessity.

INDEX TERMS: *Smart building automation, PLC smart system, Smart lightening system.*

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I. INTRODUCTION

Buildings throughout the world consume a major amount of energy, which is more or less one-third of the total initial energy resources. Smart buildings use communication technologies (ICT) and information to enable the control and operations of automated building. Building Automation is the centralized automatic control of a building's power, heating, ventilation and air conditioning, lighting and other systems through a building automation system (BAS) like PLC or building management system. Programmable Logic Controllers or PLCs are broadly used in the automation of different processes throughout the industry so by implementing a PLC based automation system. It can be easily guaranteed a long life system plus the ease of programming allows further enhancement and addition of extra appliances or increasing functionality of the system. In this paper, the parameters temperature and human presence are being discussed. The PLC continuously monitors these parameters and instantly executes the predefined subroutine to take mandatory action if any parameter triggers a threshold value. For example, if the temperature of the room increases beyond the set point, the PLC, upon sensing the trigger, turns on the fan and continues to keep it in on state until the temperature is lowered and brought within the set point value. Similarly, if the human enters or leaves the room, the lights of the room turns ON or OFF. In both cases the being conserved. The work covered in the under seen paper utilizes the PLC from LS corporation Korea, the PLC main unit used is XBM-DR16S, along with the main unit a temperature module namely FBs-TC6 is added in aid to address the temperature measurement through various sources.

II. LITRATURE REVIEW

Ashfaq Ahmed Baloch et.al 2017, studied different simulation tools for energy saving and building lighting systems. Various tools are used to conserve the energy according to respective models of smart buildings like Matlab, Energy Plus, Matlab-GUI (Graphical User Interface), Laboratory Virtual Instrument Engineering Workbench (LabVIEW), Design of Experiments (DOE), Daylight (Day SIM), Production System (CLIPS), Building Optimisation (BuildOpt). [1] Abhishek Bhati et.al 2017, implemented the smart building technology on the Singapore city, they covered that consumer's behavioural pattern about the energy saving, the gap on the technology designing and the maturity as it does not take perceptions and behaviours of people as part of functionality. The efficiency of smart home technologies is dependent on the artificial intelligence prototypes that allow the smart home system to interact smoothly with consumers. [2] Bin zhou et.al 2016, reviewed briefly on the functional modules and architecture of smart home energy management systems HEMS. The advanced HEMS infrastructure and home appliances in smart houses are thoroughly analysed [3].

Vahid Hosseinnezhad et.al 2016, gave idea about smart technology-based cities that have been furnished with various electronic devices based on Internet of Things (IoT), for making smarter than previous. The concepts of smart cities on their applications and motivations are being explored. Moreover, the IoT based technologies for smart cities and their features regarding components have been discussed. [4] A.S. Biradar et.al 2016, concluded from the existing research in the field of smart home and lighting systems that home automation can make a difference regarding renewable energy sources usage and better energy management. The design and implementation of system done by using three methods, RF remote control, motion sensor technology and Wi-Fi Router hand held to control of the selective home devices [5] Ahmed, S. Faiz et.al 2015, Energy Conservation and Management System", designed and implemented the Building Automation System, from which up to 30% to 40% of energy consumption can be minimized, which makes a huge difference for energy to conserve. For the sake of this efficient automation, Programmable Logic Controller (PLC) is employed as a main controller to monitor controlling appliances various system parameters as per required [6]

III. DEMERITS OF THE MANUAL BUILDING MAINTENANCE SYSTEM

- The light, once turned on, continues to remain on until turned off manually. If the light is on without purpose or during the day time, energy is continuously wasted.
- As the temperature of the environment decreases or increases, either because of over crowdedness or external weather, there is no proper system other than manual heating/cooling control to adjust the temperature change.
- Lack of automatic appliance control results in excessive and useless running, which decreases the useful life of the appliances in the system in the long run.

IV. PLC AUTOMATED SYSTEM MINIMIZES THE HUMAN ASSISTANCE

Automatic control or automation is the technology by which a procedure or process is performed with reduced human assistance. Automation is the use of various control systems for operating equipment such as machinery, heat treating ovens, processes in factories, stabilization and steering of ships, boilers, switching on telephone networks, aircraft and other processes in factories and other applications and vehicles with minimal human intervention. Some processes have been completely automated. For the building automation purpose, different types sensors are employed. The sensors tend to minimize the human involvement and hence the personal error is also decreased. The smart automated system shall monitor environment parameters particularly, defined by the type of sensors used, and adjust the operations of different subsystems in order to keep the values within the threshold points. PLC automation for the purpose of energy conservation is a well influenced subject all over the world. The special standards and equipments for Building energy conservation have been developed and research specific to this field ensures continued enhancement to the existing solutions.

V. DESIGNING & DEVELOPMENT OF AUTOMATED BUILDING MANAGEMENT SYSTEM

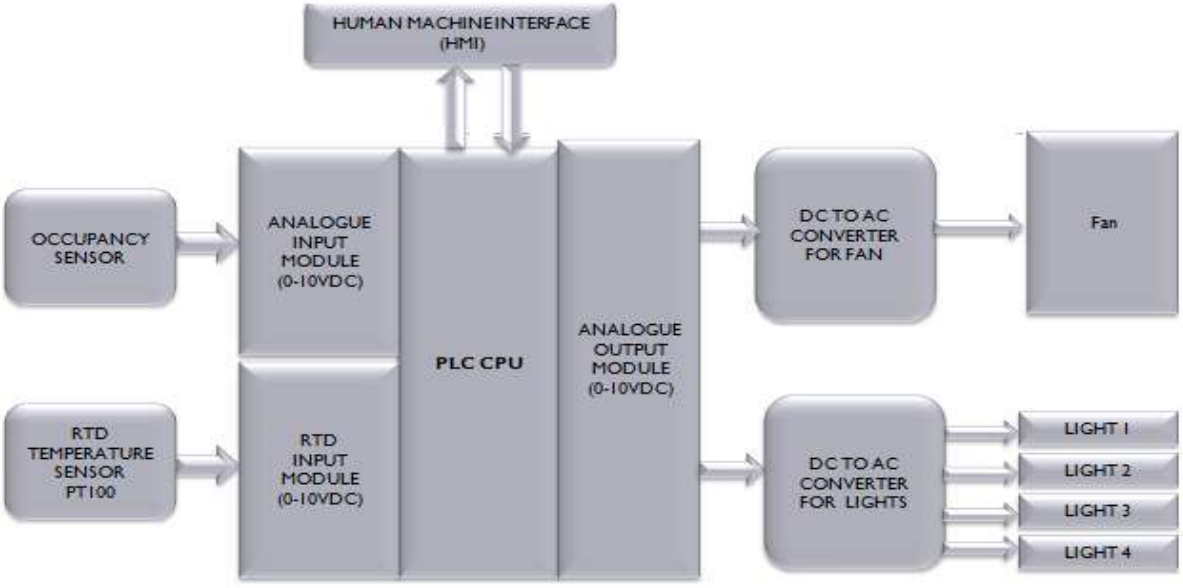

Fig1. BLOCK DIAGRAM OF SMART PLC SYSTEM

VI. PROGRAMMABLE LOGIC CONTROLLER (PLC) CONTROL SYSTEM

An industrial computer control system consists of HMI, PLC CPU, RTD Input module, Analogue input module, Analogue output module, AC to DC converter circuits. PLC CPU module is the computer's main brain control system that continuously observes the state of input devices and makes decisions based upon a custom program to control the state of output devices and also takes the data to and from the HMI. The HMI is a dashboard or use interface that connects a person to the system, device or machine.

RTD INPUT MODULE: It interfaces the RTD temperature sensor, this module converts temperature sensor resistance in to meaningful data (Arithmetic value) for the PLC CPU.

ANALOG INPUT/OUTPUT MODULE: It interfaces the Occupancy Sensor; this module converts (0-10V) Occupancy sensor voltages in to meaningful data (Arithmetic value) for the PLC CPU. Output module is used to interface the Analogue Output devices. This module converts meaningful data (Arithmetic value) from the PLC CPU. (0-10V) Voltages.

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DC TO AC CONVERTER FOR FAN AND LIGHTS: This module interfaces the AC load like Fan and lights, accepts the dc (0-10v) DC signal from the PLC and provides(0-220Vac)output voltages to AC loads and controls the switching.

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VII. TEMPERATURE AND MOTION DETECTORS

Resistance temperature detectors (RTDs), are temperature measuring sensors. The RTD wire is a pure material, typically nickel, platinum or copper. The material has an accurate resistance or temperature relationship which is used to provide an indication of temperature. PT100 is the most common type has a resistance of 138.4 ohms at 100°C and 100 ohms at 0°C and further have a resistance of 1000 ohms at 0 °C. An occupancy sensor (PIR) used to detect the presence of a person which controls temperature or lights or ventilation system. Human Beings radiate thermal energy of wavelength around 9-10 micro-meter every day. Passive Infrared Sensor (PIR) is an electronic device, designed to detect this IR wavelength when a human being is in its vicinity. A simple lens is used to have a wide range for detection. Sensors may also be calibrated in such a way so as to ignore domestic pets by setting a higher sensitivity threshold value, or by ensuring that the floor of the room remains out of focus.

VIII. EFFICIENT ALGORITHM FOR FAN ENERGY CONSERVATION

A good control algorithm is essential part for any efficient system. In this project a control algorithm is designed and implemented for efficient controlling of the fans and lights in such a way that throughout the system consumes minimum energy and gives maximum output. The algorithm first detects and check the presence of the persons in the room, if there is no existence of any person in the room then it will turns OFF the fan, If it found any person in that area then it turns ON the Fan, then according to the number of persons in the room algorithm PLC detects temperature change and control the speed of a fan without any human intervention As the temp increases the speed of the fan increases and vice versa. Occupancy sensor gives signal to the PLC to increase or decrease the No: of lamps (on/off) depending upon the requirement of light. If the lighting condition is low from some set threshold set value, this algorithm turn on more lights to satisfy the need of that place. Similarly, if there is no one present on certain area then it reduces or may be turn off all the lights. In this way this algorithm turns on and off lights as per requirement and no extra and unused lights utilize energy. In this way this simple but very efficient algorithm can save extra and wasted electrical energy and make our proposed system more efficient and optimal.

IX. RESULTS AND DISCUSSIONS

Power Consumption in Constant V/S Propotional System: The amount of power consumed in manual and automated system is conducted to highlight the significance of Building Automation in the purpose of Power consumption. A study comparing the experimental results clearly illustrated the amount of power saved after replacing the manual system with an automated one. The calculations and results are mentioned as under:

Constant Speed Control Mode: The rotation of the fan blades attached to the hub, make Cool air descends from the ceiling and circulates in the room because of the fan. This makes a fan very useful especially in hot weather. Normally we use fan in constant speed without depending upon the temperature change

Fig.2

AVERAGE CONSTANT POWER
P avg = 100+100+100+…….+100 / 10
P avg = 1000/10 = 100 watt

ENERGY CALCULATION
E=P*T
E=100*10
E=1000 WH or 1 kWH

Proportional Power Control Mode: As the temp increases the speed of the fan increases which cause increase in power of fan and vice versa

- PLC detects temperature change and control the speed of a fan without any human intervention
- As the temp increases the speed of the fan increases and vice versa
- As we know that speed depends upon to the voltage applied to the fan
- The power of the fan is given by a formula
- The load of fan depends upon current which is constant
- Occupancy sensor like gives signal to the PLC to increase or decrease the No: of lamps (on/off) depending upon the requirement of light

Fig.3

<u>Averagae Propotional Power Calculation</u>
P (avg) = 60+70+80+100+100+100+90+80+70 / 10
P (avg) = 840 / 10
P (avg) = 84 watt or 0.8 kW
<u>Energy Calculation</u>
E=P*T
E=84*10 = 840 WH
E=0.84 kWH

III. COMPARISON WITH OR WITHOUT SMART PLC PROPORTIONAL CONTROL

- At Normal Mode: The temperature is 35.4°C, fan's power is maximum i-e 100 watt means energy is being wasted
- At Proportional Mode: If the temperature reaches at 47.4°C, fan's power is controlled i-e 94.8 watt means energy is being saved
- As the temp increases the speed of the fan increases and vice versa but in proportional mode it is controllable.

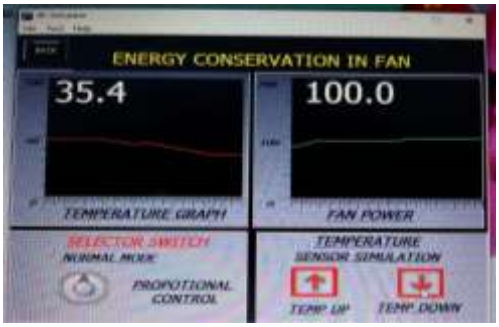

Fig.4

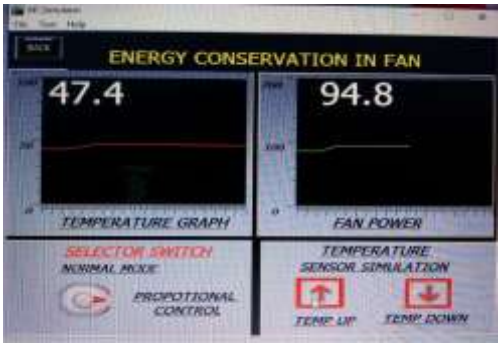

Fig.5

At Morning /Day Time

- At Normal Mode: The 1000 lumens of photocell showing 96-watt (total light power) i-e all four lights are ON which is wastage of energy. (Lumens is the measure of total amount of visible lights)
  At Proportional Mode: the 557 lumens of photocell showing 48 watt of light power which is controlled and two lights are ON i-e energy is being saved

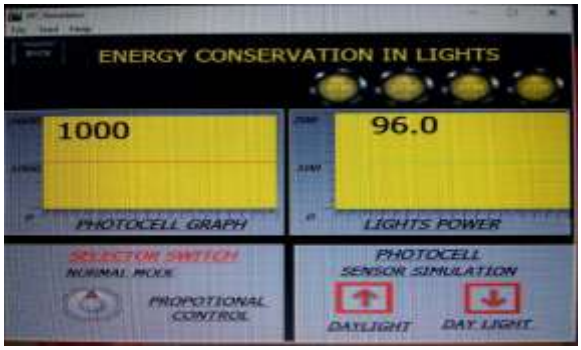

Fig.6

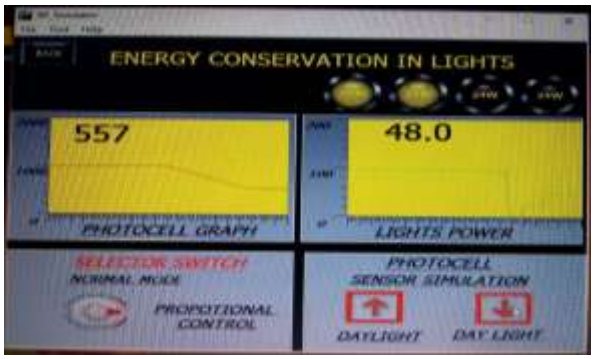

Fig.7

At the Evening or Night Time: At Proportional Mode: furthermore at 407 lumens of photocell showing 72 watt of light power which is controlled and three lights are ON, energy is being saved.

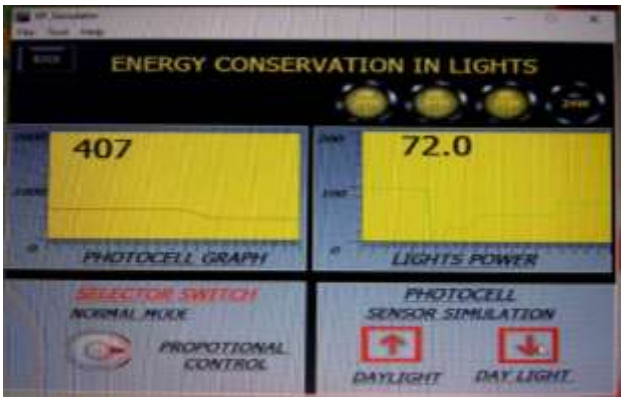

Fig.8

Percentage of Power Saved After Automation

Now we have the total power consumed by both the systems, the percentage of power saved by the system as under

[(1-E2)/E1] * 100
[(1-0.84)/1] * 100 = 16

As we have found from the above results that the 16% of energy can be saved by proportional power control method

X. SMART LIGHTING SCHEME

- Lighting uses 40 % of the energy in commercial buildings alone, more than any other building system.
- Lighting scheme is necessary because it can eliminate 60 percent or more of the wasted lighting energy in buildings while enhancing the productivity and occupant comfort.
- Cost reductions are only one reason that wider use of lighting controls makes sense.
- Lighting includes the use of both artificial light sources like lamps and light fixtures, as well as natural illumination by capturing daylight.
- Day lighting (using windows, skylights, or light shelves) is sometimes used as the main source of light during daytime in buildings.

EFFICIENCY

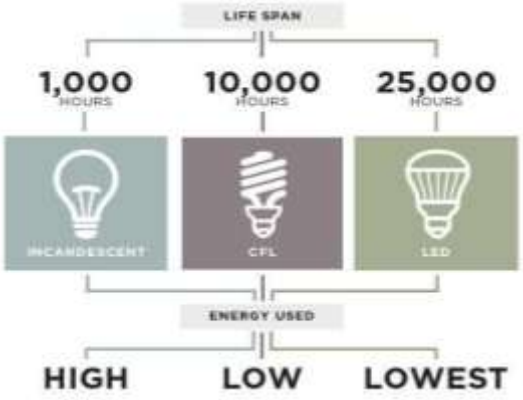

Fig.9

NATURAL ILLUMINATION

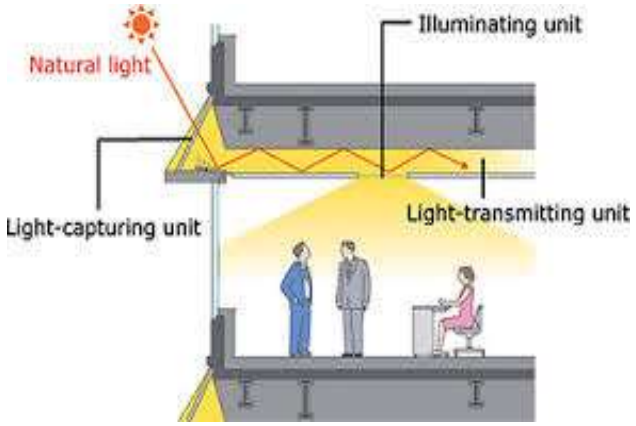

Fig.10

XI. CONCLUSION

PLC Automatic system removes the human intervention which makes the process smart. From the results the energy consumption by inductive loads (Fan) has reduced by 16%. Energy reduction will gives benefits to the consumers in terms of reducing the cost of electricity bills. The proposed system can be easily installed in any small or large building environment and implemented its efficiency by means of cost, it could be said that it's very cost effective.

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