Intellectual Journal of Energy Harvesting and Storage
Vol. 4, No. 2, December 2026, pp. 117~122
ISSN: 2963-6272, DOI: 10.11591/ehs.v4i2.pp117-122

Solar-based street light with automatic control unit

Kalagotla Chenchireddy, Soma Vignesh Kumar, Pasupulati Vijay Shankar, Abbavathini Karthik, Esthari Vamshi Krishna
Department of Electrical and Electronics Engineering, Geethanjali College of Engineering and Technology, Hyderabad, India

Article Info

Article history:

Received Mar 30, 2026
Revised Apr 17, 2026
Accepted Nov 1, 2026

Keywords:

Arduino/microcontroller
Automatic street lighting
Charge controller
Energy efficiency
Renewable energy
Solar energy

ABSTRACT

Street lighting is essential for providing safety and visibility on roads during nighttime. However, traditional street lighting systems consume a large amount of electrical energy and often operate even when lighting is not required. To overcome this problem, a solar-based street light with an automatic control unit is proposed. In this system, a solar panel collects sunlight during the daytime and converts it into electrical energy, which is stored in a rechargeable battery. The stored energy is then used to power the street lights at night. A light dependent resistor (LDR) is used to detect the surrounding light intensity and automatically switch the street lights ON when it becomes dark and OFF during daylight. A controller unit manages the operation of the system and ensures proper coordination between all components. Light-emitting diode (LED) lights are used as the light source because they consume less power and provide better efficiency. The proposed system helps reduce electricity consumption, minimize energy wastage, and promote the use of renewable energy sources. It is an economical, reliable, and environmentally friendly solution for modern street lighting systems in cities, highways, and rural areas.

This is an open access article under the CC BY-SA license.

Corresponding Author:

Kalagota Chenchireddy
Department of Electrical and Electronics Engineering, Geethanjali College of Engineering and Technology
Hyderabad, Telangana, India
Email: chenchireddy.kalagotla@gmail.com

1. INTRODUCTION

The paper explains an automatic street light control system designed to reduce electricity waste and make street lighting smarter. The system uses a PIC16F877A microcontroller along with two sensors: a light dependent resistor (LDR) sensor to detect whether it is day or night, and photoelectric sensors to detect the movement of vehicles or people on the road. During the daytime, the LDR senses sunlight and keeps the street lights turned OFF. At night, the system becomes active, and when a vehicle or object passes near a sensor, the nearby street light automatically turns ON and then turns OFF after the object moves away. This helps ensure that lights are used only when needed. The system also includes components like relays and a regulated power supply to control the lamps. A prototype of the system was developed and tested successfully. Overall, the system helps save energy, reduce manual work, and improve the efficiency of street lighting, making it useful for highways and urban roads [1].

This paper explains a smart street lighting system that uses solar energy to reduce electricity waste and improve efficiency. The system uses a microcontroller along with LDR and infrared (IR) sensors to automatically control street lights. The LDR sensor detects daylight and darkness, so the lights remain OFF during the day and turn ON at night. The IR sensor detects vehicles or pedestrians on the road and increases the brightness of the street lights when movement is detected, while reducing the intensity when the road is empty to save energy [2].

The system is powered by solar panels and rechargeable batteries, making it environmentally friendly and independent of the main power supply. It can also be monitored through internet of thing (IoT) technology, which allows real-time control and fault detection. Overall, the system helps save energy, reduce maintenance costs, and improve the efficiency of street lighting, making it suitable for modern smart cities [3].

This paper explains a solar-powered smart street lighting system that helps save energy and reduce electricity costs. The system uses solar panels to collect sunlight during the day and store the energy in batteries, which are then used to power light-emitting diode (LED) street lights at night. A microcontroller controls the entire system and helps it work automatically [4]. An LDR sensor detects whether it is day or night, so the lights turn ON at night and turn OFF during the daytime without manual control. The system also uses a traffic sensor to detect vehicles on the road [5].

When there are no vehicles, the street lights glow at a low brightness level, and when a vehicle is detected, the brightness increases to provide better visibility. By combining solar energy, sensors, and LED lights, the system reduces energy consumption and makes street lighting more efficient, cost-effective, and environmentally friendly [6].

This paper explains a solar-powered LED street lighting system designed to save electricity and improve efficiency. The system uses solar panels to collect sunlight during the day and store the energy in rechargeable batteries, which are then used to power the street lights at night. An Arduino Uno microcontroller controls the entire system. It uses an LDR sensor to detect whether it is day or night and an IR sensor to detect the movement of vehicles or people. When it becomes dark, the system becomes active, but the lights only turn ON when motion is detected, which helps reduce unnecessary energy usage. The system also includes components like a relay module, charge controller, and LED lights to manage power and lighting operations. The results show that the system works effectively and provides enough lighting while using less energy [7]. Overall, this smart street lighting system is cost-effective, energy-efficient, and environmentally friendly, making it suitable for modern cities [8]–[12].

2. SYSTEM CONFIGURATION

The system is designed using a combination of hardware components that work together to provide automatic and energy-efficient street lighting. The main part of the system is the Arduino Uno microcontroller, which controls the operation of all other components [13]–[15]. A solar panel is used to collect sunlight during the day and convert it into electrical energy. This energy is stored in a rechargeable battery so that it can be used to power the street lights at night. To make the system automatic, sensors are used. An LDR detects the level of light in the environment and helps determine whether it is day or night. When it becomes dark, the system activates the street lights automatically. An IR sensor is used to detect the movement of vehicles or pedestrians on the road. When motion is detected, the LED street lights turn on to provide lighting, and when there is no movement, the lights remain off or operate at lower brightness to save energy [16]–[19].

Other components such as a charge controller, relay module, and LED lights help regulate power and control the switching of the lights. By working together, these components allow the system to operate automatically, reduce energy consumption, and provide efficient street lighting. Figure 1 presents a simple overview of how the proposed system is designed to provide an energy-efficient street lighting solution using solar power and automatic control. The system starts with the solar panel, which captures sunlight during the daytime and converts it into electrical energy. This energy is then passed to a charge controller, which regulates the voltage and current to ensure safe and efficient charging of the battery.

The battery stores the electrical energy so that it can be used later, especially during the night when sunlight is not available. An LDR is connected to the system to detect the intensity of surrounding light. When the LDR senses sufficient daylight, it keeps the street lights turned OFF. When it becomes dark, the LDR sends a signal indicating low light conditions. The signal is processed by the controller (relay/microcontroller unit), which acts as the main control unit of the system. Based on the signal received from the LDR, the controller decides whether the street lights should be turned ON or OFF. Finally, the LED street lights are powered by the battery through the controller. When darkness is detected, the controller activates the LED lights to illuminate the street. When daylight returns, the controller automatically turns the lights OFF, helping to save energy and ensure efficient operation.

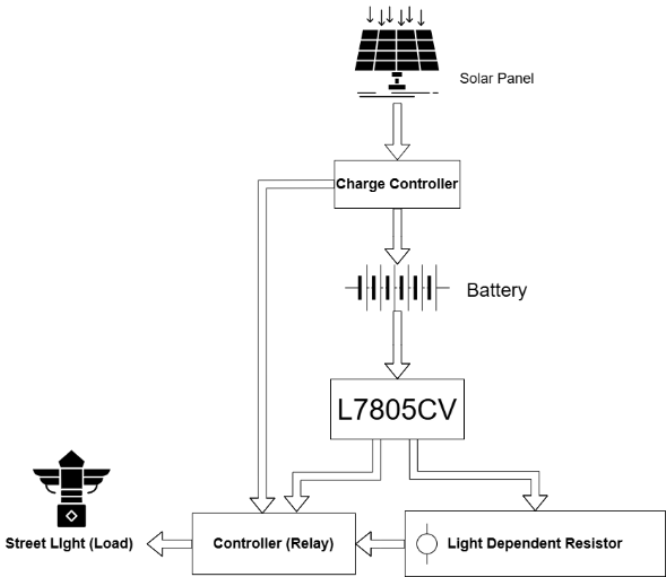


Figure 1. Block diagram representation of the proposed system

3. METHOD

The system works by using a solar panel to collect sunlight during the day and store the energy in a battery. An LDR sensor checks the light level and helps the system know whether it is day or night. When it becomes dark, the street lights are activated. An IR sensor then detects vehicles or people on the road. If movement is detected, the LED lights turn ON to provide lighting. When there is no movement, the lights stay OFF or run at low brightness to save energy. The microcontroller controls the entire process and makes the system work automatically [20].

3.1. Battery pack setup

The battery pack is used to store the electrical energy produced by the solar panel during the daytime. This stored energy is then used to power the street lighting system at night. The battery is connected to the system through a charge controller, which helps regulate the charging and prevents overcharging or damage to the battery. The stored power is supplied to the microcontroller, sensors, and LED lights, allowing the street lighting system to operate continuously and efficiently even when there is no sunlight.

3.2. Motor selection and mounting

The motor is selected based on the power and performance required for the system. It should be efficient, reliable, and capable of operating with the available power supply. After selecting the suitable motor, it is properly mounted on a stable frame or base to ensure smooth and safe operation. The motor is securely fixed using screws or brackets to avoid vibration or movement during operation. Proper alignment and connection with other components are also maintained so that the system can work efficiently and safely.

3.3. Controller connection

The controller acts as the main unit that manages and controls the entire system. All components, such as the sensors, battery, and LED lights, are connected to the controller through proper input and output pins. The sensors send signals to the controller, and based on these signals, the controller processes the information and controls the operation of the lights. Proper wiring and connections are maintained to ensure stable communication between the controller and other components, allowing the system to operate smoothly and automatically.

3.4. Speed regulation configuration

The speed regulation configuration is used to control and adjust the speed of the motor according to the system requirements. A suitable control method is used so that the motor can operate at a stable and efficient speed. The controller sends signals to regulate the motor's speed, ensuring smooth operation and preventing sudden changes. Proper configuration helps maintain consistent performance, improves efficiency, and protects the motor from damage due to over-speed or unstable operation.

3.5. Charging arrangement

The charging arrangement is used to store the electrical energy generated by the solar panel during the daytime. The solar panel converts sunlight into electrical energy and sends it to a charge controller. The charge controller regulates the voltage and current to ensure safe and efficient charging of the battery. It also protects the battery from overcharging and deep discharge. The stored energy in the battery is then used to power the controller and LED street lights during the night. This arrangement ensures a continuous and reliable power supply for the street lighting system [21].

3.6. Performance testing

Performance testing is carried out to check whether the system works properly and efficiently. During testing, each component—such as the solar panel, battery, sensors, controller, and LED lights is observed to ensure they function as expected, with their specifications presented in Table 1. The system is tested under different conditions, such as day and night, and when motion is detected on the road. This helps verify that the lights turn ON and OFF automatically and that the system operates smoothly. The testing results confirm that the system works reliably and saves energy.

Table 1. System parameters

No.	Parameter	Typical value/range
1	Solar panel power	20 W–150 W
2	Solar panel voltage	12 V/24 V
3	Battery capacity	12 Ah–100 Ah
4	Battery voltage	12 V/24 V
5	LED lamp power	5 W–60 W
6	Controller efficiency	85%–98%
7	Operating time	8–12 hrs
8	System voltage	12 V/24 V
9	Charging time	5–8 hrs
10	Battery type	Lead-acid/Li-ion
11	Light control threshold	10–50 lux
12	Load current	0.5–5 A

4. RESULTS AND DISCUSSION

Figure 2 shows the experimental setup of the proposed system works by combining solar energy, sensors, and a microcontroller to provide automatic and energy-efficient street lighting. During the daytime, the solar panel absorbs sunlight and converts it into electrical energy. This energy is stored in a rechargeable battery, which acts as the power source for the system during the night. A charge controller is used to regulate the charging process and protect the battery from overcharging or damage.

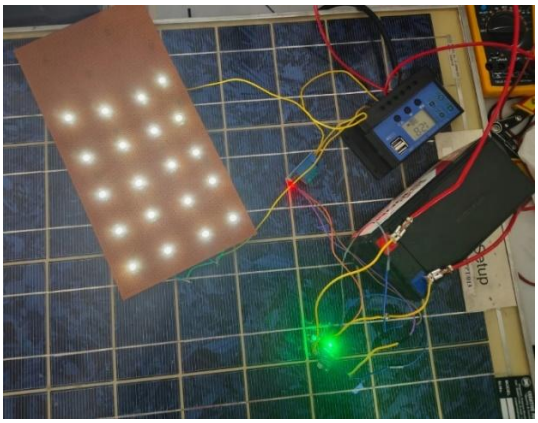


Figure 2. Solar-based street lighting system with automatic control unit

The system uses an LDR to detect the intensity of light in the environment. When there is sufficient sunlight, the resistance of the LDR decreases and the street lights remain OFF. When the light level decreases

in the evening, the resistance of the LDR increases and it sends a signal to the microcontroller, indicating that it is night-time. The microcontroller then activates the street lighting system.

Once the system is active, an IR sensor is used to detect the movement of vehicles or pedestrians on the road. When motion is detected, the microcontroller receives the signal and turns ON the LED street lights to provide proper illumination. When there is no movement on the road, the lights remain OFF or operate at a lower brightness level, which helps in reducing unnecessary power consumption. In this way, the system ensures that the street lights operate only when required. By using solar power, automatic sensing, and smart control, the system reduces energy wastage, lowers electricity costs, and provides an environmentally friendly solution for modern street lighting.

The developed system was tested to evaluate its performance and efficiency in providing automatic street lighting. During the testing process, the solar panel successfully collected solar energy during the daytime and stored it in the battery through the charge controller. The stored energy was sufficient to power the street lights during nighttime operation.

The LDR sensor effectively detected changes in light intensity. When there was enough sunlight, the system kept the street lights turned OFF. As the light intensity decreased in the evening, the LDR detected darkness and sent a signal to the controller, which automatically turned ON the LED street lights. When daylight returned, the controller switched the lights OFF again.

The LED street lights provided sufficient illumination while consuming less power compared to traditional street lights [22]. The overall system operated smoothly and demonstrated reliable automatic control without the need for manual intervention. From the results, it was observed that the system can significantly reduce electricity consumption, minimize energy wastage, and lower operational costs. Therefore, this solar-powered automatic street lighting system can be considered an effective and environmentally friendly solution for modern street lighting applications [23].

5. CONCLUSION

In conclusion, the proposed solar-powered automatic street lighting system provides an efficient and reliable solution for street illumination. By using solar energy, sensors, and a controller, the system operates automatically without the need for manual control. The solar panel collects energy during the day and stores it in the battery, which is then used to power the street lights at night. The use of the LDR sensor helps the system detect day and night conditions, ensuring that the lights turn ON only when it is dark and turn OFF during the daytime. This helps in reducing unnecessary power consumption. The LED lights also contribute to energy savings due to their low power usage and long lifespan. Overall, the system helps save energy, reduce electricity costs, and promote the use of renewable energy. It is a practical and environmentally friendly solution that can be used for street lighting in cities, highways, and rural areas.

REFERENCES

[1] Y. Wu, C. Shi, X. Zhang, and W. Yang, "Design of new intelligent street light control system," in *IEEE ICCA 2010*, IEEE, Jun. 2010, pp. 1423–1427, doi: 10.1109/ICCA.2010.5524348.

[2] M. Al-Mahbashi, A. Ahmed, A. Khader, S. Ahmad, M. A. Damos, and A. Abdu, "A Robust Vision-Based Framework for Traffic Sign and Light Detection in Automated Driving Systems," *Computer Modeling in Engineering & Sciences*, vol. 146, no. 1, pp. 1–10, 2026, doi: 10.32604/cmes.2025.075909.

[3] M. D. Vijay, K. Shah, G. Bhuvaneswari, and B. Singh, "LED based street lighting with automatic intensity control using solar PV," in *2015 IEEE IAS Joint Industrial and Commercial Power Systems / Petroleum and Chemical Industry Conference (ICPSPCIC)*, IEEE, Nov. 2015, pp. 197–202, doi: 10.1109/CICPS.2015.7974074.

[4] M. Wali, T. Iqbal, A. Salam, and S. Syafrinal, "Designing a Solar-Powered IoT-Based Flood Early Warning System Prototype with Audio-Visual Alarm for Aceh Region," *Design Journal*, vol. 4, no. 1, pp. 18–40, Jan. 2026, doi: 10.58477/dj.v4i1.386.

[5] X. Ni, C. Kühnel, and X. Jiang, "Thermal Detection of People With Mobility Restrictions for Barrier Reduction at Traffic Lights Controlled Intersections," *IEEE Open Journal of Intelligent Transportation Systems*, vol. 7, pp. 908–922, 2026, doi: 10.1109/OJITS.2026.3672067.

[6] N. E. Kuamthab and F. Mustafa, "Development of Solar Powered LED Street Lighting with Auto Intensity Control," *Progress in Engineering Application and Technology*, vol. 2, no. 2, pp. 576–589, 2021.

[7] J.-J. Sáenz-Peñafiel, J.-L. Posadas-Yagüe, and J.-L. Poza-Lujan, "Validation of a Proposed Lighting Comfort Formula for User-Adaptive Street Lighting Systems," in *Distributed Computing and Artificial Intelligence, 22nd International Conference*, 2026, pp. 243–253, doi: 10.1007/978-3-032-04160-9_22.

[8] A. Mukhtar and M. R. Kumar, "Advance Solar Power LED Street Lighting With Auto Intensity Control," *Journal of Emerging Technologies and Innovative Research (JETIR)*, vol. 7, no. 5, pp. 974-983, 2020.

[9] S. M. Qaisar, W. M. Alzahrani, F. M. Almojalid, and N. S. Hammad, "A Vehicle Movement Based Self-Organized Solar Powered Street Lighting," in *2019 IEEE 4th International Conference on Signal and Image Processing (ICSIP)*, IEEE, Jul. 2019, pp. 445–448, doi: 10.1109/SIPROCESS.2019.8868384.

[10] D. Sunehra and S. Rajasri, "Automatic street light control system using wireless sensor networks," in *2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI)*, IEEE, Sep. 2017, pp. 2915–2919, doi: 10.1109/ICPCSI.2017.8392257.

[11] S. Ahmed, N. Tasneem, M. Saidur, R. Ahmed, and H. Zenan, "Solar Powered Traffic Sensitive Automated LED Street Lighting

System," BRAC University, 2012.
[12] I. Pujotomo and R. A. Diantari, "Smart Solar-Powered Street Light Monitoring and Control System," *Advanced Science Letters*, vol. 24, no. 12, pp. 9675–9677, Dec. 2018, doi: 10.1166/asl.2018.13111.
[13] M. A. Wazed, N. Nafis, M. T. Islam, and A. S. M. Sayem, "Design and Fabrication of Automatic Street Light Control System," *Engineering e-Transaction*, vol. 5, no. 1, pp. 27–34, 2010.
[14] N. Kumar and M. Kumar, "Controlling of Solar Powered LED Street Lights Using Auto-intensity Control Mechanism," in *Smart Energy and Advancement in Power Technologies*, Singapore: Springer, 2022, pp. 301–311, doi: 10.1007/978-981-19-4971-5_23.
[15] A. Jain and C. Nagarajan, "Efficient Control Algorithm for a Smart Solar Street Light," in *2015 9th International Conference on Next Generation Mobile Applications, Services and Technologies*, IEEE, Sep. 2015, pp. 376–381, doi: 10.1109/NGMAST.2015.40.
[16] D. A. Devi and A. Y. L. Kumar, "Design and Implementation of CPLD based Solar Power Saving System for Street Lights and Automatic Traffic Controller," *International Journal of Scientific and Research Publications*, vol. 2, no. 11, 2012, doi: 10.13140/RG.2.2.11523.60963.
[17] K. E. Ch. V. Sagar, H. Alchilibi, N. M. Raslan, B. Jyothi, K. S. Kumar, and A. Lalitha, "Design and Implementation of a Solar powered LED Street Lighting System with Automatic Intensity Control for Energy Efficiency," in *2024 International Conference on Augmented Reality, Intelligent Systems, and Industrial Automation (ARIIA)*, IEEE, Dec. 2024, pp. 1–4, doi: 10.1109/ARIIA63345.2024.11051566.
[18] N. Lokhande, E. Patil, R. Kapadi, and M. Tamboli, "Embedded System Based Smart Street Light," *Journal of Integrated Engineering Sciences*, vol. 2, no. 1, pp. 01–11, Apr. 2026, doi: 10.63686/jies.v2i1023.
[19] S. C. Abadi, D. J. Saputro, M. N. Rizal, A. Mulyadewi, and E. Mardoyo, "Street Lighting Design with IoT-Based Energy Management in Cibuluh Village," *Brilliance: Research of Artificial Intelligence*, vol. 6, no. 1, pp. 54–61, Feb. 2026, doi: 10.47709/brilliance.v6i1.7853.
[20] L. He and W. Feng, "Optimization of traffic light scenario algorithms for Apollo-based autonomous driving," in *International Conference on Frontiers of Traffic and Transportation Engineering (FTTE 2025)*, F. Gao and J. Wu, Eds., SPIE, Feb. 2026, p. 153, doi: 10.1117/12.3102532.
[21] A. Kumar and S. Prajapati, "Solar-powered urbanization," *Solar-Powered Urbanization for a Sustainable Future*. CRC Press, 2026, doi: 10.1201/9781003652229.
[22] W. Y. Leong, "Smart Pavement Systems with Embedded Sensors for Traffic and Environmental Monitoring," in *8th International Conference on Knowledge Innovation and Invention*, Basel Switzerland: MDPI, Jan. 2026, p. 12, doi: 10.3390/engproc2025120012.
[23] L. G. Rodríguez, L. C. Santos, and M. I. L. Galdo, "Engineering Sustainable Escape Lighting Systems for Marine Vessels: A Photovoltaic and ATS-Based Approach," in *The 1st International Online Conference on Marine Science and Engineering (IOCMSE 2025)*, Basel Switzerland: MDPI, Feb. 2026, p. 2, doi: 10.3390/eesp2026041002.