Sunlight Uses in IT Office

A PROJECT REPORT

Submitted by,

DEEPIKA C.S - 20211COM0075

DISHIK L SETTY - 20211COM0006

PAAVANA GOWDA - 20211COM0029

Under the guidance of,

Ms. IMPA BH

in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

COMPUTER ENGINEERING

At

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY

BENGALURU

JANUARY 2025

PRESIDENCY UNIVERSITY

SCHOOL OF COMPUTER SCIENCE ENGINEERING

CERTIFICATE

This is to certify that the Project report **"Sunlight Uses in IT Office"** being submitted by **"DEEPIKA C. S, DISHIK L SETTY, PAAVANA GOWDA"** bearing roll number(s) **"20211COM0075, 20211COM0006, 20211COM0029"** in partial fulfilment of requirement for the award of degree of Bachelor of Technology in Computer Engineering is a Bonafede work carried out under my supervision.

Ms. IMPA BH
Assistant Professor
School of CSE
Presidency University

Dr. Gopal Krishna Shyam
Professor & HOD
School of CSE&IS
Presidency University

Dr. L. SHAKKEERA
Associate Dean
School of CSE
Presidency University

Dr. MYDHILI K NAIR
Associate Dean
School of CSE&IS
Presidency University

Dr. SAMEERUDDIN KHAN
Pro-Vc School of Engineering
Dean -School of CSE&IS
Presidency University

PRESIDENCY UNIVERSITY

SCHOOL OF COMPUTER SCIENCE ENGINEERING

DECLARATION

We hereby declare that the work, which is being presented in the project report entitled **"Sunlight Uses in IT Office"** in partial fulfilment for the award of Degree of **Bachelor of Technology in Computer Engineering,** is a record of our own investigations carried under the guidance of **Impa B H,** Assistant Professor School of Computer Science Engineering & Information Science, Presidency University, Bengaluru.

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

ROLL NUMBERS	NAMES	SIGNATURE
DEEPIKA C. S	20211COM0075	Deeni
DISHIK L SETTY	20211COM0006	
PAAVANA GOWDA	20211COM0029	Paavana

ABSTRACT

This study explores the harvesting and use of direct solar rays for solar lighting systems in a non-residential building. This system uses natural daylight, thus reducing energy consumption while providing clean and renewable sources of energy. Incorporating this daylighting into a building sustains the natural alternative to traditional electric lighting energy use and ecological impact. This proposed system consists of three basic elements: a light collector mounted on the building's wall, a modular light conduit ceiling attached along the false ceiling plane, and light extractor fittings that provide the best distribution of light. Together, they capture, guide, and disperse sunlight effectively throughout interior spaces. While a personalized system may adapt to specific characteristics of the particular building, such as orientation, latitude, and longitude, it ultimately utilizes day lighting to reduce reliance on electric lighting, improving energy savings. This paper offers a critical review of the anidolic collector system and its use in modern daylighting frameworks. A particular emphasis is laid on the patient optimization of parameters like light transmission and diffusion, yielding well-illuminated interior occupations, even during variable sunlight availability during the day. The arrangement of various optical components in the system further improves its performance, efficiency, and effectiveness. In connection with this daylighting framework, various experiments have been conducted to assess its efficacy in the physical environment. Testing was performed in a functioning prototype within the Lledó S.A. premises, where continued testing and eventual modification are ongoing. Insight from such trials may help inform future changes and assist in their widespread application in commercial and institutional buildings. Integrating innovative daylighting techniques, the solar lighting system indicates a great advance in sustainable architecture. These observations and conclusions form the basis for further developing new lighting solutions that are in line with world efforts to reduce acute energy consumption and carbon footprints.

ACKNOWLEDGEMENT

First of all, we indebted to the **GOD ALMIGHTY** for giving me an opportunity to excel in our efforts to complete this project on time.

We express our sincere thanks to our respected Dean **Dr. Md. Sameeruddin Khan,** Pro-VC, School of Engineering and Dean, School of Computer Science Engineering & Information Science, Presidency University for getting us permission to undergo the project.

We record our heartfelt gratitude to our beloved Associate Deans **Dr. Shakkeera L and Dr. Mydhili K Nair,** School of Computer Science Engineering & Information Science, Presidency University, and Dr. Gopal Krishna Shyam Head of the Department, School of Computer Science Engineering & Information Science, Presidency University, for rendering timely help in completing this project successfully.

We are greatly indebted to our guide **Impa B H,** Assistant Professor School of Computer Science Engineering & Information Science, Presidency University for her inspirational guidance, and valuable suggestions and for providing us a chance to express our technical capabilities in every respect for the completion of the project work. We would like to convey our gratitude and heartfelt thanks to the PIP2001 Capstone Project Coordinators Dr. Sampath A K, Dr. Abdul Khadar A and Mr. Md Zia Ur Rahman, department Project Coordinators Dr. Sudha P and Git hub coordinator Mr. Muthuraj. We thank our family and friends for the strong support and inspiration they have provided us in bringing out this project

DEEPIKA C S(20211COM0075)
DISHIK L SETTY(20211COM0006)
PAAVANA GOWDA(20211COM0029)

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

CHAPTER-1

INTRODUCTION

It is not a novel revelation that all stakeholders today are awakening to the realization of the impacts renewables can have on buildings. Everybody is engaged in changing the mentality as well as economic strategies of all the sectors that are involved to find an immediate necessity to undertake suitable training about the handling of materials, applications for structural construction as well as energy attribute of conservation and degradation from the environment. Examples of this are the United Nations Environment Program's "Global Green New Deal" (March 9, 2009), the European Commission's "Greenlight" project (March 2006), and the "Greenbook" Commission of European Communities (March 2006).

It's now a matter of common understanding that daylighting is largely accepted by office buildings without the need for arguments whatsoever. Daylighting saves space in conjunction with enhancing the health of the building's occupants. When a building benefits its occupants, they, in turn, benefit the company and its owners through enhanced employee performance facilities [4], [5]. Certainly, daylighting systems provide for considerable inbuilt effects for the beneficial growth of a building's occupants and so should be given serious consideration in building design since these systems can satisfy building owners as well as the population as a whole. It is thus mandated that visual comfort in rooms be provided in terms of qualities and criteria for illumination levels, luminance, glare index, and color composition. The required level may also be dependent on what activities are to be conducted in them.

At present, everybody is at work to secure some reduction for the possibility of the CO_2 emissions. The era when the first consumer was energy brought with it the obligation of conservation once more. Similarly, in Spain, the impact of task lighting in commercial buildings is around 22% of energy consumption, while a law, negotiated with technology about its efficiency, establishes minimum standards for such buildings, BOE 28 March 2006. Real decreto 1369/2009, for the ecological design of energy devices, Directive CE-91/2002 about energetic efficiency on real buildings).

Optical design is of great value in applications where high concentration and therefore high-efficiency perforation matter. For instance, anidolic systems would make this potential in these directions much bigger; however, sadly, not many commercial solutions are available currently, the main blame stemming from hefty manufacturing and installation costs. The recent literature is filled with descriptions of anidolic daylight systems on buildings (from the Solar Energy and Building Physics Laboratory-LESO) concerning integrated design, simulations and results for façade applications in a building.

The design has in view to employ light for the lighting of buildings towards building facades and is to be adaptable to the particularities of a building even though a boost can be seen in performance once fitted into the building planning. Morning studies have shown that it provides potential as light on the premise that the optimization of solar energetics did indeed fail in the second round for the firms.

This work is part of the ADASY project, though the whole daylighting system is already developed and its prototype is installed in the facilities of Lledó S.A. this work mainly targets the collecting system and crystalizing its design optimizational process. This will involve an examination of the problem concerning the specific functions assigned to each of its component parts; investigations, therefore, will be classified accordingly-collection, transmission and distribution of light.

The collector first carries out the addition of all the possible light flux, as high-luminosity duct has been oriented in a high-reflectivity manner; the second one does this under a different point of light concerning the caption systems of light T-CPC(Truncated Compound Parabolic Concentrator) matrix geometry.

The subsequent assessment tests the performance of selected collectors, imposing a few plenary solar irradiance condition specifically applicable to the city of Madrid. The innovation in this collectors' system relies on the optimal selection of the various geometrical parameters of the dipole matrix, such as compact ratio and tilt angle.

After striking the top, sunlight power is transferred into other areas in the room where the direct sunlight cannot reach. The conversion is done through the horizontal light is then coursed through these devices, which contain a highly reflective mirroring system by means of total internal reflection. A study will be presented dealing with the behavior of light in this medium so that one could estimate losses, which would certainly be relevant to design the subsequent light extraction and distribution system.

Finally, a light extraction/distribution system needs assembling, aimed at aggrandizing the efficacy of the distribution of light within the room as uniformly as possible. This will include multiple extraction devices that will gauge varying powers of irradiance and include surfaces exhibiting variants in roughness to circumvent "hot spots".

CHAPTER-2

LITERATURE SURVEY

In order to confront notable challenges in the building sector in the European Commission, accountable for about 40% of energy consumption and 36% of greenhouse gas emissions, the scientific community guided by policy makers is running round the clock to deliver and adopt into practice innovative solutions and advanced practices and regulations, respectively. In recent years the building regulations have been giving a boost to phased decarbonization in the building sector, heightening energy performance of the building by gradually introducing new requirements. Retreating 2010, the recast Energy Performance of Buildings Directive (EPBD) must impose requirements geared toward the long-term goal of meeting environmentally and energy-efficient programs based on nearly Zero Energy Buildings (nZEB) for both new and existing buildings. This introduces several measures for energy efficiency across the public building sectors, considering certain drivers and barriers [2], and optimized how it was calculated [3].

A declaration of nZEB is THE building combining levels of energy consumption while generating energy from renewable sources; also, generating the required percentage that minimally offsets energy demands for thermal comfort. A special focus with regard to nZEB performance is how to accommodate or integrate the renewable systems placed within the confines of the building or adjacent to them. These renewable technologies are usually supplied to the building envelope - mainly walls and roofs.

Typically, the building facade is a transitional interface that accommodates the outer atmosphere and the indoor ambience. By the interaction of renewable energy (especially solar), the building facade is authoritative in defining occupants' comfort, energy demands, and aesthetics. A number of variables must thus be looked at when it comes to designing a façade design, climate and surrounding conditions, architectural interior and spatial characteristics, occupant preferences regarding comfort and costs, etc. From the engineering and architectural points of view, In recent years there has been growing interest paid towards the strategic development of the façades of buildings, which meet some high-performance regulations while perhaps not being aesthetically pleasing.

This strategic development brings forth an integrated system of technology and innovations into the formal widened extent of functions of the fa?aud? [4].

In this case, facade elements can present energy flexibility to the buildings with regard to thermal competence of composite elements according to the climate profile and based on usage of the building-and flameless by the ability to adapt or automate to alter the imposed conditions. Really, from the sensing of an innovation-based adaptation framework for facade elements, other such innovations based on renewable energy could become serious candidates for improvements in energy demands in buildings [5].

Whole buildings take a broad multi-scale, multi-material form, with a conviction for the exceptional-a framework on approaches tending to analysis with a predominately large effect. Turning toward that sector, BIPV stands at close proximity with works at a scholarly level on design, control, and application to a built setting; it would become much harder to infuse functional systems that are flexible while not normally relevant, while one has to reconcile such conflictual factors as life-cycle assessment and real enhancement this lends to energy amelioration and reduction [6].

This paper presented a general view of some studies on integrated solar energy systems installed on building-enveloping structures published in the last five years. The main features of the reviewed works, their results through comparative table classification, and a discussion pointing out trends in this field.

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

1. **Limited Sunlight Utilization**

At this time, the sunlight applications are rather ineffective ways of distributing natural light all over wide office spaces. It is suggested they work by means of mirrors and reflective surfaces, but certainly, these make it no easier to transfer light over larger distances, while reflection loss becomes definitely a concern.

2. **Energy Storage and Management**

Many schemes do not integrate solar energy storage into a functional light automation interface. The near-ideal sample code contains code for solar panel and battery monitoring; however, predictive energy management or smart algorithms that combine historical patterns or weather forecasts to provide flexible energy load management functionality are not immediately available.

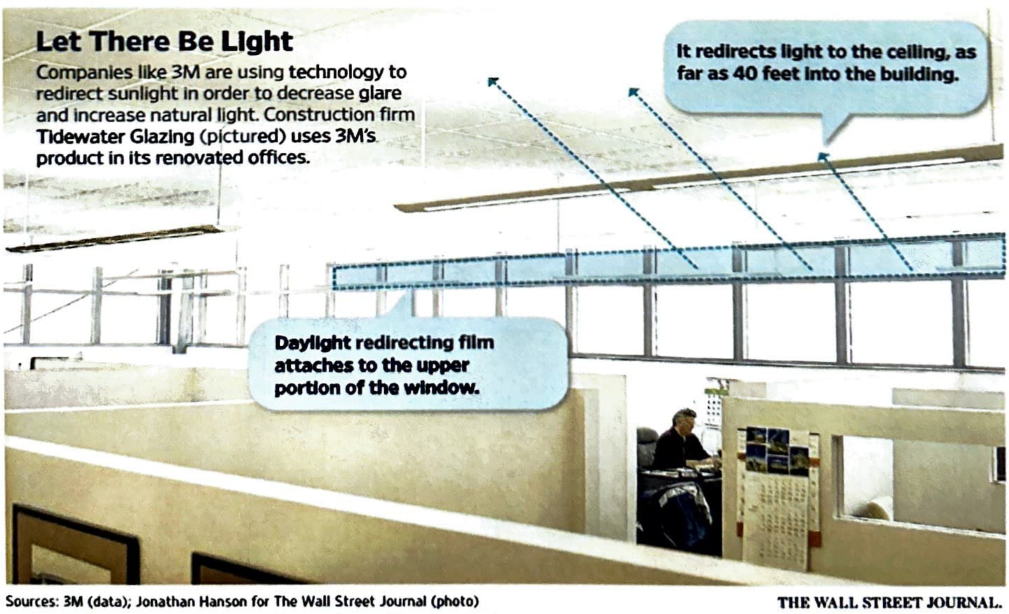


Fig 1(Daylight redirecting film attaches to the upper portion of the window.)

3. **Light Intensity Regulation**

There are not any few but very few solutions that provide dynamic intelligent control of artificial lighting relative to the natural light coming inside a particular room. This project proposes to take action upon this on LDR-based automation which doesn't incorporate sophisticated mechanisms for the luminous intensity calibration needed to achieve uniform lighting in offices.

4. **Heat Management of Mirrors**

The reflective systems directing sunlight onto the mirrors could create some heat problems. With the constant incidence of sunlight, the mirrors might become warm enough to interfere with their efficiency and thus may require cooling means, which are not referred in this regard.

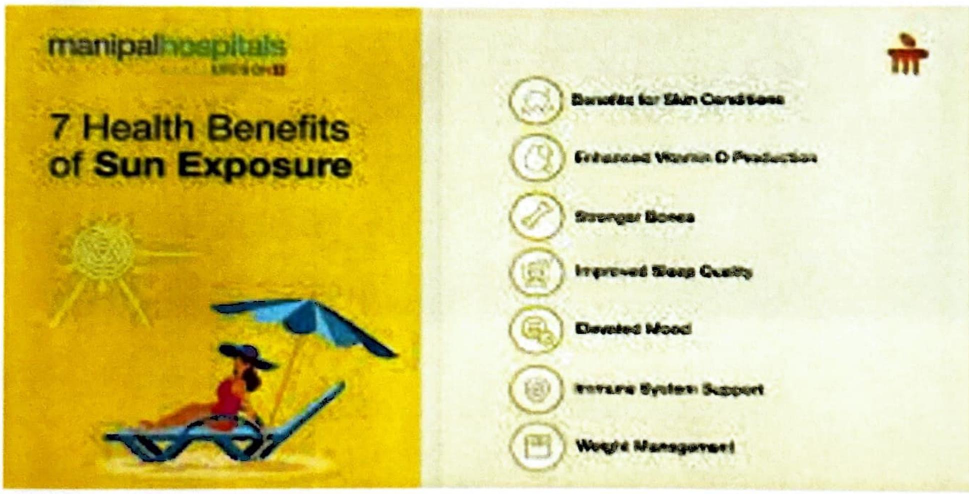


Fig 2(Benefits of the sun exposure)

5. **System Scalability and Durability**

While this method is viable for small-scale mini-projects, it didn't delve deeply into the problem of scalability for IT office premises or large commercial buildings. Not addressed in any way are questions regarding the durability of hardware components, long-term maintenance costs, as well as sturdiness and efficiency of mirrors and solar panels.

6. **Integration with Smart Building Systems**

Modern offices are increasingly switching to IoT and smart building technology. The mentioned system, however, does nothing to address the compatibility with such ecosystems that would allow centralized control and distant monitoring but also allow the integration with other energy-saving measures such as HVAC system control.

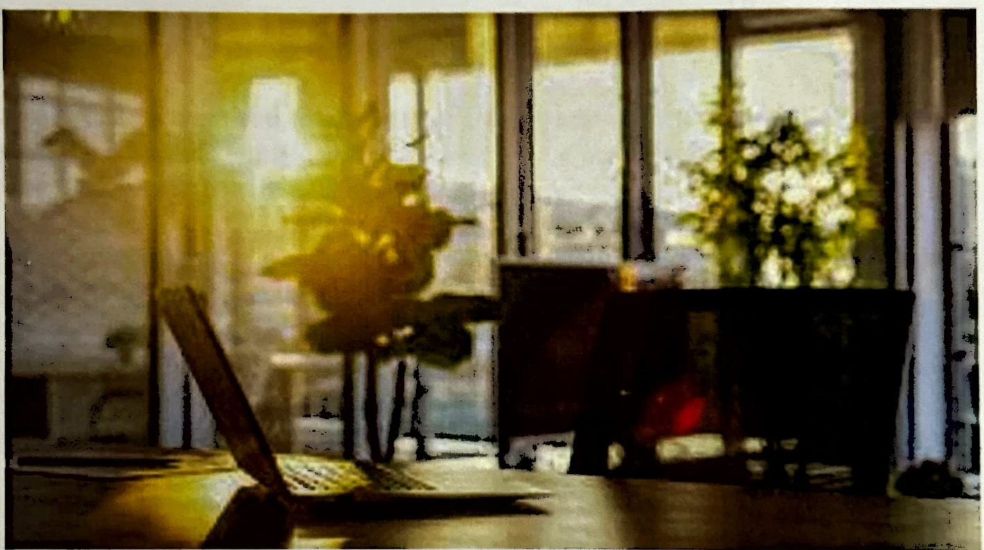


Fig 3

7. **Aesthetic and Design Constraints**

Practical difficulties arising from the use of large-sized reflective tubes and systems of mirrors in working space come from their aesthetic nature and spatial constraints, which the approach adopted here did not take into consideration.

8. **Environmental Variability**

The system assumes a consistent sunlight and being exposed to weather variability, such as humidity-an affect that dispersed very much-seasonal changes, and even dust covering mirrors-were not factored into that performance.

CHAPTER-4

PROPOSED METHODOLOGY

This study deals with the capture and use of direct solar rays for solar lighting systems in a non residential building. This system utilizes natural daylight during the day, which greatly reduces energy consumption and provides a clean and renewable energy source. A building incorporating daylighting creates a natural alternative for electric lighting usage concerning energy demands and potential ecological impacts.

The proposed system consists of three main elements: a light collector mounted at the wall of the building, a modular light conduit ceiling affixed along the plane of the false ceiling, and light extractor fittings so as to achieve the best light distribution. All these components capture, guide, and scatter sunlight very effectively in the interior space.

While the personalized systems might adapt to a unique set of features of the specific building, e.g., orientation, latitude and longitude, it therefore ultimately uses day lighting in order to cut back on electric lighting and thereby enhance energy savings.

The paper reviews the anidolic collector system and its application in modern daylighting systems. The main focus is on the incremental optimization of parameters such as light transmission and diffusion, which lead to an increase in lux level in the interior working environment even under dynamic sunlight variability during the daytime. Furthermore, the arrangement of different optical components in the system serves to enhance its performance, efficiency, and effectiveness.

Numerous tests have been conducted in connection with this daylighting system in order to assess its effectiveness in the physical environment. Testing was carried on a working prototype at Lledó S.A., where further testing and modifications are still underway. Knowledge gained from such trials may serve as a guiding light for future modifications and help effect their wide application in commercial and institutional buildings.

The solar lighting system, integrating new daylighting techniques, points to a great advance in sustainable architecture. These observations and conclusions form the basis for further development of new lighting solutions which remain in keeping with world efforts to eliminate acute pollution, landscape and ecological distortion and consumption and footprint energy. structural and comparative analysis on different technology progress concerning façade-integrated solar energy systems.

The classification itself refers to some core tendencies and development of technology in respect to façade BI-SES systems. For thermal systems, the areas examined were thermal management, insulation properties, and energy efficiency gains; with photovoltaic integrated systems examined for energy conversion efficiency, material properties, and design. Hybrid systems were reviewed on combined performance, acceptability of integration, and potential energy savings.

However, this in-depth review of several experimental and numerical studies brings to the limelight the methods adopted for their performance evaluations; while the experimental studies were largely based on real-world installations and test setups, the numerical analyses applied computational models and simulation technologies to predict system performance against defined environmental conditions.

The procedures developed in this study facilitate a systematic and holistic interpretation of the design systems of façade-integrated solar energy. The formalized presentation of the analysis center, based on the study type, technological type, and methodological model, affords great insight into the development trajectories and future directions of BI-SES applications. It contributes to expanding the datastores of knowledge within modern sustainable building technologies and thus emphasizes the role of integrated solar solutions in pushing green energy-efficient architectural designs forward.

CHAPTER-5

OBJECTIVES

1. **Efficient Sunlight Utilization**

Design and implement a system that can collect and equally distribute harvested sunlight through vast office spaces so that artificial lighting could be reduced to minimum levels during daylight periods.

2. **Automated Lighting Control**

Design and set up a lighting automation system that works on the principle of detecting the ambient light levels by employing a light-dependent resistor sensor to automatically switch on or off the artificial lights based on the overall brightness of the environment.

3. **Energy Savings through Solar Integration**

The use of energy generated by solar panels as incorporated within the lighting systems offers such benefits as supplying power for artificial lights when there is low sunlight and therefore an immediate role in effective electrical energy conservation.

4. **Battery Monitoring System**

In-built in the solar panel battery will be a voltage monitor, enabling excursionously prompt service previously in order to provide an efficient method of usage of energy and legislative functionality.

5. **Dynamic Light Adjustment**

A system should be created which will automatically switch on or off the artificial lights in distinguishably separate zones within the territory of the office environment to optimize lighting conditions yet still be sufficiently energy-efficient as per the users' comfort.

6. **Hardware Demonstration**

To be done as a working prototype mini-project of the proposed system in real conditions, consisting of coupled sunlight dampening and light automation by means of solar energy use.

7. **Energy Efficiency Optimization**

Aimed at assessing how energy consumption in IT offices can be reduced by replacing conventional lighting systems with a hybrid sunlight/solar-powered artificial lighting system.

8. **Environmental Impact Reduction**

To encourage the practice of sustainable energy by implementing renewable energy in large office spaces and reducing its dependency on non-renewable-based electricity.

CHAPTER-6

SYSTEM DESIGN & IMPLEMENTATION

1. System Overview

This system suggests optimizing lighting in large office spaces using natural sunlight, solar power, and automatic lighting controls. More specifically, it entails a system of sunlight collection and diffusion mechanisms, a solar energy storage unit, and automatic environmental brightness-controlled lightings.

2. Key Components

➢ **Sunlight Collection and Reflection Mechanism:**

- Sunlight collection and reflection system
- Large reflective tubes placed outside the building collect sunlight.

➢ **Solar Energy Storage:**

- Solar panels collect sunlight and store energy in batteries, which is then used to power artificial lights.
- That energy is used to power artificial lights during low or no sunlight.

➢ **Light Automation:**

- An LDR sensor detects ambient light.
- The relay module turns on and off the artificial lights automatically according to the reading from the LDR.

➢ **Monitoring and Display System:**

- The voltage monitoring circuit with a voltage divider measures the charge level of the battery.

- An LCD monitors real-time voltage levels and lighting status so that the user is informed.

3. System Design

➢ **Hardware Design:**

- **Sensors:** The LDR detecting light intensity and voltage divider for battery monitoring.
- **Actuators:** The relay that controls the switch of the artificial lights on and off.
- **Solar Power Unit:** Solar panel and rechargeable batteries store energy for use purposes.
- **Display Module:** An I2C-based LCD, which displays voltage and lighting status..

➢ **Software Design:**

- Arduino microcontroller programmed in C++
- Reads input from the LDR and voltage sensors and controls the relay.
- The light shall only turn on if it is dark, whether the daylight or solar-powered batteries have drained down and may be unusable at this point.

4. Implementation Details

➢ **Circuit Connections:**

- A1 pin of the Arduino connected to the LDR to sense ambient light intensity.
- Analog-to-digital voltage divider for sensing battery voltage for configuration.
- A relay module to digital pin 2 to control lights.
- LCD I2C interface with the Arduino displays system status.

➢ **System Logic Flow:**

- **Sunlight Detection:**
  - The light-dependent resistor (LDR) would measure ambient light intensity.
  - As light levels drop below a certain preset level, the relay would then turn on, powering the artificial lights.

- **Solar Power Management:**
    - Battery is regulated by voltage coming from a solar panel, ensuring sufficient charge in battery and hence supply for lights.
    - Caution signals are generated using LCD, to alert user when the voltage in the panel is below the specified threshold.
- **Automated Control:**
    - The relay will automatically operate the lights using the LDR input to switch them on and off.
    - The system works on automatic control and needs no manual intervention.
- **Code Implementation:**

- The Arduino code will take sensor readings, check for voltages, guide and operate the relay, and provide updates in the LCD, which takes full advantage of powering the lights on except where otherwise needed.

5. **System Benefits:**

- **Energy Efficiency:** Combination of natural sunlight and solar panel can greatly minimize electric consumption.
- **Automation:** No manual operation of backlights.
- **Real-Time Monitoring:** Notifies the user about battery voltage and light status.
- **Scalability:** The system can be scaled up to be used in wider office areas by adding mirrors and sensors for better lighting conditions in future. The design is sustainable, cost-effective, and ensures proper levels of lighting across large IT office spaces.

CHAPTER-7

TIMELINE FOR EXECUTION OF PROJECT

(GANTT CHART)

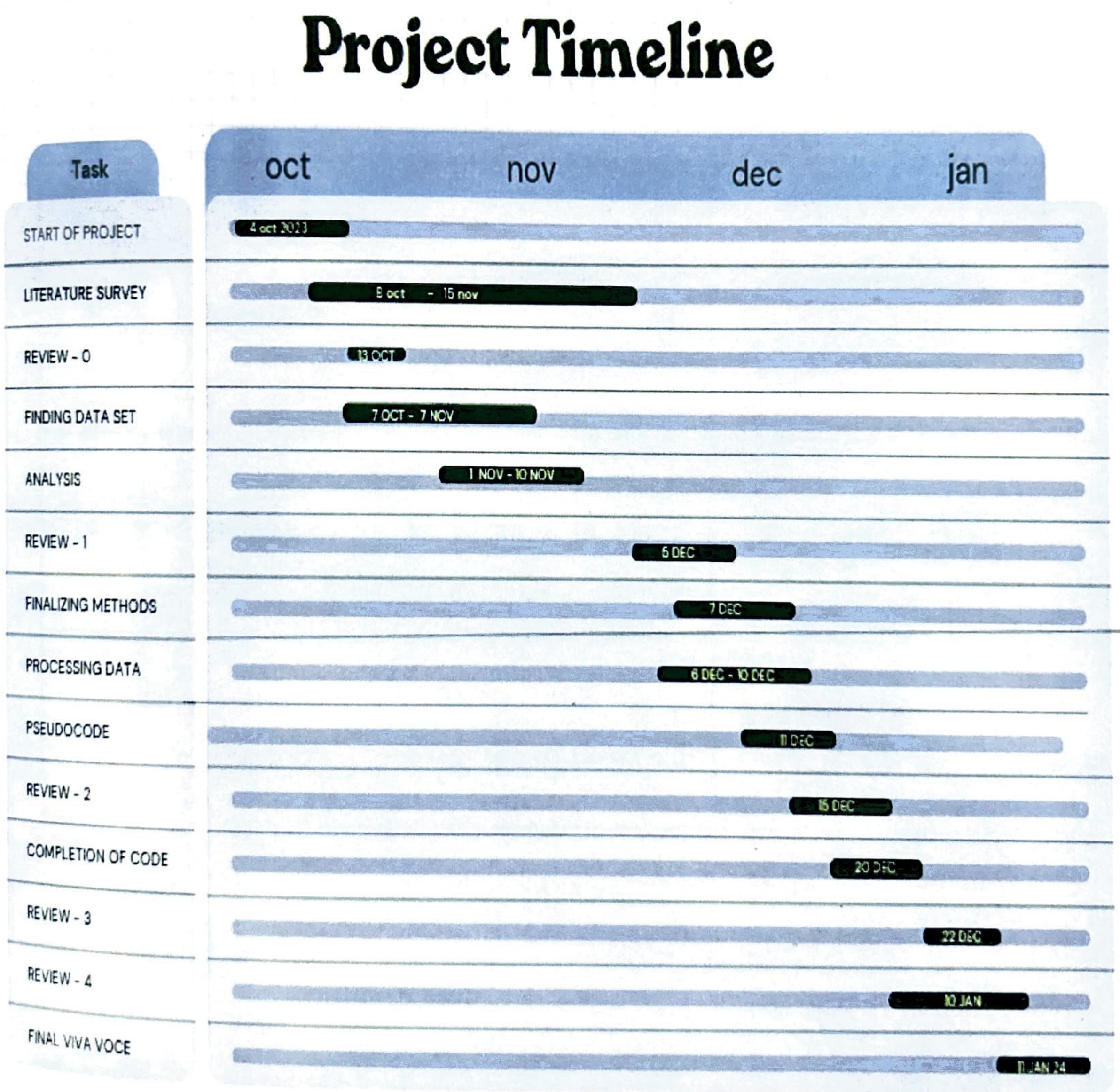


Fig 4

Sl. No	Review	Date	Scheduled Task
1	Review-0	09-10-23 to 13-10-23	Initial Project Planning
2	Review-1	23-10-23 to 02-11-23	Planning and Research
3	Review-2	19-11-23 to 26-11-23	Data Collection and Preprocessing, Model Implementation, Testing
4	Review-3	13-12-23 to 25-12-23	Optimization
5	Viva-Voce	01-01-25 to 12-01-25	Deployment and Evaluation

CHAPTER-8

OUTCOMES

- **Reduced Energy Consumption**

This system shows a large energy-saving potential through maximum use of natural sunlight and a supplement to the light source from solar PV through the use of solar-powered Artificial Lighting only when necessary.

- **Automated Lighting Control**

The system uses the LDR (Light Dependent Resistor) as a sensor to automatically adjust from light to darkness or vice versa. The LDR is used to operate the lighting control unit.

- **Efficient Solar Energy Utilization**

Solar panel and battery installations allow the office to be totally free from commercial power; the solar energy formed and stored during the day lights at low sunlight and night time.

- **Real-Time Monitoring and Feedback**

The use of the LCD display shows critical data in real-time regarding the solar battery voltage and lighting status. This helps the user monitor the performance of his system with ease.

- **Improved Sustainability**

The use of the LCD display shows critical data in real-time regarding the solar battery voltage and lighting status. This helps the user monitor the performance of his system with ease.

- **Cost-Effectiveness**

Thus this design ensures lower electricity bills, and minimizes the need for artificial light during the day, providing a low-cost approach to lighting solutions for IT offices

- **Enhanced User Experience**

Automation in the system ensures consistency in light conditions, thereby enhancing a user's comfort and productivity within the workspace.

- **Scalable and Adaptable Design**

Establishing the prototype on how buildings can integrate natural and solar power lighting systems is the foundation for implementing larger-scale projects.

CHAPTER-9

RESULTS AND DISCUSSIONS

RESULTS:

- **Energy Efficiency Achieved**

The automated lighting systems efficiently used natural sunlight and other forms of solar energy to lessen their dependence on ordinary electricity. Automatic lighting always ensured that neither energy nor the appropriate illumination conditions were wasted.

- **Successful Light Automation**

Light automation using LDR in the system always sensed the ambient light levels, turning on and off the artificial lights as necessary. A smooth light control operation without the added burdens of manual control was achieved.

- **Accurate Voltage Monitoring**

The voltage divider circuit displayed readings from the solar battery in real-time on the LCD, thus ensuring continuous monitoring of what energy is available for use with artificial lighting.

- **Operational Feasibility of the Prototype**

The mini project successfully demonstrated the practically achievable integration of natural sunlight, solar energy, and automated lighting systems. It has therefore effectively validated the practical feasibility of this particular design with respect to the avoidance of electricity consumption.

- **Improved User Convenience**

Automated operation with real-time monitoring contributed to user convenience: users could rely on the system for ensuring consistent lighting conditions without manual adjustment of the lights.

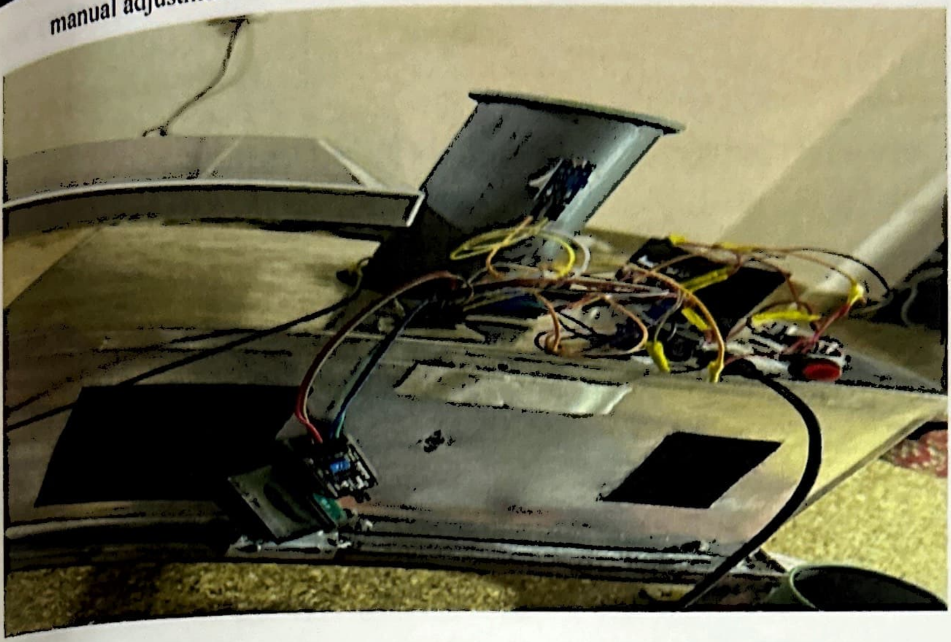


Fig 5(The final model)

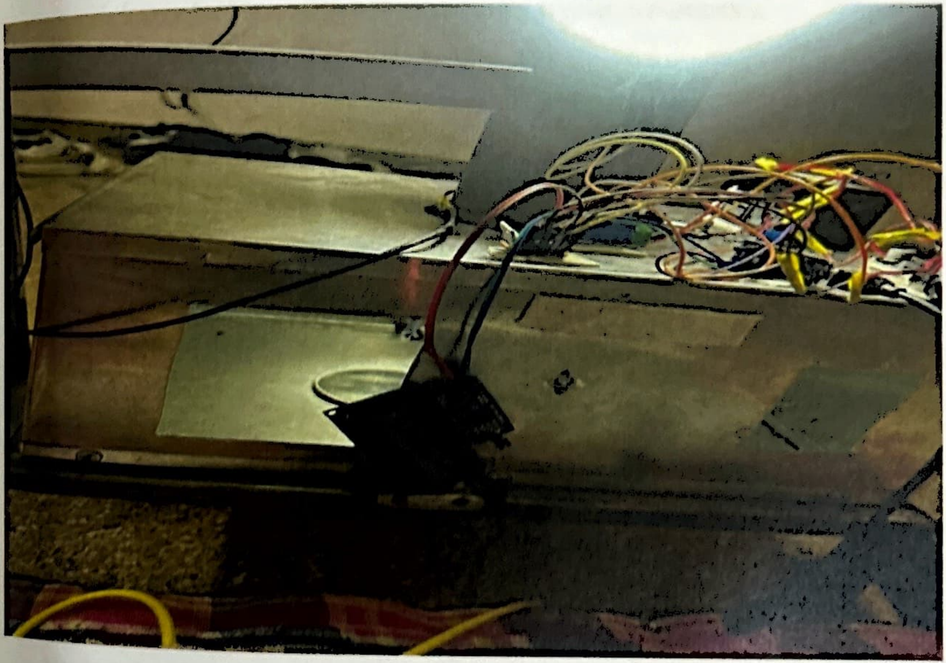


Fig 6(Working model)

DISCUSSION:

- **System Performance**

The automatic light control reflects a good management of light intensity from the sun, solar energy, and electric lighting. With the aid of the parabolic mirrors and the reflective tubes, enough sunlight reaching even a considerable distance has been recorded, but some small light losses through reflective surfaces were observed and would allow some further improvement.

- **Reliability of Light Detection**

The sensor can sense any variation in the ambient light conditions and thus can energize or de-energize the relay for switching on artificial lights in case of failed illumination. However, if dust or any obstruction is obstructing the LDR or the mirrors, it may lead to a malfunction, requiring regular maintenance.

- **Solar Energy Utilization**

The solar panel-battery combination has successfully energized certain artificial lights during dim sunlight situations. Another improvement could be the introduction of advanced energy management algorithms to optimize battery charge and discharge cycles to extend its service life.

- **Scalability Challenges**

The working prototype has served the purpose of proof of concept, but the potential to scale the system for larger office spaces could start being an issue. One major problem would be the even distribution of sunlight over great distances. This could also be solved by adding a mirror or by any advanced light-diffusion technology.

- **Environmental and Seasonal Factors**

External environmental conditions such as weather and seasonal variations in sunlight availability are known factors that contribute to the performance of the system. Backup power or hybrid energy systems will provide adequate confidence for use in sectors where periods of exposure to cloud saturation or extended rainy days become limiting options.

Future Improvements

- **Advanced Sensors:** Sophisticated sensor technology such as photodiodes or multi-spectrum sensors would provide more accurate light detection information.
- **Smart System Integration:** IoT capabilities could provide control and monitoring of the system and interaction with other smart building technologies.
- **Light Calibration:** Implementing dynamically adaptive light output according to the workspace needs will bring greater comfort to the user and further enhance energy efficiency.

SUN RAYS USES IN IT OFFICE

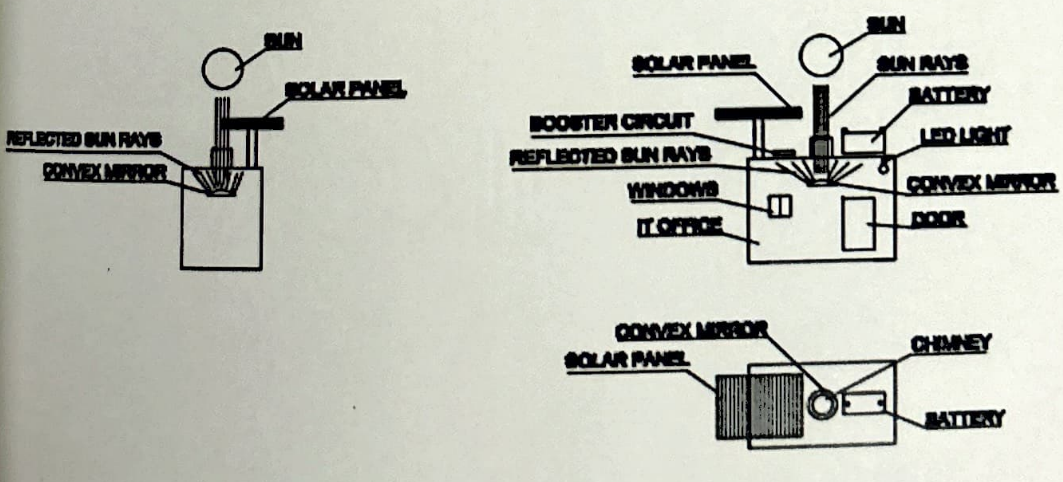


Fig 8

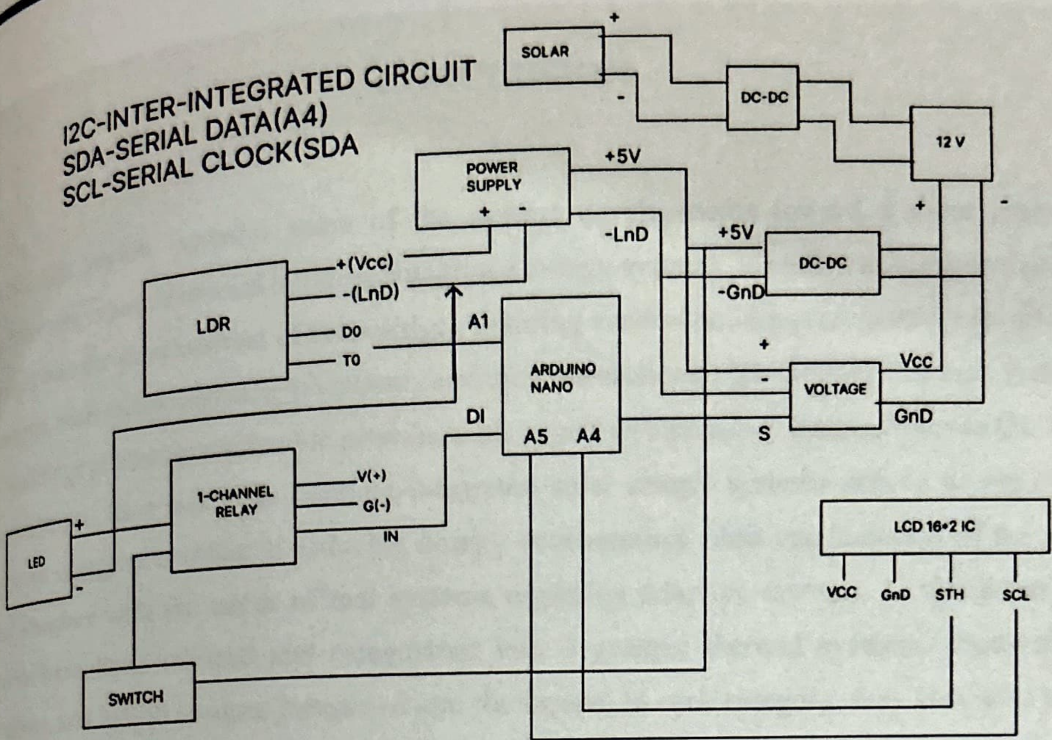


Fig 9(Architecture)

CHAPTER-10

CONCLUSION

While this review portrays some of the newest developments toward a more practical architecture oriented toward building-integrated energy systems, it aspires to bring forth some insight into the development of knowledge regarding various building-integrated solar energy systems, their technologies, applications, and their interactions with the grid. The wall systems of buildings possess considerable promise with regard to increasing sustainability in the built environment. Its a mix with building-integrated solar energy systems echoes its ability to enhance occupant comfort in reducing energy consumption, meet requirements of the grid, and interface with the needs of real systems regarding adaptive systems. In this paper, 71 works have been selected and categorized into 3 groups: thermal systems, photovoltaic systems, and hybrid systems integrated into the façade. In each category, they have also been sorted according to the type of study (if it applied), the technological tools employed, the variables of the parametric analyses, and performance evaluations pursued.

The results suggest that there is no convergence to a particular trend for these solar thermal systems. Instead, there is first priority in the active and passive integration approaches as per modularity and multifunctionality for a building element. Ranging from the innovative design of systems to new modes of operation and new materials, there have been some activities. The outcomes for photovoltaic systems from the current review identified three basic design trends: i) standard BIPV is enhanced by intelligent ventilation in that space, ii) use of photovoltaic technology integrated into building façades acting as a shading device.

REFERENCES

1. European Parliament 'Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)' Official Journal of the European Union 2010; 2010 [Google Scholar]
2. L. Aelenei, H. Petran et al., New challenge of the public buildings: nZEB findings from IEE RePublic_ZEB Project, Energy Proc. **78**, 2016–2021 (2015) [CrossRef] [Google Scholar]
3. L. Aelenei, S. Paduos et al., Implementing cost-optimal methodology in existing public buildings, Energy Proc. **78**, 2022–2027 (2015) [CrossRef] [Google Scholar]
4. M. Formentini, S. Lenci, An innovative building envelope (kinetic façade) with shape memory alloys used as actuators and sensors, Autom. Constr. **85**, 220–231 (2018) [CrossRef] [Google Scholar]
5. F. Pomponi et al., Energy performance of Double-Skin Façades in temperate climates: a systematic review and meta-analysis, Renew. Sustain. Energy Rev. **54**, 1525–1536 (2016) [CrossRef] [Google Scholar]
6. J. Borggaard et al., 'Control, estimation and optimization of energy efficient buildings, Proc. Am. Control Conf. 837–841 (2009) [Google Scholar]
7. A. Prieto et al., Feasibility study of self-sufficient solar cooling facade applications in different warm regions, Energies **11** (2018) [Google Scholar]
8. C. Maurer, C. Cappel, T.E. Kuhn, Progress in building-integrated solar thermal systems, Solar Energy **154**, 158–186 (2017) [CrossRef] [Google Scholar]
9. L.G. Valladares-Rendon, G. Schmid, S.-L. Lo, Review on energy savings by solar control techniques and optimal building orientation for the strategic placement of facade shading systems, Energy Build. **140**, 458–479 (2019) [Google Scholar]
10. A. Velasco et al., Assessment of the use of venetian blinds as solar thermal collectors in double skin facades in mediterranean climates, Energies **10** (2017) [Google Scholar]
11. Y. Sun et al., Thermal evaluation of a double glazing facade system with integrated Parallel Slat Transparent Insulation Material (PS-TIM), Build. Environ. **105**, 69–81 (2016) [CrossRef] [Google Scholar]
12. Y. Sun et al., Integrated semi-transparent cadmium telluride photovoltaic glazing into windows: Energy and daylight performance for different architecture designs, Appl. Energy **231**, 972–984 (2018) [CrossRef] [Google Scholar]
13. R. O'Hegarty, O. Kinnane, S.J. McCormack, Review and analysis of solar thermal facades, Solar Energy **135**, 408–422 (2016) [CrossRef] [Google Scholar]
14. C. Lamnatou et al., Modelling and simulation of Building-Integrated solar thermal systems: behaviour of the system, Renew. Sustain. Energy Rev. **45**, 36–51 (2015) [CrossRef] [Google Scholar]
15. A. Buonomano et al., Building-façade integrated solar thermal collectors: energy-economic performance and indoor comfort simulation model of a water based prototype for heating, cooling, and DHW production, Renew. Energy (2018) [Google Scholar]
16. R. Agathokleous *et al.*, Building facade integrated solar thermal collectors for air

heating: experimentation, modelling and applications, Appl. Energy **239**, 658–679 (2019) [CrossRef] [Google Scholar]

17. C. Garnier, T. Muneer, J. Currie, Numerical and empirical evaluation of a novel building integrated collector storage solar water heater, Renew. Energy **126**, 281–295 (2018) [CrossRef] [Google Scholar]
18. K. Resch-Fauster et al., Overheating protection of solar thermal facades with latent heat storages based on paraffin-polymer compounds, Energy Build. **169**, 254–259 (2018) [CrossRef] [Google Scholar]
19. M. Ibanez-Puy et al., Ventilated Active Thermoelectric Envelope (VATE): analysis of its energy performance when integrated in a building, Energy Build. **158**, 1586–1592 (2018) [CrossRef] [Google Scholar]
20. F. Guarino et al., PCM thermal storage design in buildings: Experimental studies and applications to solaria in cold climates, Appl. Energy **185**, 95–106 (2017) [CrossRef] [Google Scholar]
21. L. Navarro et al., Experimental study of an active slab with PCM coupled to a solar air collector for heating purposes, Energy Build. **128**, 12–21 (2016) [CrossRef] [Google Scholar]
22. F. Hengstberger et al., High temperature phase change materials for the overheating protection of facade integrated solar thermal collectors, Energy Build. **124**, 1–6 (2016) [CrossRef] [Google Scholar]
23. J. Shen et al., Characteristic study of a novel compact Solar Thermal Facade (STF) with internally extruded pin-fin flow channel for building integration, Appl. Energy **168**, 48–64 (2016) [CrossRef] [Google Scholar]
24. W. He et al., CFD and comparative study on the dual-function solar collectors with and without tile-shaped covers in water heating mode, Renew. Energy **86**, 1205–1214 (2016) [CrossRef] [Google Scholar]
25. A. Giovanardi *et al.*, Integrated solar thermal facade system for building retrofit, Solar Energy **122**, 1100–1116 (2015) [CrossRef] [Google Scholar]
26. W. He et al., Operational performance of a novel heat pump assisted solar facade loop-heat-pipe water heating system, Appl. Energy **146**, 371–382 (2015) [CrossRef] [Google Scholar]
27. L. Li, M. Qu, S. Peng, Performance evaluation of building integrated solar thermal shading system: building energy consumption and daylight provision, Energy Build. **113**, 189–201 (2016) [CrossRef] [Google Scholar]
28. A.K. Shukla, K. Sudhakar, P. Baredar, A comprehensive review on design of building integrated photovoltaic system, Energy Build. **128**, 99–110 (2016) [CrossRef] [Google Scholar]
29. M. Tripathy, P.K. Sadhu, S.K. Panda, A critical review on building integrated photovoltaic products and their applications, Renew. Sustain. Energy Rev. **61**, 451–465 (2016) [CrossRef] [Google Scholar]
30. S. Aguacil, S. Lufkin, E. Rey, Active surfaces selection method for building-integrated photovoltaics (BIPV) in renovation projects based on self-consumption and self-sufficiency, Energy Build. **193**, 15–28 (2019) [CrossRef] [Google Scholar]
31. X. Chen, H. Yang, J. Peng, Energy optimization of high-rise commercial buildings integrated with photovoltaic facades in urban context, Energy **172**, 1–17 (2019) [CrossRef] [Google Scholar]

32. E. Biyik *et al.*, A key review of building integrated photovoltaic (BIPV) systems, Eng. Sci. Technol. **20**, 833–858 (2017) [Google Scholar]
33. A.K. Shukla, K. Sudhakar, P. Baredar, Recent advancement in BIPV product technologies: a review, Energy Build. **140**, 188–195 (2017) [CrossRef] [Google Scholar]
34. R.A. Agathokleous, S.A. Kalogirou, Part II: thermal analysis of naturally ventilated BIPV system: modeling and simulation, Solar Energy **169**, 682–691 (2018) [CrossRef] [Google Scholar]
35. Y. Cheng *et al.*, An optimal and comparison study on daylight and overall energy performance of double-glazed photovoltaics windows in cold region of China, Energy **170**, 356–366 (2019) [CrossRef] [Google Scholar]
36. C. Qiu, H. Yang, W. Zhang, Investigation on the energy performance of a novel semi-transparent BIPV system integrated with vacuum glazing, Build. Simul. **12**, 29–39 (2019) [CrossRef] [Google Scholar]
37. O.S. Asfour, Solar and shading potential of different configurations of building integrated photovoltaics used as shading devices considering hot climatic conditions, Sustainability **10** (2018) doi: 10.3390/su10124373 [CrossRef] [Google Scholar]
38. J. Huang et al., Numerical investigation of a novel vacuum photovoltaic curtain wall and integrated optimization of photovoltaic envelope systems, Appl. Energy **229**, 1048–1060 (2018) [CrossRef] [Google Scholar]
39. Y. Luo, L. Zhang, Z. Liu, X. Su et al., Coupled thermal-electrical-optical analysis of a photovoltaic-blind integrated glazing facade, Appl. Energy **228**, 1870–1886 (2018) [CrossRef] [Google Scholar]
40. A. Tablada et al., design optimization of productive facades: integrating photovoltaic and farming systems at the tropical technologies laboratory, Sustainability **10** (2018) [Google Scholar]
41. K. Sornek, M. Filipowicz, J. Jasek, The use of fresnel lenses to improve the efficiency of photovoltaic modules for building-integrated concentrating photovoltaic systems', J. Sustain. Dev. Energy Water Environ. Syst. **6**, 415–426 (2018) [CrossRef] [Google Scholar]
42. A. Karthick *et al.*, Performance study of building integrated photovoltaic modules, Adv. Build. Energy Res. **12**, 178–194 (2018) [CrossRef] [Google Scholar]
43. W. Zhang, L. Lu, J. Peng, Evaluation of potential benefits of solar photovoltaic shadings in Hong Kong, Energy **137**, 1152–1158 (2017) [CrossRef] [Google Scholar]
44. S. Tak *et al.*, 'Effect of the changeable organic semi-transparent solar cell window on building energy efficiency and user comfort, Sustainability **9** (2017) [Google Scholar]
45. M. Wang *et al.*, Comparison of energy performance between PV double skin facades and PV insulating glass units, Appl. Energy **194**, 148–160 (2017) [CrossRef] [Google Scholar]
46. G.Y. Palacios-Jaimes *et al.*, Transformation of a University Lecture Hall in Valladolid (Spain) into a NZEB: LCA of a BIPV system integrated in its facade, Int. J. Photoenergy (2017) doi: 10.1155/2017/2478761 [Google Scholar]
47. acade integration, Solar Energy **140**, 162–170 (2016) [CrossRef] [Google Scholar]
48. K. Connelly *et al.*, Design and development of a reflective membrane for a novel Building Integrated Concentrating Photovoltaic (BICPV) 'Smart Window' system',

Appl. Energy **182**, 331–339 (2L.A.A. Bunthof *et al.*, Impact of shading on a flat CPV system for f016) [CrossRef] [Google Scholar]
49. M. Wang *et al.*, Assessment of energy performance of semi-transparent PV insulating glass units using a validated simulation model, Energy **112**, 538–548 (2016) [CrossRef] [Google Scholar]
50. F. Favoino *et al.*, Optimal control and performance of photovoltachromic switchable glazing for building integration in temperate climates, Appl. Energy **178**, 943–961 (2016) [CrossRef] [Google Scholar]
51. S.F.H. Correia et al., Scale up the collection area of luminescent solar concentrators towards metre-length flexible waveguiding photovoltaics, Progr. Photovolt. **24**, 1178–1193 (2016) [CrossRef] [Google Scholar]
52. Y. Wu *et al.*, Smart solar concentrators for building integrated photovoltaic facades, Sol. Energy **133**, 111–118 (2016) [CrossRef] [Google Scholar]
53. M. Sabry, Prismatic TIR (total internal reflection) low-concentration PV (photovoltaics)-integrated facade for low latitudes, Energy **107**, 473–481 (2016) [CrossRef] [Google Scholar]
54. J. Cipriano *et al.*, Development of a dynamic model for natural ventilated photovoltaic components and of a data driven approach to validate and identify the model parameters, Solar Energy **129**, 310–331 (2016) [CrossRef] [Google Scholar]
55. J. Hofer *et al.*, Parametric analysis and systems design of dynamic photovoltaic shading modules, Energy Sci. Eng. **4**, 134–152 (2016) [CrossRef] [Google Scholar]
56. J. Peng et al., Numerical investigation of the energy saving potential of a semi-transparent photovoltaic double-skin facade in a cool-summer Mediterranean climate, Appl. Energy **165**, 345–356 (2016) [CrossRef] [Google Scholar]
57. L.S. Pantic et al., Electrical energy generation with differently oriented photovoltaic modules as facade elements, Thermal Sci. **20**, 1377–1386 (2016) [CrossRef] [Google Scholar]
58. H.-M. Liu et al., Improving the performance of a semitransparent bipv by using high-reflectivity heat insulation film, Int. J. Photoenergy (2016) doi: 10.1155/2016/4174216 [Google Scholar]
59. J. Kang, C. Cho, J.-Y. Lee, Design of asymmetrically textured structure for efficient light trapping in building-integrated photovoltaics, Org. Electr. **26**, 61–65 (2015) [CrossRef] [Google Scholar]
60. Y. Luo, L. Zhang, Z. Liu, J. Wu et al., Numerical evaluation on energy saving potential of a solar photovoltaic thermoelectric radiant wall system in cooling dominant climates, Energy **142**, 384–399 (2018) [CrossRef] [Google Scholar]
61. R.J. Yang, Overcoming technical barriers and risks in the application of building integrated photovoltaics (BIPV): hardware and software strategies, Autom. Construct. **51**, 92–102 (2015) [CrossRef] [Google Scholar]
62. J. Lee et al., Renewable energy potential by the application of a building integrated photovoltaic and wind turbine system in global urban areas, Energies **10** (2017) [Google Scholar]
63. C.-M. Lai, S. Hokoi, Solar facades: a review, Build. Environ. **91**, 152–165 (2015) [CrossRef] [Google Scholar]
64. C. Lai, S. Hokoi, Experimental and numerical studies on the thermal performance of ventilated BIPV curtain walls, Indoor Built Environ. **26**, 1243–1256

(2017) [CrossRef] [Google Scholar]
65. M. Debbarma, K. Sudhakar, P. Baredar, Thermal modeling, exergy analysis, performance of BIPV and BIPVT: a review, Renew. Sustain. Energy Rev. **73**, 1276–1288 (2015) [Google Scholar]
66. R.A. Agathokleous, S.A. Kalogirou, Double skin facades (DSF) and building integrated photovoltaics (BIPV): a review of configurations and heat transfer characteristics, Renew. Energy **89**, 743–756 (2016) [CrossRef] [Google Scholar]
67. X. Zhang et al., Active Solar Thermal Facades (ASTFs): From concept, application to research questions, Renew. Sustain. Energy Rev. **50**, 32–63 (2015) [CrossRef] [Google Scholar]
68. Z. Nagy et al., The adaptive solar facade: from concept to prototypes, Front. Architectur. Res. **5**, 143–156 (2016) [CrossRef] [Google Scholar]
69. J. Peng et al., Comparative study of the thermal and power performances of a semi-transparent photovoltaic facade under different ventilation modes, Appl. Energy **138**, 572–583 (2015) [CrossRef] [Google Scholar]
70. A. Chialastri, M. Isaacson, Performance and optimization of a BIPV/T solar air collector for building fenestration applications, Energy Build. **150**, 200–210 (2017) [CrossRef] [Google Scholar]
71. H. Dehra, An investigation on energy performance assessment of a photovoltaic solar wall under buoyancy-induced and fan-assisted ventilation system, Appl. Energy **191**, 55–74 (2017) [CrossRef] [Google Scholar]
72. M. Smyth et al., Experimental performance characterisation of a hybrid photovoltaic/solar thermal facade module compared to a flat integrated collector storage solar water heater module, Renew. Energy **137**, 137–143 (2019) [CrossRef] [Google Scholar]
73. S. Barman et al., Assessment of the efficiency of window integrated CdTe based semi-transparent photovoltaic module', Sustain. Cities Soc. **37**, 250–262 (2018) [CrossRef] [Google Scholar]
74. M. Ahmed-Dahmane, A. Malek, T. Zitoun, Design and analysis of a BIPV/T system with two applications controlled by an air handling unit', Energy Convers. Manag. **175**, 49–66 (2018) [CrossRef] [Google Scholar]
75. A. Gaur, G.N. Tiwari, Analytical expressions for temperature dependent electrical efficiencies of thin film BIOPVT systems, Appl. Energy **146**, 442–452 (2015) [CrossRef] [Google Scholar]
76. A. Buonomano *et al.*, BIPVT systems for residential applications: an energy and economic analysis for European climates, Appl. Energy **184**, 1411–1431 (2016) [CrossRef] [Google Scholar]
77. J. Oh *et al.*, An integrated model for estimating the techno-economic performance of the distributed solar generation system on building façades: focused on energy demand and supply, Appl. Energy **228**, 1071–1090 (2018) [CrossRef] [Google Scholar]
78. M.A.C. Sousa, L. Aelenei, H. Gonçalves, Comportamento térmico de um protótipo BIPV combinado com armazenamentode água: análise experimental, in *CIES2020-XVII Congresso Ibérico e XIII Congresso Ibero-americano de Energia Solar*. LNEG-Laboratório Nacional de Energia e Geologia (2020) 1167–1174 [Google Scholar]
79. J.M. Lourenço et al., Thermal behavior of a BIPV combined with water storage: an

experimental analysis, Energies **14**, 2545 (2021) [CrossRef] [Google Scholar]
80. K. Bot, L. Aelenei, H. Gonçalves, Design de um protótipo BIPVT e análise por meio de computação dinâmica de fluídos, in *CIES2020-XVII Congresso Ibérico e XIII Congresso Ibero-americano de Energia Solar*. LNEG-Laboratório Nacional de Energia e Geologia (2020) pp. 1185–1192 [Google Scholar]
81. L. Aelenei, R. Pereira, A. Ferreira et al., Building Integrated Photovoltaic System with integral thermal storage: a case study, Energy Proc. **58**, 172–178 (2014) [CrossRef] [Google Scholar]
82. L. Aelenei, R. Pereira, H. Gonçalves et al., Thermal performance of a hybrid BIPV-PCM: modeling, design and experimental investigation, Energy Proc. **48**, 474–483 (2014) [CrossRef] [Google Scholar]
83. R. Pereira, L. Aelenei, Optimization assessment of the energy performance of a BIPV/T-PCM system using genetic algorithms, Renew. Energy (2018) [Google Scholar]
84. K. Bot *et al.*, Performance assessment of a building integrated photovoltaic thermal system in mediterranean climate—a numerical simulation approach', Energies **13** (2020) [Google Scholar]
85. K. Bot *et al.*, Performance assessment of a building-integrated photovoltaic thermal system in a mediterranean climate—an experimental analysis approach, Energies **14**, 2191 (2021) [CrossRef] [Google Scholar]

APPENDIX-A

(PSUEDOCODE)

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Pin Definitions
const int voltagePin = A0;   // Pin for reading the voltage from the voltage divider
const int ldrPin = A1;       // Pin for reading the LDR value
const int relayPin = 2;      // Pin controlling the relay (also controls the light)

// LCD setup (address 0x27 is a common I2C address for 16x2 LCD)
LiquidCrystal_I2C lcd(0x27, 16, 2);  // Set the LCD address (0x27), width (16), and height
(2)

// Voltage threshold and LDR thresholds
const float voltageThreshold = 5.0;  // Voltage value to trigger relay (in volts)
const int ldrThresholdDark = 500;    // LDR threshold for dark detection (adjust as needed)
float vOUT = 0.0;
float vIN = 0.0;
float R1 = 3000.0;
float R2 = 750.0;
int val = 0;

void setup() {
 pinMode(voltagePin, INPUT);
 pinMode(ldrPin, INPUT);
 pinMode(relayPin, OUTPUT);  // For controlling the relay (which controls the light)
 digitalWrite(relayPin, LOW);  // Ensure relay/light is off initially

// Initialize the LCD
```

```
  lcd.begin(16, 2); // Initialize a 16x2 LCD display
  lcd.init();
  lcd.backlight();   // Turn on the backlight
  lcd.clear();       // Clear any previous content

  Serial.begin(9600);          // For debugging via serial monitor
}

void loop() {
  // Read and scale the voltage from the solar panel (12V)
  val = analogRead(voltagePin);
  vOUT = (val * 4.0) / 1023.0;
  vIN = vOUT / (R2 / (R1 + R2));

  // Read the LDR value
  int ldrValue = analogRead(ldrPin); // Read the LDR value
   lcd.setCursor(0, 0); // Set the cursor to the first line
  lcd.print("Voltage: ");
  lcd.print(vIN, 1); // Display the voltage with 1 decimal place

  // Now check if it's dark (LDR detects darkness)
  if (ldrValue > ldrThresholdDark) {
   lcd.setCursor(0, 1); // Move to the second line
   lcd.print("Light: ON   "); // Turn on the light (dark + no sunlight)
   digitalWrite(relayPin, HIGH); // Turn on light (via relay)
  }

  else {
   lcd.setCursor(0, 1); // Move to the second line
   lcd.print("Light: OFF  "); // Keep light off (bright + sunlight)
   digitalWrite(relayPin, LOW);   // Turn off light (via relay)
  }
```

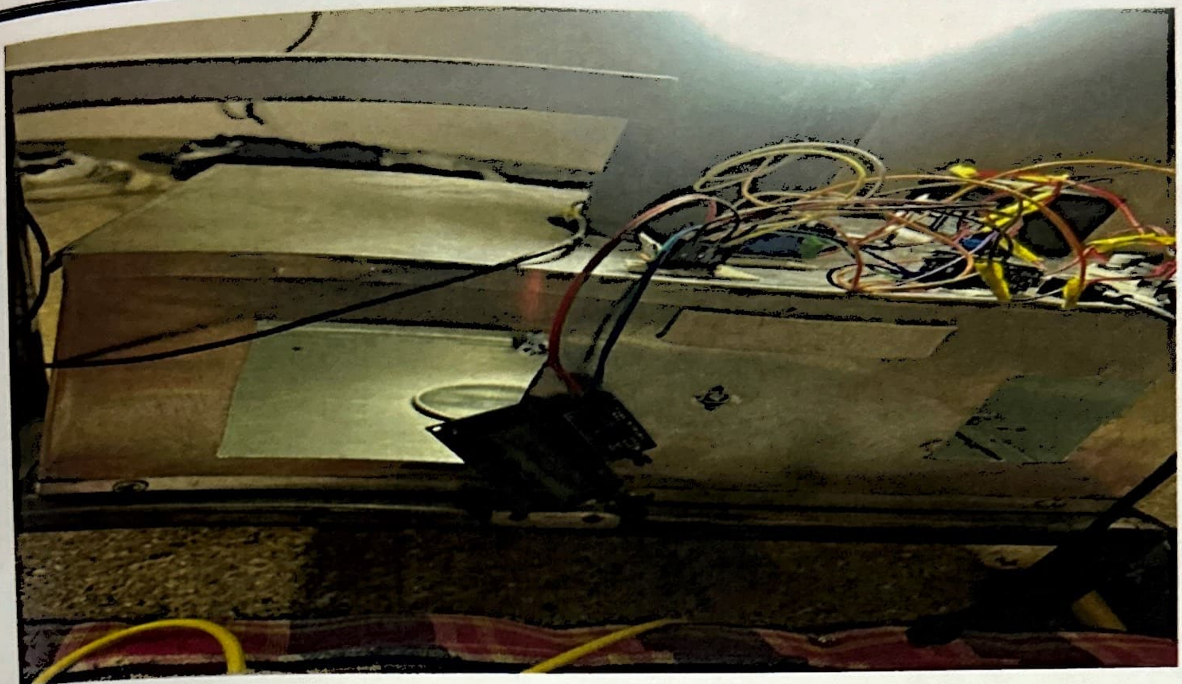
```
// Debug output to Serial Monitor
Serial.print("Voltage: ");
Serial.print(vIN);
Serial.print(" V, LDR Value: ");
Serial.println(ldrValue);

delay(1000); // Delay for 1 second before repeating the loop
}
```

APPENDIX-B

(SCREENSHOTS)

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Pin Definitions
const int voltagePin = A0;      // Pin for reading the voltage from the voltage
divider
const int ldrPin = A1;          // Pin for reading the LDR value
const int relayPin = 2;         // Pin controlling the relay (also controls the
light)

// LCD setup (address 0x27 is a common I2C address for 16x2 LCD)
LiquidCrystal_I2C lcd(0x27, 16, 2);  // Set the LCD address (0x27), width
(16), and height (2)

// Voltage threshold and LDR thresholds
const float voltageThreshold = 5.0;  // Voltage value to trigger relay (in
volts)
const int ldrThresholdDark = 500;    // LDR threshold for dark detection
(adjust as needed)
float vOUT = 0.0;
float vIN = 0.0;
float R1 = 3000.0;
float R2 = 750.0;
int val = 0;

void setup() {
  pinMode(voltagePin, INPUT);
  pinMode(ldrPin, INPUT);
  pinMode(relayPin, OUTPUT);  // For controlling the relay (which controls
the light)
  digitalWrite(relayPin, LOW);    // Ensure relay/light is off initially

  // Initialize the LCD
  lcd.begin(16, 2);  // Initialize a 16x2 LCD display
  lcd.init();
  lcd.backlight();    // Turn on the backlight
  lcd.clear();        // Clear any previous content

  Serial.begin(9600);              // For debugging via serial monitor
}
```

```
void loop() {
  // Read and scale the voltage from the solar panel (12V)
  val = analogRead(voltagePin);
  vOUT = (val * 4.0) / 1023.0;
  vIN = vOUT / (R2 / (R1 + R2));

  // Read the LDR value
  int ldrValue = analogRead(ldrPin);  // Read the LDR value
    lcd.setCursor(0, 0);  // Set the cursor to the first line
  lcd.print("Voltage: ");
  lcd.print(vIN, 1);  // Display the voltage with 1 decimal place

    // Now check if it's dark (LDR detects darkness)
    if (ldrValue > ldrThresholdDark) {
      lcd.setCursor(0, 1);  // Move to the second line
      lcd.print("Light: ON   ");  // Turn on the light (dark + no sunlight)
      digitalWrite(relayPin, HIGH);  // Turn on light (via relay)
    }

     else {
      lcd.setCursor(0, 1);  // Move to the second line
      lcd.print("Light: OFF  ");  // Keep light off (bright + sunlight)
      digitalWrite(relayPin, LOW);   // Turn off light (via relay)
    }


  // Debug output to Serial Monitor
  Serial.print("Voltage: ");
  Serial.print(vIN);
  Serial.print(" V, LDR Value: ");
  Serial.println(ldrValue);

  delay(1000); // Delay for 1 second before repeating the loop
}
```



APPENDIX-C

ENCLOSURES

International Journal of Research Publication and Reviews
(Open Access, Peer Reviewed, International Journal)
(A+ Grade, Impact Factor 6.844)

ISSN 2582-7421

Sr. No: IJRPR 124023-4

Certificate of Acceptance & Publication

This certificate is awarded to "DEEPIKA C.S", and certifies the acceptance for publication of paper entitled "Sunlight Uses In IT Office" in "International Journal of Research Publication and Reviews", Volume 6, Issue 1 .

Signed Ankit Agarwal

Editor-in-Chief
International Journal of Research Publication and Reviews

Date 22-01-2025

International Journal of Research Publication and Reviews
(Open Access, Peer Reviewed, International Journal)
(A+ Grade, Impact Factor 6.844)

ISSN 2582-7421

Sr. No: IJRPR 124023-3

Certificate of Acceptance & Publication

This certificate is awarded to "DISHIK L. SETTY", and certifies the acceptance for publication of paper entitled "Sunlight Uses In IT Office" in "International Journal of Research Publication and Reviews", Volume 6, Issue 1 .

Signed Ankit Agarwal

Editor-in-Chief
International Journal of Research Publication and Reviews

Date 22-01-2025

International Journal of Research Publication and Reviews

(Open Access, Peer Reviewed, International Journal)

(A+ Grade, Impact Factor 6.844)

ISSN 2582-7421

Sr. No: IJRPR 124023-2

Certificate of Acceptance & Publication

This certificate is awarded to "PAAVANA GOWDA", and certifies the acceptance for publication of paper entitled "Sunlight Uses In IT Office" in "International Journal of Research Publication and Reviews", Volume 6, Issue 1 .

Signed Ankush Agarwal

Date 22-01-2025

Editor-in-Chief

International Journal of Research Publication and Reviews

16% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography

Match Groups

- **96 Not Cited or Quoted 16%**
  Matches with neither in-text citation nor quotation marks
- **0 Missing Quotations 0%**
  Matches that are still very similar to source material
- **0 Missing Citation 0%**
  ...ches that have quotation marks, but no in-text citation
- **...ited and Quoted 0%**
  ...ches with in-text citation present, but no quotation marks

Top Sources

- 11% Internet sources
- 9% Publications
- 11% Submitted works (Student Papers)

...ags

...s for Review

...ious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

turnitin   Submission ID [redacted]1:3195801867

Page 3 of 37 - Integrity Overview

Match Groups

- **36 Not Cited or Quoted 16%**
  Matches with neither in-text citation nor quotation marks
- **0 Missing Quotations 0%**
  Matches that are still very similar to source material
- **0 Missing Citation 0%**
  Matches that have quotation marks, but no in-text citation
- **0 Cited and Quoted 0%**
  Matches with in-text citation present, but no quotation marks

Top Sources

11% Internet sources
9% Publications
11% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Student papers	Presidency University	9%
2	Internet	www.rees-journal.org	2%
3	Student papers	Symbiosis International University	2%
4	Internet	ouci.info	2%
5	Publication	Daniel Vázquez-Mallol, Mario González-Montes, Antonio Álvarez Fernández-Balbu...	<1%
6	Student papers	Pioneer Junior College	<1%
7	Internet	www.bigee.net	<1%
8	Internet	www.researchgate.net	<1%
9	Internet	research.unl.pt	<1%
10	Publication	Carol Bot, Laura Aelenei, Maria da Glória Gomes, Carlos Santos Silva. "A literature...	<1%

turnitin   Submission ID [redacted]1:3195801867

SUSTAINABLE DEVELOPMENT GOALS

The Project Work Carried out here is mapped to SDG-04 Quality Education. The provided Arduino project illustrates a simple yet effective system that monitors voltage from a solar panel and light intensity using an LDR (light-dependent resistor) to control a relay connected to a light source. This design, paired with a LiquidCrystal_I2C display for real-time data feedback, has potential applications that align with themes of inclusive growth, accessibility, and sustainability.

PRESIDENCY UNIVERSITY
School of Computer Science and Engineering
PIP2001-Capstone Project Check list

SL. No	SUBMISSION CHECK LIST ITEM	Give Completion Status as Yes / No. If No - Mention the problem you have.
1	Are the contents arranged in the specified sequence? 1.Cover & Title Page 2.Certificate 3.Declaration 4.Abstract 5.Acknowledgement 4.List of Tables, Figures & Table of Contents 5.Chapters (Introduction, Literature review, Research Gaps of Existing Methods, Proposed Methodology, Objectives, System Design & Implementation, Timeline for execution of Project, Results & Discussions, Conclusion, References) 6.Appendices A, B & C.	Yes.
2	Are the page dimensions and binding specifications followed ? •The dimension of the report should be in A4 size. •The project report should be hard bound using a flexible cover of the thick art paper. •Outer Binding should be of CREAM (#FFFDD0) color. •ONE copy of the report (hard copy only) should be submitted to the School. •ONE copy of the report (hard copy only) should be submitted to the Supervisor. •Each student in the batch should have one copy.	Yes.
3	Are the typing instructions followed as given? •One-and-a-half spacing should be used for typing the general text. •The chapter name shall be center-aligned and typed in the font style 'Times New Roman'; the font size should be 16 and bold. •Heading shall be left aligned and typed in the Font style 'Times New Roman' and Font size 14 and bold. •Subheading shall be left aligned and typed in the Font style 'Times New Roman' and Font size 12 and bold. •The general text shall be justified and typed in the Font style 'Times New Roman' and Font size 12.	Yes
5	Proof of publications/Conference Paper Presented /Certificates of all students enclosed?	Yes
6	Include certificate(s) of any Achievement/Award won in any project-related event enclosed if any	No
7	Similarity Index / Plagiarism Check report clearly showing the Percentage (%)- first page enclosed?	Yes.
8	Details of mapping the project with the Sustainable Development Goals (SDGs) enclosed?	Yes
9	Are the Documents uploaded by students in GITHUB: 1. Complete Code (with all the supporting files). 2. Signed Final Report PDF. 3. Final Review PPT.	No

Group No: COM-23
Program: B.TECH
Title: Sunlight User in ET Office
Team Leader Name: Deepika C.S
Team Leader Mobile No: 6360691724