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Energy Efficient Street Light Controlling System using Arduino Microcontroller in Comparison with 8051 Microcontroller

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ABSTRACT

Aim: The major aim of the research is an energy efficient street light controlling system using Arduino Microcontroller in comparison with 8051 Microcontroller based systems. **Materials and Methods**: There are two sample groups (Arduino Microcontroller and 8051 Microcontroller with 20 samples. The sample size is calculated using G power with pre-test power of 80 % and the alpha value is 0.05 (error rate). **Results:** From the research, the proposed solution has 95.67 % of energy efficiency, whereas the Energy Efficiency of a light dependent resistor is only 83.23 %. The novel street light control system outperforms the traditional street light control system. There is a statistical difference in the Novel Street Light control system and traditional street light signal systems ($p < 0.05$). The significance value is 0.001. **Conclusion:** A novel street light control system using Arduino Microcontroller performs significantly better than a 8051 Microcontroller based systems.

Keywords: Street Light Monitoring, Novel Street Light Control System, Energy Efficiency, Arduino Microcontroller, 8051 Microcontroller,Energy Efficiency.

INTRODUCTION

The function of street lighting is to keep pedestrians and automobiles safe. Every city in India has a street lighting system that is based on the availability of electricity as well as the demand(Laddad and Phade 2017) . Several strategies have been developed to reduce the quantity of electricity utilised. Each engineer working in this field is concerned about the idea of designing a new streetlight system that does not consume large amounts of electricity and illuminates large areas with the highest intensity of light (Islam et al., n.d.) Providing street lighting is one of the most important and costly responsibilities of a city(Hermoso-Orzáez and Gago-Calderón 2020).Because of security concerns, a recent street lighting legislation mandates that all lights be turned on throughout the night. This leads to inefficient energy management, which results in reduced lamp life and light pollution (Nagamani et al. 2019). In light of the issues with current street lighting systems, it has been proposed to modify the street lighting behaviour system to make it more environmentally friendly and cost-effective. Security surveillance systems, RFID tags in luggage, sensors in the chemical industry, smart homes, military applications, healthcare, industrial management, and a range of other applications employ the Arduino Microcontroller (Sunehra and Rajasri 2017) Automation systems are preferable over manual mode because they

save energy by reducing the amount of energy used. From ceiling fans to washing machines and other applications, automation systems play an important role in making daily living more comfortable and convenient for users.Street lights, among other intriguing applications, play an important role in our surroundings as well as providing light for safety during nighttime driving.

In recent years, a significant amount of research has been conducted on the street light monitoring control system. Based on an examination of different characteristics anticipated by other academics, 189 journals have been published in Google Scholar and IEEE Xplore in the recent 5 years. Control strategies and methods for the street light monitoring system include the design and implementation of CPLD-based solar power saving systems for street lights and autonomous traffic controllers (Gautham et al. 2016) Another approach that has been developed is a compact silicon chip with a high driving power. This chip can be utilised in smart city lighting systems for high-power LED dimming, giving a constant current to drive an LED while avoiding EMI (Electromagnetic Induction). However, the chip design is extremely complex, making this technology prohibitively expensive (Boyce 2008) Another way is to use a street lighting monitoring system, which generates reports that describe energy consumption on a regular basis. This would serve as a warning to the public about the rise in electricity consumption. However, the amount of data that needs to be managed is substantial, and it is not organised in a consistent way, making implementation challenging (Parekar and Dongre 2015).To track the sunshine, a similar way of using a light-dependent sensor that is interfaced to the AVR microcontroller has been created. When it's dark outside, the LED will turn on, and vice versa, relying solely on the ON/OFF feature (Islam et al., n.d.)Previously our team has a rich experience in working on various research projects across multiple disciplines(Ezhilarasan et al. 2021; Balachandar et al. 2020; Muthukrishnan et al. 2020; Kavarthapu and Gurumoorthy 2021; Sarode et al. 2021; Hannah R et al. 2021; Sekar, Nallaswamy, and Lakshmanan 2020; Appavu et al. 2021; Menon et al. 2020; Gopalakrishnan et al. 2020; Arun Prakash et al. 2020)

Energy consumption is a major drawback in earlier studies and it is a severe problem in most of the cities, urban areas which is caused by manual systems. The aim of the research is to design an energy efficient street light controlling system that reduces energy consumption with the help of novel street light control systems using Arduino microcontrollers in comparison with 8051 microcontrollers.

MATERIALS AND METHODS

This study was carried out in the Communication Laboratory, Department of Electronics and Communication Engineering at Saveetha School of Engineering, SIMATS. The number of samples taken for the proposed system and the Existing system is 20. Group 1 is a novel street light control system using Arduino microcontroller and group 2 is 8051 Microcontroller. Sample Size calculation (Chandrasekara et al. 2020) of the proposed system and the existing system is 20 and pretest gain power is 80%.

The group 1 sample preparation is a revolutionary street light control system based on the Arduino microcontroller. Arduino is an open-source hardware platform based on ATmega32 series controller microcontroller boards and an Integrated Development Environment (IDE) for creating and uploading code to the microcontroller. It can be powered by a battery or an AC-to-DC adaptor through USB. The processing module of the system is Arduino. It collects data from the LDR, processes it, and outputs it to LEDS either directly or via a relay and transistor mechanism.

A street light control system employing an 8051 microcontroller is the sample prepared for group 2. C++ is used to programme the microcontroller. The microcontroller's Port 3.0 provides power to the relay. The IR sensor is connected to the microcontroller's port 2.0. Port 2.0 is initially set to high (1) and port 3.0 to low (2). (0). When the IR sensor is activated, the relay activates and turns on the LED, and vice versa. The testing setup used for this study is an MCU microcontroller with an ESP8266 WIFI module to estimate the characteristics of Energy Saving, Energy Consumption, and Energy Efficiency with regard to novel street lights utilising an Arduino microcontroller and an 8051 microprocessor.

Statistical analysis

IBM SPSS 27.0.1 (Sathiyaraj and Bharathi 2019) was used for statistical comparison of parameters like novel street light using Arduino microcontroller and 8051 Microcontroller. The significance value of the independent t-test was $p < 0.05$ which was done in SPSS Software. The statistical analysis for novel street lights using Arduino microcontroller and 8051 Microcontroller was done. The calculation is performed utilizing G-power 0.8 with a confidence interval of 95 %.

RESULTS

From the research, the proposed solution saves 76.8 % of energy, whereas the 8051 microcontroller only saves 56.23 %. The novel street light control system using Arduino microcontroller outperforms the 8051 microcontroller. There is a statistical difference between the Arduino microcontroller system and 8051 microcontroller systems ($p < 0.05$).

Figure 1 shows the proposed framework diagram of a street light monitoring system using Arduino microcontroller. It displays the diagrammatic representation of Automatic Switching ON and OFF street lights using an Arduino microcontroller in Proteus software. Fig. 2 is a diagrammatic representation of Automatic switching ON and OFF street lights using an 8051 microcontroller. Fig. 3 shows that novel street light control systems using arduino microcontrollers save 76.8 % of energy. Fig. 4 indicates an arduino microcontroller based novel street light control system predicted 25.56 % of energy consumption. Fig. 5 represents that novel street light control systems using arduino microcontrollers achieve 95.67 % of energy efficiency compared to 8051 microcontrollers.

The evaluation metrics for arduino microcontroller and 8051 microcontroller classifiers are shown in Table 1. novel street light monitoring control using an arduino microcontroller outperforms energy saving, energy consumption and energy efficiency compared to street light control using 8051 microcontroller. Table 2 represents the significance of the intelligent street light signal system by doing an independent sample t-test in SPSS software. There appears to be a statistical significance difference of $p < 0.05$ and Table 3 shows the independent sample t-test which was performed in SPSS software.

DISCUSSION

The findings of this study show that a novel street light control system based on an Arduino microcontroller outperforms an 8051 microcontroller-based street light monitoring system. An arduino microcontroller has a 95.67 percent energy efficiency, which is higher than that of 8051 microcontrollers. An arduino microcontroller saves 76.82 percent of the electricity used by an 8051 microcontroller, which saves 56.23 percent. An arduino microcontroller consumes 25.56 percent of the energy consumed by an 8051 microcontroller, which consumes 54.34 percent.

According to the SPSS study, group 1 performs much better than group 2 with a 12 percent ideal performance. This study(Lepcha 2019) presents a method for controlling street lights using the LDR sensor, which saves up to 58 percent of energy for both residential and commercial applications. An embedded system was used to create and implement the proposed IOT-based Automatic street light monitoring and vehicle counting system (Roy et al. 2018) . This research study is based on a smart street light auto-switching technology that saves 78 percent on electricity. This Arduino-based research (Sunehra and Rajasri 2017) will give a reliable technique for lighting systems and make the entire energy-saving process simpler and more efficient. To control the street light system, an Arduino Uno is employed as the brain. The results suggest that energy savings of up to 65 percent can be achieved, as well as a 53 percent improvement in lamp lifetime. The suggested microcontroller-based street light monitoring control system (Abdullah et al. 2019) is cost-effective and saves 73.28 percent energy. It allows us to avoid the problems of manual switching that plague today's world, and, more importantly, it allows us to reduce primary costs and maintenance.

The study's goal (Gautham et al. 2016; Kalam et al. 2020) to find the most cost-effective, environmentally beneficial, and safe technique to save energy. It effectively addresses the two problems that the world is facing today: energy conservation and incandescent light disposal. According to statistics, it has the potential to save more than 40% of the electrical energy currently utilised by motorways. The adopted model ((Bansal 2021; Arjun et al. 2019) is the most cost-effective and secure method of energy conservation. According to statistics, national highways, state highways, and local street lights currently consume 35 percent to 40 percent of electrical energy. The street light control and fault detection system is powered by an Arduino (Rai, Kumari, and Verma 2020). The Arduino Uno was used to successfully build a functional prototype of a street lighting automation system. When comparing LED for street lighting automation systems to LED for public street lighting, about 16.67 percent of energy may be saved. The purpose of this study (Nagamani et al. 2019) was to regulate the intensity of street lights from 7 p.m. to 7 a.m. This effort is critical to complete because it has the potential to minimise the enormous amount of energy wasted by traditional street lights. The objective of this research has been achieved as the system proves that power electricity can be saved up to 40 % to 45 % per month.

The researchers are developing new strategies to address the study's flaws, which include the power harvesters' ability to generate only a little amount of electricity. New processes and generation methods are necessary to lower the cost of electricity. The idea could be used in a variety of settings, including industries, institutions, and major retail mall parking lots. Surveillance on corporate campuses and in the workplace can be done with this. A smart lighting system, according to the proposed technique, can aid cities in energy conservation. Because it's critical to conserve energy. This method presents a potential means of lowering energy use.

CONCLUSION

Novel Street Light control systems using arduino microcontrollers clearly tackle major problems like Energy wastage. The novel street light control systems using an arduino microcontroller with an energy efficiency of 95.67 % has performed significantly better than the 8051 microcontroller with an energy efficiency of 83.23 % .

DECLARATION

Conflicts of Interest

No conflict of interest in this manuscript

Author Contributions

Author GC was involved in data collection, data analysis & manuscript writing. Author KV was involved in conceptualization, data validation, and critical review of manuscripts.

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TABLES AND FIGURES

Table 1. Group statistics of a novel street light control system using arduino microcontroller saves 76.8 % and 8051 microcontroller 56.23 %

GROUP STATISTICS			
DEVICES	**Electrical Energy Saved**	**Energy Consumption**	**Energy Efficiency**
Arduino Microcontroller	76.82%	25.56%	95.67%
8051 Microcontroller	56.23%	54.34%	83.23%

Table 2. For arduino microcontroller and 8051 microcontroller based systems, statistical calculations like mean, standard deviation, and standard error mean are used. In the t-test, the energy efficiency parameter is employed. The Arduino microcontroller has a standard error mean of 0.9892 whereas 8051 microcontroller has standard error mean of 0.6791.

Group		**N**	**Mean**	**Standard Deviation**	**Standard Error Mean**
Energy Efficiency	**Arduino Microcontroller**	10	95.67	2.7801	0.9892
	8051 Microcontroller	10	83.23	1.023	0.6791

Table 3. Independent sample tests between arduino microcontroller and 8051 microcontroller-based systems were performed using statistical techniques. For the comparison of arduino microcontroller and 8051 microcontroller-based systems, an independent sample T-test with a 95% confidence interval and a significance threshold of 0.001 is used.

Group		**Levene's Test for Equality of Variances**		**t-test for Equality of Means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval (Lower)	95% Confidence Interval (Upper)
Accuracy Rate	**Equal variances assumed**	7.623	0.001	18.271	18	.000	13.782	0.8901	11.9881	14.8981
	Equal variances not assumed	5.687	0.001	8.982	12.091	.000	12.901	0.7891	10.8921	13.7891

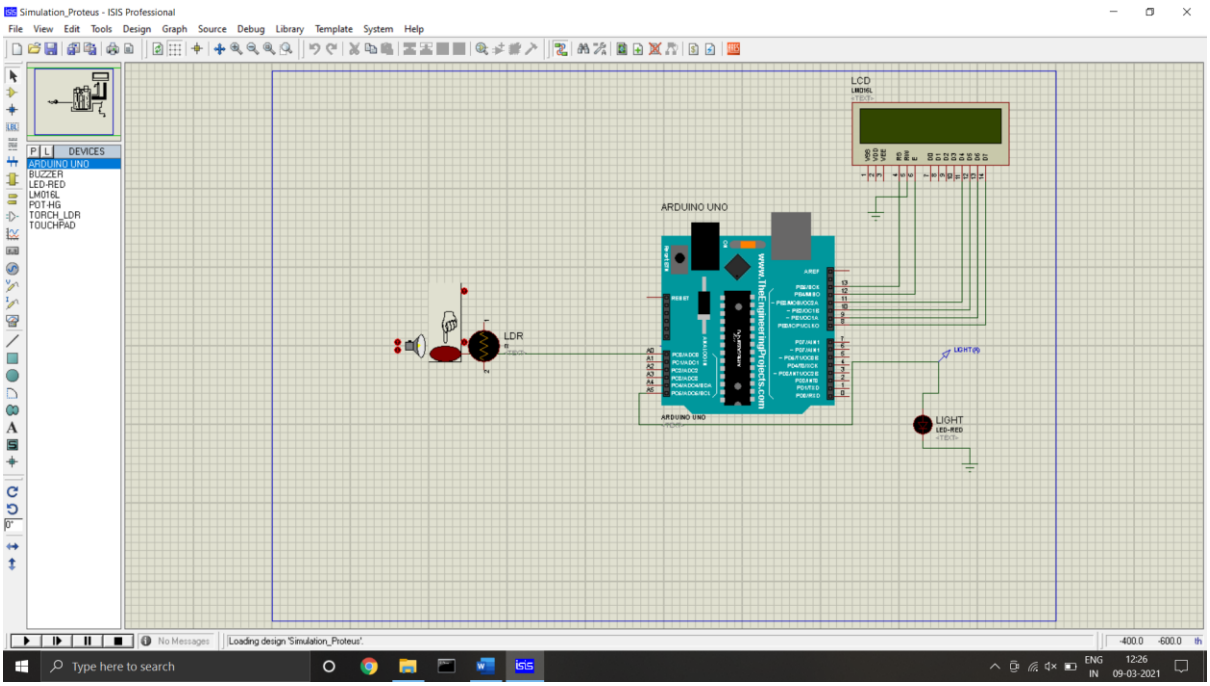

Fig. 1. Diagramatic Representation of Automatic Switching ON and OFF street lights using Arduino microcontroller in Proteus software.

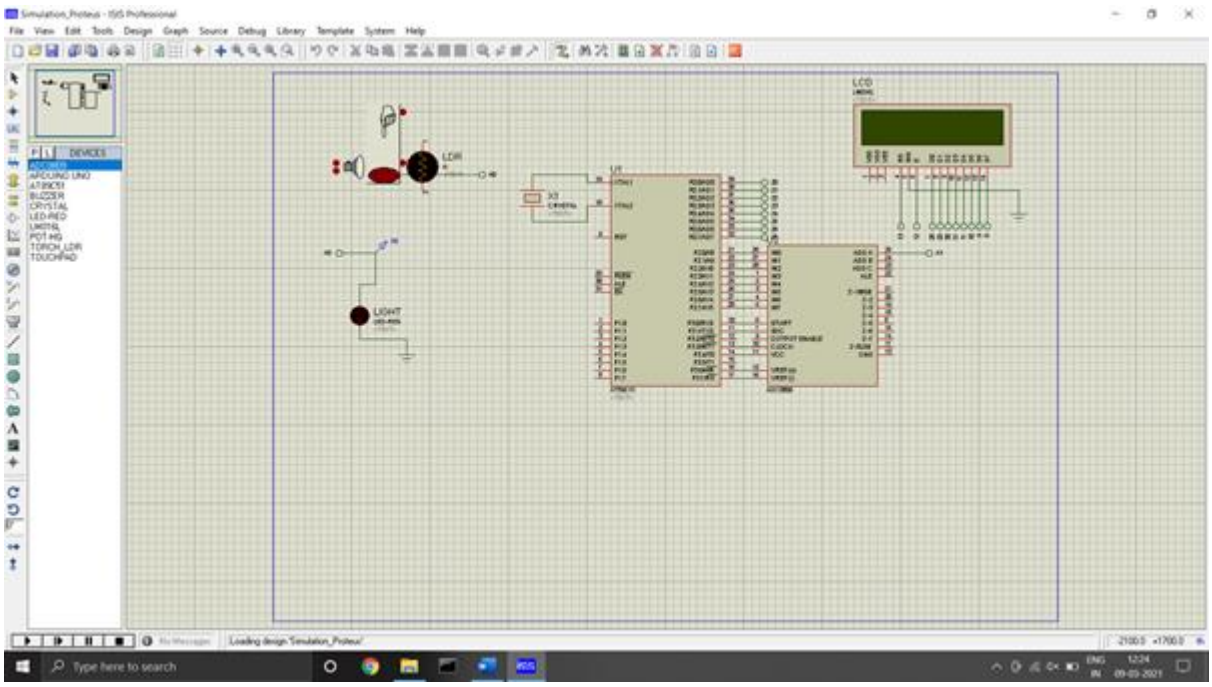

Fig. 2. Diagramatic representation of Automatic switching ON and OFF street lights using 8051 microcontroller in Proteus software.

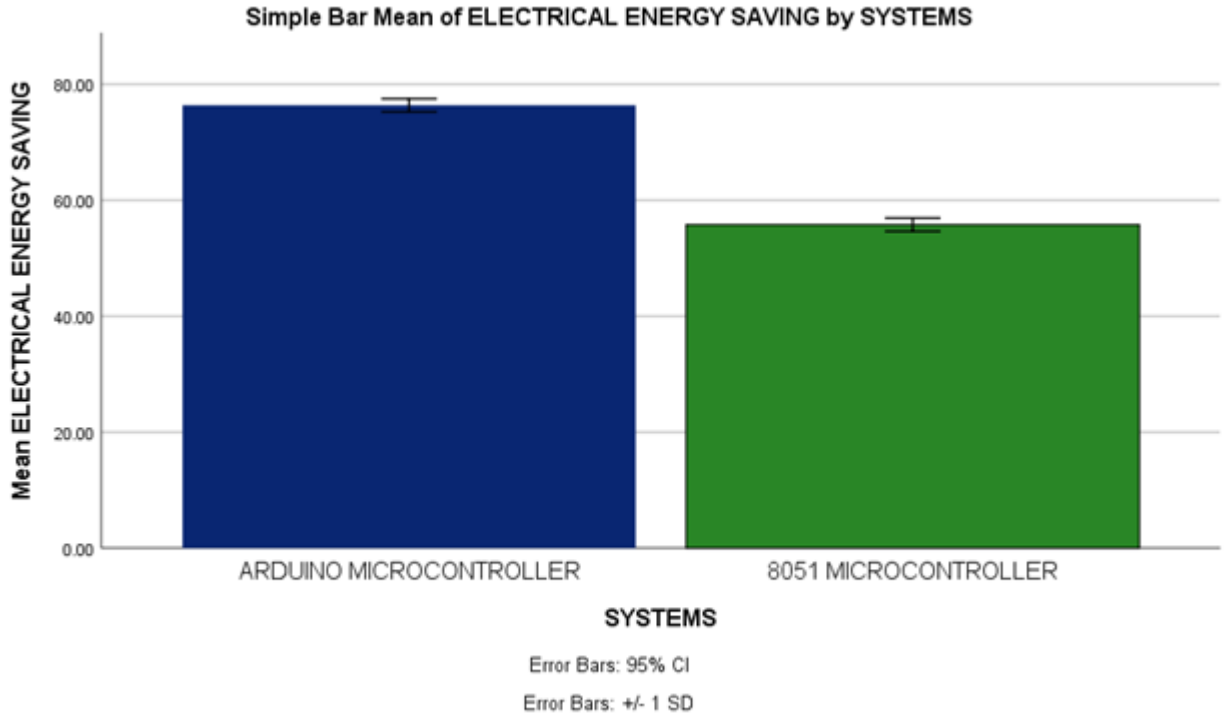

Fig. 3. Comparison of a novel light control system using arduino microcontroller and 8051 microcontroller in terms of Electrical Energy Saved X-Axis: arduino microcontroller and 8051 microcontroller. Y-Axis: Energy saving is +/- 1SD.

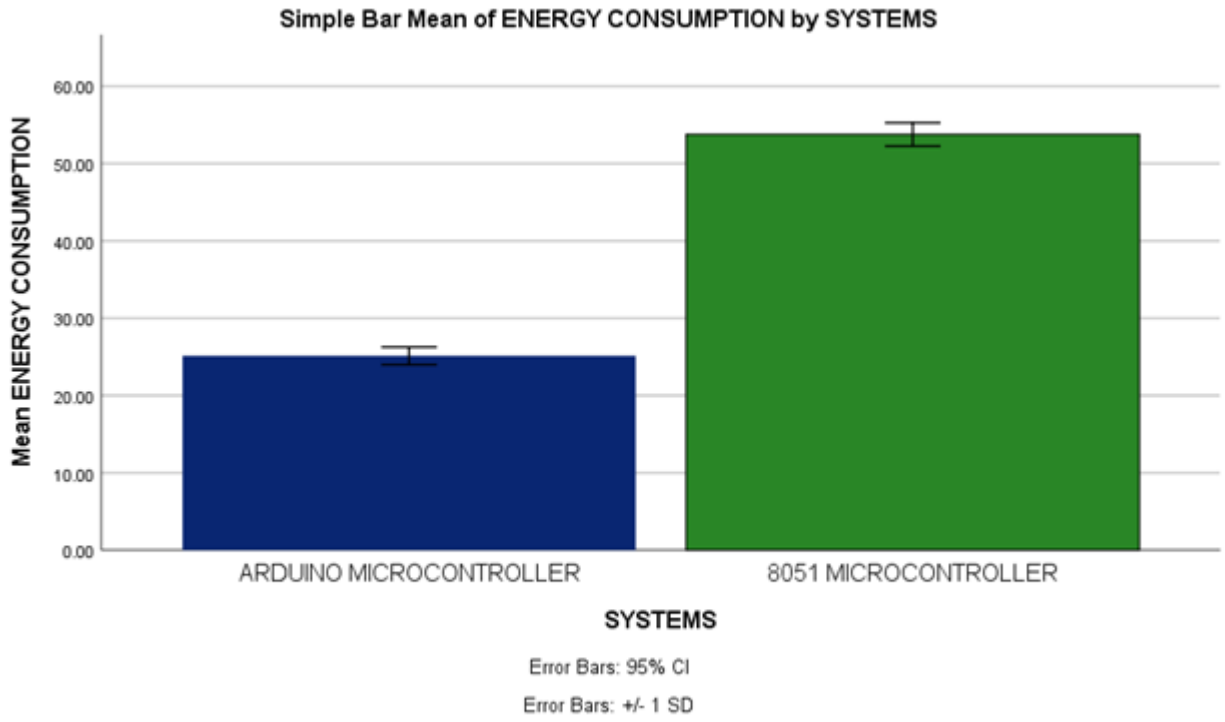

Fig. 4. Comparison of a novel light control system using arduino microcontroller and 8051 microcontroller in terms of energy consumption X-Axis: arduino microcontroller and 8051 microcontroller. Y-Axis: Energy saving is +/- 1SD.

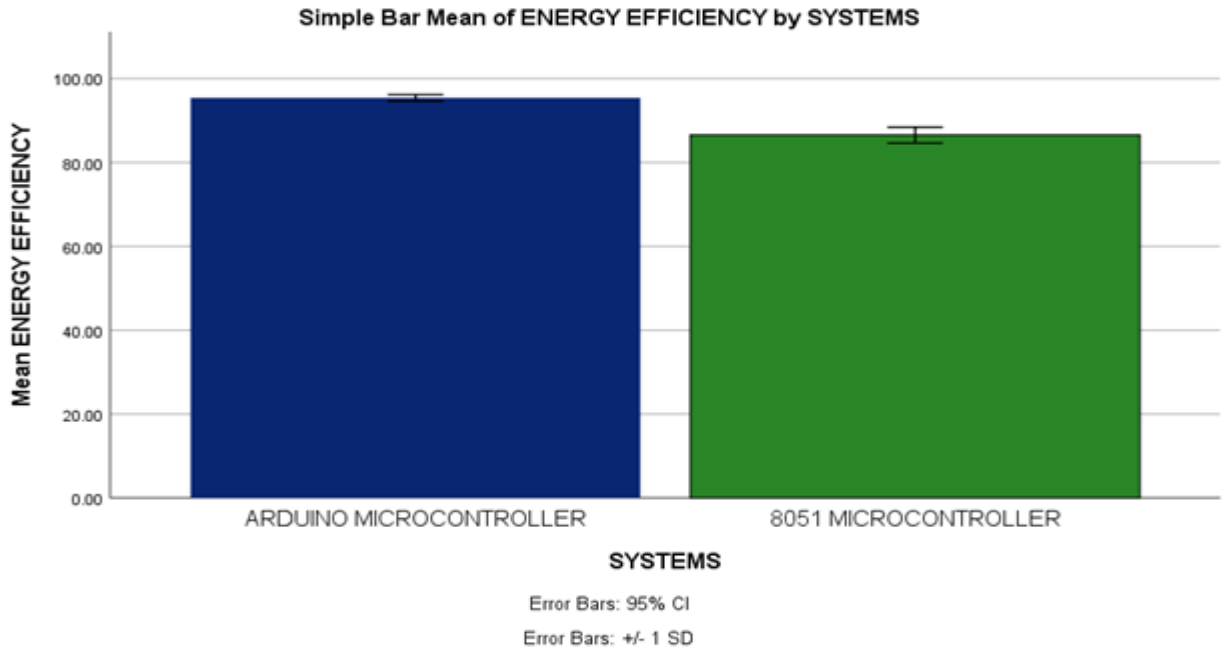

Fig. 5. Comparison of a novel light control system using arduino microcontroller and 8051 microcontroller in terms of energy efficiency X-Axis: arduino microcontroller and 8051 microcontroller. Y-Axis: Energy saving is +/- 1SD.