Review Article

Indian Journal of Science and Research

Yadav S. *et al.,* Ind. J. Sci. Res. 2025, 5(3), 113-116

ISSN 2583 – 2913

DESIGN AND IMPLEMENTATION OF A SOLAR-POWERED SMART TREE SYSTEM FOR STREET LIGHTING, OXYGEN GENERATION, AND HYDROGEN PRODUCTION

Yadav Sonali*[1], Suryawanshi Priyanka[2], Prof. V.B Pansare[3] and Prof. G.P.Overikar[4]

Abstract: This paper presents a novel solar-powered system inspired by the natural function of trees in harnessing sunlight for energy conversion. This research introduces an innovative urban infrastructure modeled after the biological functions of real future trees. Designed to enhance and environmental sustainability, the system -named the Artificial Oxygen of Tree -combines solar power with electrolysis technology to provide very clean energy and improve air quality. Photovoltaic panels mounted on the upper structure harvest a solar energy, which is then used to power both LED streetlights and an electrolysis of unit. Positioned above sewage of tanks, the unit splits wastewater into the hydrogen and oxygen gases. The hydrogen is collected for clean fuel of the applications, while the oxygen is released into the atmosphere. This multifunctional design integrates renewable power generation, energy-efficient lighting, hydrogen production, and air purification, offering a scalable and eco-friendly solution tailored for urban deployment.

Keywords: Oxygen Releaser, Breathable Environment Generator, Eco-Lighting Unit.

Introduction: Trees play the crucial of role in sustaining life of the Earth by the absorbing carbon dioxide and releasing oxygen, a process essential for maintaining ecological balance. Natural trees are the fundamental of the maintain ecology balance by absorb the carbon dioxide and the releasing the oxygen. However, rapid urbanization and deforestation have led to a significant decline in green cover, adversely affecting air quality and contributing to environmental concerns a like climate change to and respiratory a disorders. As cities expand, the challenge of preserving the air quality has grown more urgent. To the address this, researchers have developed the concept of an Artificial Oxygen Tree- a manmade system designed to mimic the atmospheric benefits of real trees. This technological solution aims to reduce pollution, support sustainable urban development, and offer an alternative means of producing breathable air in densely populated environments.

***Corresponding author**

Department of mechanical engineering,
Shree Tuljabhavani College of Engineering Tuljapur

E-mail: sonaliyadav72267@gmail.com,

Article recived on: 13 May 2025
Published on web: 10 July 2025, www.ijsronline.org

Literature Review: Across the globe, researchers and engineers are actively working toward innovative, sustainable solutions to meet the growing energy and environmental demands of modern society. Among these efforts, K. S. Lackner has made notable contributions by exploring passive techniques for capturing carbon dioxide directly from the atmosphere—an approach aimed at mitigating the escalating impacts of climate change. One emerging concept gaining attention is the *Solar Tree*, envisioned as a clean energy solution tailored for urban settings. Recent studies have explored the integration of nanowire-based solar cells into Solar Tree designs. These nanostructures possess exceptional light-absorbing properties, making them highly effective for harvesting solar energy. By incorporating such advanced materials, Solar Trees offer a promising avenue for efficient energy generation, while also serving as eco-friendly lighting systems in smart city environments. This approach marks a significant step forward in the development of green technologies and urban sustainability.

Electrolysis: Electrolysis is an electrochemical technique that employs electrical energy to decompose water molecules into hydrogen and oxygen gases. This process takes place in a water-based solution where two electrodes — the anode and the cathode — are immersed. When voltage is applied, hydrogen gas is released at the cathode (negative terminal), and oxygen is liberated at the anode (positive terminal). The ratio of hydrogen to oxygen production follows the molecular structure of water (H_2O), typically producing twice as much hydrogen as oxygen. In practical applications, efficiency can be hindered by system resistance, necessitating the use of electrolytes like potassium hydroxide or sulfuric acid. These additives enhance conductivity, reduce energy losses, and improve gas output rates, making the process viable for energy storage and clean fuel generation.

Solar Panels: Solar panels, also known as photovoltaic (PV) modules, are engineered to convert solar radiation into usable electrical power through the photovoltaic effect. They consist of multiple interconnected solar cells typically made from silicon semiconductors. When exposed to sunlight, these cells generate direct current (DC) electricity by mobilizing electrons within the material. To make this energy compatible with conventional electrical systems, it is routed through an inverter that converts it into alternating current (AC). Modern solar panels are designed for long-term outdoor use, featuring tempered glass coverings and durable frames that protect against environmental wear. Depending on their structure and efficiency, panels are categorized into monocrystalline, polycrystalline, or thin-film types, each suited for different spatial and energy requirements.

Solar panels function as the primary component for converting solar energy into electrical power within the smart tree system. These panels rely on the photovoltaic effect, where semiconductor materials, such as silicon, generate electrical current upon the exposure to sunlight. When solar radiation strikes the surface of these cells, it excites electrons, causing them to flow and produce direct current (DC) electricity.

Table -1: Design and Implementation of a Solar-Powered Smart Tree System for Street Lighting, Oxygen Generation, and Hydrogen Production

Product details			
Solar panel	45 watt	Radiations	5
Anode	Positive	oxygen	1
cathode	Negative	hydrogen	1
Electrolysis	H_2O	Potassium hydroxide	60%
Street Light	35w	White	1

Each solar cell is composed of a p-n junction that creates an internal electric field. This field drives the movement of charge carriers — electrons and holes — resulting in the generation of a continuous electrical current. The power output of a solar panel depends on several factors, including solar irradiance, cell efficiency, orientation, temperature, and shading conditions.

Calculations

Assumptions:

- Energy from solar panels: 15W (3 solar panels × 5W each)
- Electrolysis efficiency: Around 70% (typical for small-scale systems)
- Water volume: 5 liters (5,000 mL)
- Energy consumption for electrolysis: Roughly 4.8 kWh to produce 1 cubic meter (1,000 liters) of hydrogen.

The basic reaction in electrolysis of water is:

$$= 2H_2O \rightarrow 2H_2 + O_2$$

Parameter	Value
Total Energy from Solar Panels	15W (0.015 kW)
Operating Time (hours)	1 hour
Energy Input per Hour	0.015 kWh
Hydrogen Production Efficiency	0.036 m³/kWh
Hydrogen Produced in 1 Hour	0.00054 m³ (0.54 liters)
Oxygen Production Efficiency	0.018 m³/kWh
Oxygen Produced in 1 Hour	0.00027 m³ (0.27 liters)

Indian Journal of Science and Research

Yadav S. *et al.,* Ind. J. Sci. Res. 2025, 5(3), 113-116

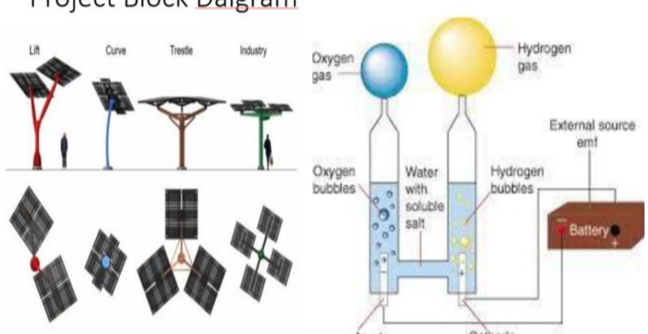
SUMMARY

- Hydrogen Production: 0.54 liters per hour (from 3 solar panels).
- Oxygen Production: 0.27 liters per hour.

The Artificial Oxygen Tree system serves as a multifunctional urban unit that integrates renewable energy generation, water electrolysis, and public lighting. Using compact photovoltaic panels, the structure produces approximately 15 watts of energy per hour under standard sunlight conditions. This power is utilized to operate an electrolysis unit of capable of converting sewage water into its elemental gases. During the one hour of operation, the system is estimated to produce around 54 milliliters of hydrogen and 27 milliliters of oxygen.

These figures are based on practical efficiency metrics, with electrolysis efficiency assumed to be around 70%, which is typical for small-scale setups. The generated gases serve dual purposes: hydrogen acts as a storable clean fuel, while oxygen contributes to improving the surrounding air quality. The harvested solar energy is simultaneously used to power energy-efficient LED lights, contributing to sustainable urban infrastructure.

Project Block Daigram



Conclusions: The development of an Artificial Oxygen Tree presents a forward-thinking solution to the environmental challenges faced in urban environments. Unlike traditional greenery, this system does not depend on soil, regular maintenance, or water for plant growth, making it particularly effective in congested city spaces where natural vegetation is scarce. The prototype successfully combines solar energy harvesting, hydrogen and oxygen generation through electrolysis, and efficient street lighting into one integrated structure.

By generating approximately 25 milliliters of oxygen and 50 milliliters of hydrogen, while delivering 24 watts of power from solar panels, the system demonstrates practical utility in both environmental and energy applications. A microcontroller-based control mechanism ensures responsive operation based on surrounding light levels, thereby optimizing energy use.

This hybrid infrastructure supports multiple sustainability goals, including reduced air pollution, enhanced clean energy access, and the innovative use of wastewater. It highlights the potential of smart renewable technologies in building resilient, eco-conscious urban ecosystems.

Acknowledgement: We extend our sincere gratitude to Prof. V.B. Pansare and Prof. G.P. Overikar for their invaluable mentorship, technical support, and consistent encouragement throughout the project lifecycle. Their insights greatly contributed to the refinement and successful realization of this research.

We also appreciate the Department of Mechanical Engineering at Shree Tuljabhavani College of Engineering, Tuljapur, for providing the necessary infrastructure and academic environment conducive to innovation. Special thanks to our families and peers for their continued moral support and motivation.

Working on this project has significantly broadened our understanding of renewable energy systems and their real-world applications, fostering both technical skills and a strong sense of environmental responsibility.

Conflict of Interest: The authors declare that there are no conflicts of interest regarding the publication of this project. The work presented is the result of independent research and has not been influenced by any financial, commercial, or personal relationships that could be perceived as a potential conflict.

Author Contribution: Sonali Yadav and **Priyanka Suryawanshi** contributed equally to the research, design, and development of the project. They collaboratively worked on literature review, system

modeling, and data collection. Both authors also participated in drafting, editing, and finalizing the manuscript. **Prof. V.B. Pansare** provided technical guidance, project supervision, and critical insights throughout the research process. **Prof. G.P. Overikar** offered academic mentorship, reviewed the project methodology, and ensured the overall quality and coherence of the report. All authors reviewed and approved the final version of the document.

References

1) Lackner, K.S. (2009). *Capture of Carbon Dioxide from Ambient Air*. *European Physical Journal Special Topics*, 176(1): 93–106.
2) Lackner, K.S. (2012). *The Urgency of the Development of CO_2 Capture from Ambient Air*. *Proceedings of the National Academy of Sciences of the United States of America*, 109(33): 13156–13162.
3) International Research Group on Renewable Energy. (2013). *Idea to Design a Solar Tree Using Nano-Wire Solar Cells*. *International Journal of Scientific and Research Publications*, 3(12): 1–5.
4) GreenTech Innovation Team. (2015). *PIC-Controlled Oxygen and Light Generation Using Renewable Resources*. *International Journal of Technical Research and Applications*, 3(5): 198–203.
5) Sustainable Systems Research Group. (2015). *Solar-Based Street Light with Electrolysis Integration*. *SSRG International Journal of Electrical and Electronics Engineering*, EFES: 1–4.
6) Urban Energy Systems Lab. (2015). *Vertical Wind Oxygen Tree*. *IOSR Journal of Electrical and Electronics Engineering*, 1(2): 26–29.