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SAVING ELECTRICAL ENERGY USING INTELLIGENT AUTOMATION TECHNOLOGY

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ABSTRACT

The primary objective of this study was to reduce electricity consumption by automation of the switching system of a room. A motion sensor was used which senses human movement by change in heat flux in a confined space. Appropriate circuitry has been developed to control the switching system of the room in such a way that when motion is sensed the circuit gets closed, fans and lights starts operating. When motion ceases, the circuit opens and all appliances shut down after two minutes of delay. The automation device was implemented for testing purpose in a room and data of energy consumed in KWh were collected for both manual and automatic modes. Observed data indicated that approximately 40% of electrical energy can be saved by adopting such automation systems. This study showed that a total of 140 MW of electricity can be saved by implementation of such automation systems in commercial offices in Bangladesh.

1. INTRODUCTION

1.1 Electricity Problem in Bangladesh:

Bangladesh is in a dire strait because of its recent crisis for electricity. As an under-developing country uninterrupted power supply to its industrial, commercial and residential sectors is a must to achieve higher GDP growth. To increase productivity of the existing infrastructures, to attract foreign and local investments and to create new industries, uninterrupted power supply must be ensured. According to the authority about 1400 MW to 1800 MW electricity shortage is about to be occurred in 2009, which is almost twice more than that of last year and the country need approximately 5000 MW of electricity in total [1]. The projected demand of electricity in the year of 2012 is 7900 MW and by 2020 it is believed to reach 14600 MW [2]. Therefore, the amount of electricity shortage may increase more rapidly in near future unless something is done now. Installation of new power plants and reduction of system loss may improve the situation. But gas crisis limits the possibility of new power plant implementation as right now power generation capacity of about 500 MW per day remains unutilized due to gas shortage. The present gas demand is about 2400MMCFD while our production capacity is about 1950MMCFD [3]. So it is essential that electricity consumption in different sectors should be reduced by considerable amount to improve the current situation. The electricity consumption sectors can be divided into four groups – 1.Residential, 2.Industrial, 3.Commercial and 4.Others. Electricity consumption pattern for the year 2007-08 has been shown in Fig. 1.

The figure shows that in 2007-08 approximately 47% of total energy was consumed in residential section while electricity consumption in industrial and commercial sectors was 41% and 9%, respectively. The consumption pattern is believed to be remained same in the recent years. The figure shows that in 2007-08 approximately 47% of total energy was consumed in residential section while electricity consumption in industrial and commercial sectors was 41% and 9%, respectively. The consumption pattern is believed to be remained same in the recent years.

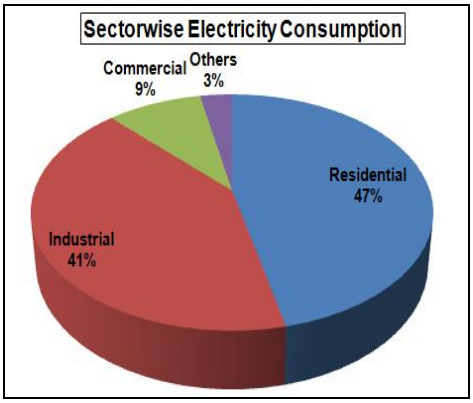

Fig 1. Electricity Consumption Pattern [4]

The focus of this study is the energy being consumed in the commercial sector. Energy consumption in commercial sector refers energies consumed in buildings and facilities of both government and private sectors -- wholesale and retail trades; the operation of hotels and restaurants; renting and business activities; financial intermediations, bank and insurance companies; public administration and defense offices; education institutes; community halls, health and social service activities. The

detail data of sectorwise electricity consumption is presented in table A.1 in Appendix 1. From this table it is quite clear that electricity consumption in different sector is increasing and in the case of commercial sector the rate increase is even higher.

In 2007-2008, commercial sector consumed nine percent (9%) of total electricity while electricity consumption in this sector has increased by 30% over the year of 2006-07 [4].

1.2 Saving Electricity

Electricity is being wasted in our country in various ways. As it has been stated earlier, we are having a huge shortage of electricity. Saving electricity and restricting its wastage are utmost necessary. Some steps have already been taken recently to save electricity:

1. Disconnecting illegal power connections
2. Introducing Day Light Saving (DST) to maximize the use of day light
3. Implementing a new dress code which allows government officials to wear light clothing instead of formal suits and ties
4. Keeping air conditioners thermostat level at 24 degrees Celsius.

However the amount of electricity wasted due to ignorance and careless behavior of people is large. A noticeable portion of electricity can be saved by disallowing this type of wastage. It is of common practice that people do not play active role on reducing consumption of electricity by carefully switching off the electrical devices while they are not in use. Most of the time people do not switch off lamps, fans and other appliances while leaving the room for a short period of time. As a result the more the time spent outside the room, the more energy is wasted.

2. OBJECTIVE

In this study the primary focus was the wasted energy due to careless behavior in the commercial office buildings. It is mentioned earlier that about nine percent of total consumption of electricity is consumed in the year of 2007-08 at commercial sector. So a considerable portion of electricity can be saved if wasting of electricity in commercial buildings is reduced. This wastage could be easily prevented if we become more conscious to turn off the electrical appliances when they are not in use. But bringing change in human behavior is not easy. In this project an alternative measure is attempted through automation of the switching system of the room. If the switching system can be so that the presence and absence of human inside a room is detected and automatic switch off occurs during absence of people inside the room, the waste of energy can be minimized.

Automation of the switching system can be performed in many ways. The following are two probable options:

1. By using a motion sensor which senses human movement by change in heat flux in a confined space.
2. By using two door sensors which will count people entering and leaving the room with the help of appropriate circuitry.

In this current project a motion sensor with appropriate circuitry was used for automation of switching system of a closed room. Appropriate circuitry was developed to control the switching system of the room so that when motion is sensed the circuit kept closed; fans and lights starts operating. When motion sensor does not detect human motion for two minutes, the circuit breaks and appliances shut off. The automation device was implemented for testing purpose in a room containing three tube lights and a fan. Theoretically each of these tube lights consumes 40 W and the fan consumes 60 W. The modes of operation were conventional manual mode without sensor and the auto mode operating with the sensor. Data for energy consumed in KWh was collected for each of the two modes of operation for 7-10 days in rotation.

3. THEORY OF OPERATION

3.1 Block Diagram

The simplified block diagram of the set-up for automation of switching system is shown in figure 2.

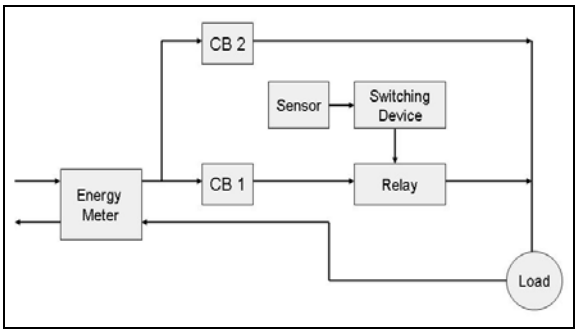

Fig 2. Block Diagram of the Automation Process

In this diagram, CB 1 refers to the circuit breaker which has been used to operate the circuit in the automatic mode and CB 2 has been used for conventional operation of the circuit.

3.2 Working Principle

The working principle for this project is simple. For this project only a few equipments were used. The block diagram of the project is shown in Figure 2. When there is human movement in the room, sensor senses movement by change in heat flux due to the heat radiated from human body and closes the circuit for operation. But when there is no movement in the room for a set time period, an electrical pulse is sent to the switching device which turns off the power supply by breaking the circuit with the help of a relay. The time delay was set to two minutes for this study. This system is capable of turning on the electrical appliances instantaneously when it senses human movement again. Energy meter was used to monitor the consumption of electrical power for both operational modes.

4. PROJECT SET-UP

The automation circuit implemented in the room consists of mainly the motion detector, controlling circuit, circuit breaker switch and an energy meter.

The Motion Detector which can sense human

movement in a confined space by change in heat flux is shown in figure 3. This motion detector, which was mounted on the wall, can sense the human movement over a range of 15ft by 10 ft.

Fig 3. Motion detector mounted on the wall

The switching system controlling circuit has been shown in Figure 4.

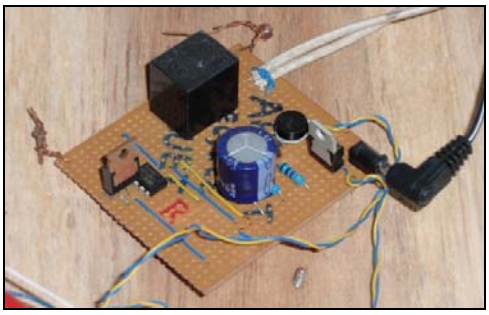

Fig 4. Controlling Circuit to Automate Electricity Switching

This control circuit is the heart of this intelligent automation switching system technology. This drives the switching system in the ON or OFF modes based on the motion detected by the sensor.

5. OBSERVATIONS

5.1 Data Presentation

Data for electricity consumption in KWh per day for each of the two operation modes were collected for two summer months. A part of such data is shown in Figures 5 and 6.

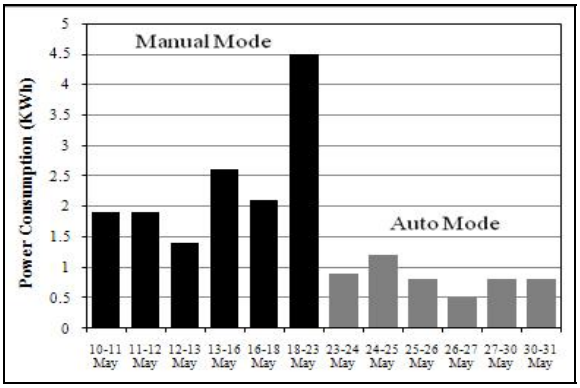

Fig 5. Power Consumption in Both Operating Modes

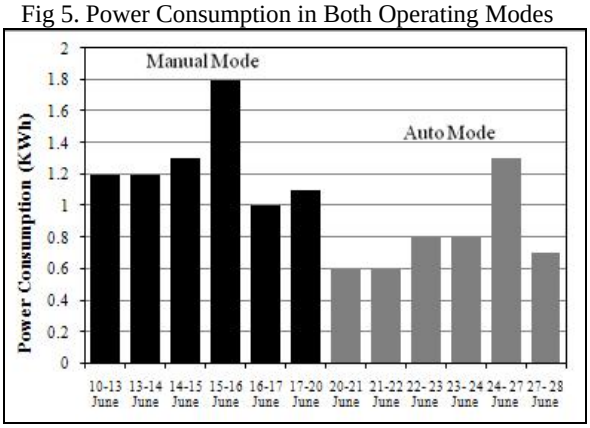

Fig 6. Power Consumption in Both Operating Modes

From Figures 5 and 6, it is clear that energy consumption in KWh per day for automation mode is much lesser than that of manual mode. Two largest bars in Figures 5 and 6 include energy consumed in the weekend too. Therefore, data for energy consumed in the working days are separated and presented in Figure 7. This figure now represents power consumption data only for regular working days excluding all the weekends and vacations. From Figures 5, 6 and 7, it can be observed that a considerable drop in power consumption occurred by using switching system automation device in the room.

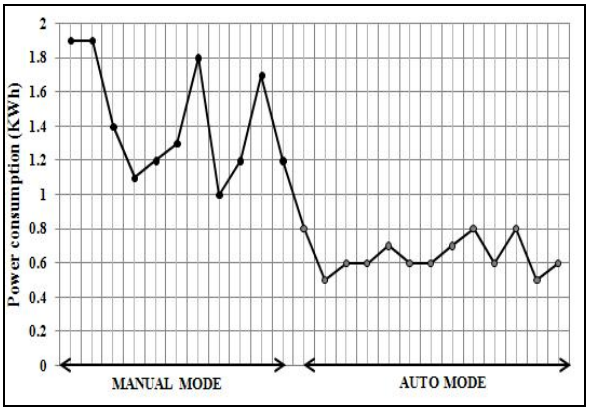

Fig 7. Power consumption per working days in both modes

5.2 Results

The results of implementing switching system automation device are highlighted in Table 1 and energy consumption data for manual mode operation is presented in Table 2.

In Table 1 power consumption in auto mode is listed with hours of operations.

Table 1: Calculated data of power consumption at Auto Mode

Hours in operation (hr)	Working hours (hr)	Power consumed (KWh)	Comments
24	8	0.7	-
24	8	0.9	-
24	8	1.2	-
24	8	0.8	-
29	13	0.5	-
67	4	0.8	Including weekend
24	8	0.8	-
24	8	1.0	-
24	8	0.6	-
24	8	0.6	-
72	8	1.1	Including weekend
24	8	0.7	-
24	8	0.6	-
24	8	0.6	-
24	8	0.8	-
24	8	0.8	-

From table 1, it is seen that power consumption per day in auto mode ranges between 0.5-1.2 KWh.

Table 2: Calculated data of power consumption at Manual Mode

Hours in operation (hr)	Working hours (hr)	Power consumed (KWh)	Comments
24	8	1.9	-
24	8	1.9	-
24	8	1.4	-
72	8	2.6	Including weekend
118.5	-	4.5	Including mid-term break
24	8	0.8	-
24	8	0.7	-
24	8	1.1	-
72	8	1.2	Including weekend
24	8	1.2	-
24	8	1.3	-
24	8	1.8	-
24	8	1.0	-
72	8	1.1	Including weekend
24	8	0.9	-
24	8	1.2	-
24	8	1.7	-

From Table 2, it is seen that power consumption in normal manual mode ranges between 0.7-2.6 KWh.

By calculation of percentage of electricity savings following results are obtained-

1. Average saving in power based on total runtime (Including vacations and weekends)
   Percentage of electricity saving per day = 36.2 %
2. Average saving in power based on total runtime (Excluding long time absence)
   Percentage of electricity saving per day = 41%
3. Average saving in power (time-weighted average)
   Percentage of electricity saving per day = 40%

6. PROJECT FINDINGS

The major findings of this study can be listed as in the following:

1. Bangladesh is having a huge shortage in electricity as electricity demand outruns electricity generation. In the current year (2009), the expected electricity shortage is expected to be approximately 1400 MW- 1800 MW.
2. The amount of electricity shortage is increasing day by day. As the projected electricity demand is 7900 MW in 2012, where the current estimated demand is 5000 MW, the situation will become more complicated unless effective steps are taken to reduce consumption.
3. A total 9% of total electricity consumption is consumed by commercial sector last year and in domestic sector the consumption rate is 47%. 9% of total electricity corresponds to 450 MW of electricity, which is being consumed by commercial sector now while 2350 MW of electricity is being consumed by domestic sector. Consumption rates in commercial sector as well as in domestic sector are also increasing quite rapidly day by day than the other sectors.
4. A considerable amount of electricity is being wasted due to unconscious behaviour of people. By minimizing this wastage a good amount of electricity can be saved thus the amount of "electricity shortage" can be reduced.
5. In the case of confined places, about forty percent (40%) of electricity can be saved by automation of switching system developed in this project.

The facts mentioned above indicates that the problem of electricity shortage can be made a little better by adopting the automation of switching system of the electrical devices used in a room. The circuit with motion detector developed in this study can be used in commercial offices, offices of educational institutions and other sectors, conference rooms, drawing room or leaving room of our. The circuit is quite flexible for use in different sectors as the delay time is adjustable and it is very easy to implement even in the existing system.

Treatment of raw data indicates that 40% of electricity can be saved by adopting the switching automation system in a room. Assuming 90% of total energy consumed in the commercial sector is used by commercial offices and rooms and 90% of total commercial offices are covered by such switching automation devices developed in this project, a total of 145 MW electrical energy can be saved nationwide (450 x 0.9 x 0.9 x 0.4). If 3% of domestic sector rooms are equipped with such switching automation devices, another 28 MW can be saved (2350 x 0.03 x 0.4).

Therefore, a total 173 MW of electricity is expected to be saved by using such automation devices.
Saving 145-175 MW electricity can be quite beneficial to our country in several aspects such as-

1. Saving of 145-175 MW electricity means, a power plant of medium capacity may not be needed. So the cost of implementation and operation of one power plant can be prevented and huge amount of money can be saved.
2. One less power plant means, a considerable amount of saving in natural gas consumption.
3. Again minimization of operation of a power plant means, lesser pollutant emission to air and water bodies.
4. This amount of electricity saving can be used for carbon trading and the country can get a considerable amount of foreign exchange money from United Nations (UN).

7. ECONOMIC FEASIBILITY OF THE AUTOMATION DEVICE

The power saving ability of the switching system automation device developed in this project has already been demonstrated above. Now the economic aspects of the device are studied below for checking the feasibility of such devices. Let us consider a room containing of the following devices:

1. An air conditioner (1350 watt)
2. A fan (75 watt)
3. 2 light bulbs (100x2 watt)
4. 2 low energy lights (20x2 watt)

Therefore, the total energy consumption of this room can be calculated as 1665 Watt.

7.1 Calculation of Monthly Saving

Assume, the working time for offices be 7 hours per day, 5 days per week and 20 days a month. In manual mode,
Monthly bill for this particular room will be 1433.6 Tk based on Tk. 6.15 per unit of electricity cost in commercial sector ($1665 \times 7 \times 20 / 1000 \times 6.15$).
If automation device were used,
Monthly bill for this particular room will be= 860 Tk
Monthly saving by using automation device for a room
= (1433.6 – 860) Tk = 573.6 Tk

7.2 Break-Even Analysis

The total cost to implement the automation device for this current project was 4000 Tk. The expected service life of the device is 10 years.

Now, considering the case of the office room, the break-even point, where the cost of the device is equal to the money saved due to the use of automation device, can be found graphically as shown in Figure 8. Therefore, the fixed capital investment will be equal to the amount of savings after 140 working days. This corresponds to 7 months with the assumption of 20 working days per month. Therefore, it can be concluded that the economic feasibility of the switching system automation device is justified

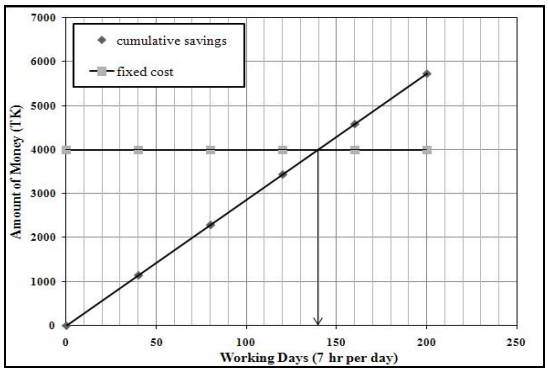

Figure 8: Break-even Analysis

8. CONCLUSION AND FUTURE WORK

This study aimed to reduce the consumption of electricity by minimizing electricity wastage due to unconscious human behavior. The study suggests that using automated switching system can save up to 40% of electricity. If all office rooms are equipped with such automation systems approximately 145 MW of electricity can be saved. This will not only help reducing the load-shedding but also increase the productivity. It will also save natural gas by eliminating one moderate size power plant. This will results in less pollution too. Thus it can be concluded that considering the critical energy situation through which Bangladesh is going through now, the implementation of such automation systems will reduce the electricity load and ensure an efficient use of energy.

Though the economic feasibility of the automation device is justified, the cost for the implementation of the automation device is relatively high for our country. If the fixed cost is reduced by 50-60% the device would become more economically attractive and popular. So the main challenges of wide use of automation devices for switching system controlling are cost reduction, easy and flexible implementation. The major cost of the device is for the sensor, which is 3000 Tk. If door sensors are used, the cost of the device can be significantly reduced.

9. REFERENCES

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APPENDIX - 1

Table A.1: Sector wise energy consumption data [4]

Year	Domestic Service (MKWh)	Industrial Service (MKWh)	Commercial Service (MKWh)	Others (MKWh)	Total (MKWh)
1994-95	4090	4546	915	1345	**10896**
1995-96	4681	4867	951	1336	**11835**
1996-97	3208	8646	586	550	**12990**
1997-98	3612	5217	714	633	**10176**
1998-99	4217	5603	742	699	**11261**
1999-00	4023	5795	770	764	**11352**
2000-01	4891	5125	824	794	**11634**
2001-02	5511	5432	876	748	**12567**
2002-03	5969	6003	1007	738	**13717**
2003-04	6598	6682	1157	898	**15335**
2004-05	6946	7153	1243	994	**16336**
2005-06	8910	9175	1595	1274	**20954**
2006-07	9006	9275	1612	1288	**21181**
2007-08	10642	9489	2095	705	**22931**