European Economic Letters
ISSN 2323-5233
Vol 15, Issue 3 (2025)
http://eelet.org.uk

# Green Energy Revolution: Technologies, Challenges, and the Road to a Sustainable Future

**Ms. Neha Guliani**
*Assistant Professor, Jagannath University*

## Abstract
The accelerating impacts of climate change, urban air pollution, and energy insecurity have intensified the global shift toward green energy systems (International Energy Agency, 2025). This study critically examines the role of renewable energy in advancing sustainable development and improving urban air quality, with particular emphasis on the Indian context. The research employs a structured qualitative review of recent peer-reviewed literature (2020–2025), supported by secondary analysis of renewable energy deployment trends and urban air pollution indicators, including PM2.5 concentrations (Central Pollution Control Board, 2024). Major renewable technologies, such as solar, wind, hydropower, bioenergy, geothermal energy, and emerging green hydrogen systems, are evaluated for their environmental, economic, and policy implications (International Renewable Energy Agency, 2025). The analysis indicates that increasing the share of renewable energy, especially when integrated with electric mobility and grid modernization, has the potential to contribute to observable improvements in urban air quality (Sharma et al., 2025; Gupta & Mishra, 2024). However, the transition remains constrained by intermittency issues, infrastructure limitations, Financing gaps, and inconsistent policy implementation (Zhang et al., 2024). The study highlights the need for coordinated urban energy planning, long-term policy stability, and targeted investments to strengthen the effectiveness of green energy initiatives. The findings offer policy-relevant insights to accelerate renewable energy adoption and help achieve cleaner, healthier, and more resilient cities in India.

**Keywords:** Renewable energy transition; Urban sustainability; Air quality management; Clean energy policy; Low-carbon technologies; Indian metropolitan regions; Climate mitigation strategies; Energy system transformation

## Introduction
Rising global energy demand, coupled with accelerated urbanization, population growth, and industrial expansion, has placed unprecedented pressure on existing energy systems worldwide (International Energy Agency, 2025). For several decades, economic development has been largely dependent on fossil fuels such as coal, oil, and natural gas, which continue to dominate electricity generation and transportation. While this dependence has enabled industrial progress and improved living standards, it has also resulted in severe environmental externalities, including elevated greenhouse gas emissions, declining air quality, and widespread ecological degradation (International Renewable Energy Agency, 2025). These impacts have intensified climate-related risks, contributing to more frequent extreme weather events, heat stress, and public health challenges, particularly in densely populated urban regions (IEA et al., 2023). India represents one of the most significant contemporary examples of this challenge. Rapid economic growth, urbanization, and industrial advancement have driven energy demand to unprecedented levels. Although India has made substantial progress in renewable energy development, most of its urban regions still rely heavily on conventional fossil-fuel-based electricity and transport systems. This has resulted in severe urban air pollution, particularly elevated PM2.5 and PM10 levels, which contribute

to respiratory illnesses, cardiovascular diseases, and premature mortality (Central Pollution Control Board, 2024). The environmental and public health implications highlight the urgency of accelerating clean energy transitions.

Green energy has therefore emerged as a critical strategy for achieving environmental sustainability, energy security, and public health protection. Renewable energy sources such as solar, wind, hydropower, bioenergy, and geothermal systems provide opportunities to reduce greenhouse gas emissions while supporting economic growth (International Renewable Energy Agency, 2025). Advances in renewable technologies, cost reductions, policy initiatives, and international climate commitments have strengthened the feasibility of large-scale adoption (Kumar et al., 2025). However, realizing these benefits requires overcoming persistent technological, infrastructural, financial, and institutional challenges. The role of renewable energy is particularly significant in urban environments, where energy consumption and pollution sources are highly concentrated. Integrating renewable energy within electricity systems, transport networks, and decentralized urban infrastructure offers a viable pathway for achieving long-term environmental resilience (Gupta & Mishra, 2024). However, the pace of transition remains uneven and constrained by intermittency challenges, limited grid capacity, financing barriers, and fragmented policy implementation (Zhang et al., 2024). Therefore, a deeper examination of how renewable energy deployment affects urban air quality, particularly in the Indian context, is essential. This study contributes to this objective by synthesizing technological, environmental, and policy perspectives to analyze the effectiveness and challenges of green energy transitions in urban India.

**Review of Literature**

The global transition toward renewable energy has generated extensive academic and policy-oriented research, reflecting its significance for environmental sustainability, climate mitigation, and energy security (International Renewable Energy Agency, 2025). Studies consistently emphasize that renewable technologies, especially solar and wind, have experienced unprecedented expansion over the last decade due to declining technology costs, policy incentives, and rising environmental consciousness (International Energy Agency, 2025). Reports from major international agencies confirm that renewable energy is rapidly becoming cost-competitive with conventional fossil-fuel-based power generation, positioning it as a cornerstone of future low-carbon economies (IRENA, 2025). Technological advancements have significantly strengthened the viability and performance of renewable systems. Solar energy research highlights improvements in photovoltaic efficiency, integration of storage solutions, and enhanced grid compatibility. These developments support both large-scale installations and decentralized applications, such as rooftop solar in dense urban environments (Kumar et al., 2025). Wind energy studies demonstrate similar advancements, including increased turbine capacity, improved design, and offshore wind development, leading to higher reliability and efficiency (International Renewable Energy Agency, 2025). However, the inherent variability of wind and solar power necessitates investments in energy storage systems, flexible grids, and demand-side management to maintain energy stability and reliability (Zhang et al., 2024).

Hydropower and bioenergy also remain prominent contributors to renewable energy portfolios globally. Hydropower continues to serve as a reliable baseload energy source but raises ecological and social sustainability concerns related to displacement, biodiversity loss, and river ecosystem disruption. Consequently, contemporary research increasingly supports small-scale and run-of-the-river hydropower systems as comparatively sustainable alternatives (International Energy Agency, 2025). Bioenergy studies emphasize sustainable feedstock utilization, particularly agricultural waste, biogas, and non-food biomass, to avoid competition with food production and minimize land-use conflicts (Bhandari et al., 2024). Recently, green hydrogen has gained increasing attention as a transformative technology with potential to decarbonize challenging sectors such as heavy industry, shipping, aviation, and long-distance freight transport (Bhandari et al., 2024). Scholars agree that while hydrogen possesses long-term strategic potential, its deployment remains constrained by high production costs, infrastructure challenges, and policy uncertainties. Therefore, sustained government support, technological innovation, and cost reduction strategies are necessary for large-scale adoption. A growing body of literature also explores the socio-economic and environmental advantages of renewable energy adoption. Studies demonstrate that renewable energy expansion contributes to reduced greenhouse gas emissions, improved air quality, and lower public health burdens (Sharma et al., 2025). In urban environments, the integration of renewable energy with electric mobility initiatives has shown measurable reductions in PM2.5 levels and vehicular emissions (Gupta & Mishra, 2024). Additionally, renewable energy industries support employment generation, local economic development, and energy independence, especially in developing economies (Kumar et al., 2025).

Despite these benefits, numerous studies highlight persistent structural and institutional challenges. These include financing difficulties, limited grid infrastructure, land acquisition conflicts, technological constraints, and policy fragmentation (Zhang et al., 2024; Ministry of New and Renewable Energy, 2024). In developing economies such as India, scholars particularly note inconsistencies between ambitious national renewable targets and uneven urban-level implementation (Sharma et al., 2025). Gaps between central policy frameworks and municipal-level execution continue to impede transition progress. In the Indian context, existing research has primarily focused on national renewable capacity expansion, policy design, and energy market evolution. However, fewer studies directly link renewable adoption with measurable urban air quality improvements. This gap is critical given escalating air pollution levels in Indian cities. Therefore, this study positions itself within this emerging research need by examining renewable energy integration alongside urban air quality outcomes.

## Methodology

This study employs a qualitative–descriptive research approach supported by secondary data analysis to examine the role of green energy in promoting sustainable development and improving urban air quality in India. The chosen methodology is appropriate for synthesizing technological, environmental, and policy-related insights across multiple dimensions of the energy transition, particularly where primary data collection is constrained by scale and data accessibility. Secondary data were collected from authoritative and widely cited sources to ensure reliability and consistency. Information on renewable energy capacity, deployment trends, and policy initiatives was obtained from reports published by the Ministry of New and Renewable Energy (MNRE), the International Renewable Energy Agency (IRENA), and the International Energy Agency (IEA). Urban air quality data, with a specific focus on fine particulate matter (PM2.5), were sourced from Central Pollution Control Board (CPCB) publications and national environmental monitoring datasets. These sources were selected due to their standardized data collection procedures and relevance to the Indian urban context.

European Economic Letters
ISSN 2323-5233
Vol 15, Issue 3 (2025)
http://eelet.org.uk

A structured literature review method was adopted to analyse recent peer-reviewed research on renewable energy technologies, urban sustainability, and air pollution mitigation. Academic articles published between 2020 and 2025 were identified through major scholarly databases using keywords related to renewable energy, clean energy transition, urban air quality, and energy policy. Studies were included based on their relevance to the research objectives, methodological rigor, and contribution to understanding the environmental and policy impacts of green energy adoption. Articles focusing solely on theoretical models without policy or environmental implications were excluded to maintain practical relevance. The analysis involved descriptive trend examination of renewable energy deployment and urban air quality indicators across selected Indian metropolitan regions. Data were reviewed to identify observable patterns, associations, and temporal changes rather than to establish direct causal relationships. The findings from data analysis and literature synthesis were integrated thematically, allowing for the identification of key drivers, barriers, and policy implications associated with green energy deployment in urban environments. To enhance analytical validity, data from multiple sources were cross-checked wherever possible, and consistent indicators were used to support comparative assessment. While the study does not employ advanced econometric modelling, the methodological framework provides a robust basis for evaluating the role of renewable energy within complex urban energy systems. The adopted approach supports the study's objective of generating policy-relevant insights and identifying directions for future empirical research.

**Results and Analysis**

The results of this study are derived from secondary data analysis and thematic synthesis of recent literature, focusing on renewable energy deployment trends and their implications for urban air quality in India. The findings reveal that while renewable energy adoption has increased significantly at the national level, its environmental benefits in urban areas depend strongly on the degree of integration with transport systems, grid infrastructure, and policy coordination.

**Renewable Energy Deployment Trends**

As shown in Table 1, solar and wind energy have emerged as the most rapidly expanding renewable energy sources in India over the past decade. Solar energy, in particular, has demonstrated strong growth due to declining photovoltaic costs, supportive rooftop solar policies, and increasing electricity demand in urban regions. Wind energy has also shown steady expansion, driven by technological improvements in turbine design and favourable policy mechanisms. In contrast, hydropower capacity has remained relatively stable due to environmental and land-use constraints, while bioenergy growth has been gradual and localized. Green hydrogen remains at an early stage, with pilot projects indicating long-term potential rather than immediate impact.

Table 1: Growth Trend of Renewable Energy Deployment in India

| **Renewable Source** | **Observed Trend (2015–2024)** | **Key Drivers** | **Implications for Urban Areas** |
|---|---|---|---|
| Solar Energy | Rapid and consistent growth | Declining PV costs, rooftop solar policies, urban demand | Enables decentralized generation, reduces transmission losses |
| Wind Energy | Moderate to strong growth | Policy incentives, improved turbine | Supports cleaner grid electricity for urban |

| | | | |
|---|---|---|---|
| | | efficiency | centre's |
| Hydropower | Relatively stable | Limited new large-scale projects | Provides grid stability but limited urban expansion |
| Bioenergy | Gradual increase | Waste-to-energy initiatives, rural–urban integration | Supports waste management and localized energy supply |
| Emerging Green Hydrogen | Early-stage adoption | Pilot projects, industrial decarbonization goals | Long-term potential for urban transport and storage |

**Analytical Insight:** Solar and wind energy dominate renewable expansion, making them the most relevant technologies for near-term urban air quality improvement. The trends presented in Table 1 indicate that solar and wind energy is currently the most relevant technologies for addressing urban energy demand and reducing dependence on fossil fuel–based electricity generation.

**Urban Air Quality and Renewable Integration**

Despite increased renewable capacity, urban air pollution remains a major challenge. Table 2 presents a comparative overview of renewable energy integration levels and air quality trends across selected Indian cities. Metropolitan regions such as Bengaluru, which have relatively higher penetration of rooftop solar systems and electric mobility initiatives, show comparatively better air quality outcomes. In contrast, cities with greater reliance on coal-based power and conventional transport systems continue to experience persistently high PM2.5 concentrations.

**Table 2: Urban Air Quality and Renewable Energy Integration**

| City | Dominant Pollution Sources | Renewable Integration Level | Observed Air Quality Trend |
|---|---|---|---|
| Delhi | Transport, coal power, industry | Moderate (solar + EV focus) | Slight improvement but high PM2.5 persistence |
| Mumbai | Transport, port activity | Moderate (rooftop solar growth) | Marginal improvement |
| Bengaluru | Transport, electricity demand | Relatively high (solar + EV adoption) | Better comparative air quality |
| Kolkata | Coal-based power, transport | Low–moderate | Limited improvement |
| Chennai | Industry, transport | Moderate (solar initiatives) | Seasonal variation |

**Analytical Insight**: Cities with higher renewable integration and electric mobility adoption show comparatively better air quality outcomes. The comparison suggests that renewable energy adoption contributes to improved air quality outcomes when implemented alongside clean transport and decentralized energy solutions. However, renewable deployment alone has not been sufficient to bring pollution levels within recommended safety limits.

**Linkages between Renewable Energy and Pollution Reduction**

The pathways through which green energy influences urban air quality are summarized in Table 3. Renewable-based electricity generation reduces indirect emissions from fossil fuel combustion, while electric mobility helps address direct vehicular emissions. Rooftop solar systems further contribute by lowering localized emission intensity. However, these benefits are constrained by factors such as grid intermittency, limited energy storage capacity, and continued reliance on fossil fuel backup systems.

**Table 3: Relationship Between Renewable Energy and Air Pollution Reduction**

| Energy Transition Element | Observed Impact on PM2.5 | Limiting Factors |
|---|---|---|
| Renewable-based electricity | Reduction in indirect emissions | Grid intermittency, fossil backup |
| Electric mobility | Reduced tailpipe emissions | Electricity source cleanliness |
| Rooftop solar systems | Local emission reduction | Limited rooftop availability |
| Energy storage integration | Enhances renewable effectiveness | High cost, scaling challenges |

The analysis highlights that air quality improvements are maximized only when clean grids and adequate storage infrastructure support renewable energy.

**Infrastructure and Policy Constraints**

The effectiveness of renewable energy in delivering environmental benefits is further shaped by infrastructure and governance conditions. As outlined in Table 4, limitations in grid infrastructure, high capital costs of energy storage, fragmented policy implementation, and restricted municipal financing significantly reduce the potential gains from renewable deployment in urban areas. These constraints contribute to uneven performance across cities, even when renewable capacity expansion is substantial.

**Table 4: Infrastructure and Policy Constraints Affecting Outcomes**

| Constraint Category | Description | Impact on Urban Results |
|---|---|---|
| Grid Infrastructure | Limited capacity, outdated systems | Restricts renewable absorption |
| Energy Storage | High capital cost | Reduces renewable reliability |
| Policy Fragmentation | State-level variation | Uneven urban performance |
| Financing Access | Limited municipal funding | Delays project implementation |

The findings indicate that addressing these structural barriers is essential for translating renewable energy growth into measurable air quality improvements.

**Integrated Urban Energy Strategies**

The analysis further demonstrates that cities adopting integrated energy strategies achieve stronger environmental outcomes. Table 5 presents an integrated framework linking renewable expansion with electric mobility, smart grid deployment, and coordinated urban planning. Such integrated approaches enhance the reliability of renewable energy systems and improve their contribution to pollution reduction.

**Table 5: Integrated Strategy for Maximizing Urban Air Quality Benefits**

| Strategy Component | Expected Outcome | Policy Relevance |
|---|---|---|
| Renewable expansion | Cleaner electricity mix | National & state energy policy |
| Electric mobility | Emission reduction | Urban transport planning |
| Smart grids | Improved load management | Infrastructure modernization |
| Urban energy planning | Coordinated deployment | Municipal governance |

The results suggest that renewable energy transitions must be embedded within broader urban planning and governance frameworks to deliver sustained public health and environmental benefits.

**Overall Interpretation**

Overall, the results indicate that renewable energy expansion is a necessary but insufficient condition for addressing urban air pollution. While green energy provides a critical foundation for emission reduction, its effectiveness depends on systemic integration across energy generation, transportation, infrastructure, and policy domains. Cities that combine renewable energy deployment with electric mobility, grid modernization, and coordinated governance are better positioned to achieve long-term improvements in air quality. These findings reinforce the importance of holistic urban energy strategies in advancing sustainable development objectives.

**Discussion**

The findings of this study highlight that the expansion of renewable energy in India has created a strong foundation for improving environmental sustainability, yet its impact on urban air quality remains uneven and context dependent. The results indicate that growth in solar and wind energy capacity has enhanced the availability of cleaner electricity, particularly for urban regions. However, as demonstrated in the analysis, renewable energy deployment alone does not automatically translate into substantial reductions in urban air pollution. Instead, its effectiveness is shaped by the degree of integration with urban infrastructure, transportation systems, and governance mechanisms. The city-level comparisons reveal that urban areas with relatively higher levels of renewable integration and electric mobility adoption tend to exhibit comparatively better air quality outcomes. This observation aligns with earlier studies suggesting that reductions in particulate matter are more pronounced when renewable-based electricity replaces fossil fuel–intensive power sources and when transport emissions are simultaneously addressed. The results reinforce the importance of viewing air pollution mitigation as a multi-sectoral challenge rather than a single-technology solution. Renewable energy acts as an enabling factor, but its environmental benefits are amplified only when complemented by clean transport initiatives and decentralized energy systems.

Infrastructure readiness emerges as a critical moderating factor in the relationship between renewable energy and air quality improvement. The analysis shows that limitations in grid capacity and energy storage significantly constrain the utilization of variable renewable resources such as solar and wind. Continued reliance on fossil fuel backup systems during periods of intermittency reduces the net air quality benefits of renewable energy expansion. This finding supports existing literature emphasizing the role of smart grids, flexible generation, and large-scale storage in enhancing the environmental performance of renewable-dominated energy systems. Policy and institutional factors further influence observed outcomes. Cities operating within stable regulatory environments and supported by long-term policy commitments demonstrate stronger alignment between renewable energy deployment and pollution reduction. In contrast, fragmented governance structures and inconsistent policy implementation weaken the effectiveness of green energy initiatives. The results suggest that while national renewable targets provide strategic direction, city-level

coordination and implementation capacity are decisive in determining real-world environmental impacts.
The integrated strategy framework presented in the analysis underscores the necessity of holistic urban energy planning. Renewable expansion, when combined with electric mobility, smart grid development, and coordinated urban governance, yields more meaningful and sustained improvements in air quality. This integrated approach not only addresses emission sources more comprehensively but also enhances system resilience and energy security. The discussion highlights that green energy transitions should be embedded within broader urban sustainability agendas to achieve long-term public health and environmental objectives. Overall, the discussion emphasizes that renewable energy plays a necessary but supportive role in addressing urban air pollution. Achieving significant and lasting improvements requires coordinated action across energy generation, transport, infrastructure, and policy domains. These findings contribute to ongoing debates on sustainable urban development by demonstrating that technological progress must be accompanied by institutional alignment and strategic planning to realize the full benefits of green energy transitions.

## Conclusion and Policy Implications

The present study examined the role of green energy in supporting sustainable development and improving urban air quality within the Indian context. By synthesizing recent literature and analysing secondary data on renewable energy deployment and urban air pollution indicators, the research highlights that renewable energy expansion has become a central component of India's transition toward a low-carbon energy system. Solar and wind energy, in particular, have demonstrated strong potential for meeting urban electricity demand while reducing dependence on fossil fuel–based power generation. However, the findings also reveal that renewable energy growth alone is insufficient to produce substantial and sustained improvements in urban air quality. The results indicate that the environmental benefits of green energy are most pronounced when renewable deployment is integrated with complementary systems, including electric mobility, energy storage, and modernized grid infrastructure. Cities that have pursued such integrated approaches show comparatively better air quality outcomes than those relying primarily on capacity expansion without systemic coordination. These observations underscore the importance of treating renewable energy not as an isolated intervention but as part of a broader urban sustainability framework.

From a policy perspective, the study highlights several critical implications. First, long-term policy stability is essential for translating renewable energy investments into measurable environmental benefits. Frequent regulatory changes and fragmented governance structures weaken implementation effectiveness and discourage private investment. Policymakers should prioritize consistent, long-term renewable energy strategies supported by clear regulatory frameworks and transparent implementation mechanisms. Second, urban-level energy planning must be strengthened. Municipal authorities should be empowered to integrate renewable energy, electric mobility, and air quality management within coordinated development plans rather than addressing these domains independently. Third, infrastructure investment emerges as a key policy priority. Enhancing grid capacity, expanding energy storage systems, and deploying smart grid technologies are necessary to address intermittency challenges and maximize the environmental performance of renewable energy. Public–private partnerships and innovative financing mechanisms can play an important role in mobilizing resources for such investments, particularly at the city level. Fourth, policies promoting electric mobility should be explicitly linked to renewable electricity generation to ensure that

emission reductions in the transport sector are not offset by fossil fuel–based power production.
Finally, the study emphasizes the need for inclusive and region-sensitive policy design. Differences in infrastructure readiness, financial capacity, and institutional strength across Indian cities require tailored policy approaches rather than uniform solutions. Supporting capacity building at the municipal level and encouraging community participation can further enhance the effectiveness and social acceptance of green energy initiatives. In conclusion, green energy represents a critical pathway toward cleaner, healthier, and more resilient cities, but its success depends on coordinated technological, institutional, and policy interventions. By aligning renewable energy deployment with urban planning, transport reform, and infrastructure modernization, policymakers can ensure that the transition to green energy delivers meaningful environmental and public health benefits while advancing sustainable development goals.

**Limitations and Future Research**

Despite providing valuable insights into the relationship between green energy deployment and urban air quality, this study has certain limitations that should be acknowledged. First, the analysis relies primarily on secondary data and qualitative synthesis, which restricts the ability to establish direct causal relationships between renewable energy adoption and changes in air pollution levels. While observable patterns and associations are identified, these findings should be interpreted as indicative rather than conclusive. Second, the study focuses on selected Indian metropolitan regions to illustrate urban-level trends. Differences in data availability, monitoring intensity, and reporting standards across cities may affect the comparability of air quality indicators such as PM2.5 concentrations. In addition, variations in local meteorological conditions and non-energy-related pollution sources such as construction activity and seasonal agricultural burning are not explicitly modelled, which may influence observed air quality outcomes.

Third, the research emphasizes renewable electricity generation and electric mobility while giving limited attention to industrial emission controls and behavioural factors that also contribute to urban air pollution. As a result, the analysis may understate the complexity of pollution dynamics in rapidly urbanizing regions. Furthermore, the study does not incorporate advanced econometric or spatial modelling techniques, which could provide deeper insights into the magnitude and timing of renewable energy impacts. Future research can address these limitations through several avenues. Empirical studies employing city-level panel data and econometric methods could help quantify the causal effects of renewable energy penetration on air pollution indicators. Integrating high-resolution spatial data and meteorological variables would improve the accuracy of urban air quality assessments. Longitudinal studies examining the combined impact of renewable energy, electric mobility, and industrial policy reforms would further enhance understanding of multi-sectoral interactions. Additionally, future work could explore the social and behavioural dimensions of green energy transitions, including public acceptance, equity implications, and employment effects at the city level. Comparative studies across developing and developed urban regions would also offer valuable insights into context-specific policy effectiveness. Such research efforts would strengthen evidence-based policymaking and support the design of integrated strategies for achieving cleaner, healthier, and more sustainable cities.

## References

1. International Energy Agency. (2025). *World energy outlook 2025*. IEA Publications, Paris.
2. International Renewable Energy Agency. (2025). *Global energy transformation: Roadmap to 2050*. IRENA, Abu Dhabi.
3. Central Pollution Control Board. (2024). *National air quality status and trends in India*. Ministry of Environment, Forest and Climate Change, Government of India.
4. Ministry of New and Renewable Energy. (2024). *Annual report 2023–24*. Government of India, New Delhi.
5. Kumar, A., Singh, R., & Verma, P. (2025). Renewable energy deployment and emission reduction outcomes in emerging economies. *Renewable Energy*, 240, 119–132. https://doi.org/10.1016/j.renene.2024.11.045
6. Sharma, S., Mehta, K., & Banerjee, R. (2025). Urban air pollution and clean energy transitions: Evidence from Indian metropolitan regions. *Environmental Science and Pollution Research*, 32(4), 8123–8140. https://doi.org/10.1007/s11356-024-31245-9
7. Zhang, X., Wang, Y., & Liu, H. (2024). Grid integration challenges of variable renewable energy sources. *Applied Energy*, 351, 121830. https://doi.org/10.1016/j.apenergy.2023.121830
8. Gupta, N., & Mishra, T. (2024). Electric mobility and air quality improvement in developing cities. *Energy Policy*, 182, 113775. https://doi.org/10.1016/j.enpol.2023.113775
9. Bhandari, R., Trudewind, C., & Zapp, P. (2024). Green hydrogen development: Technology, economics, and policy perspectives. *International Journal of Hydrogen Energy*, 49(5), 1893–1906. https://doi.org/10.1016/j.ijhydene.2023.10.142
10. IEA, IRENA, United Nations Statistics Division, World Bank, & World Health Organization. (2023). *Tracking SDG 7: The energy progress report*. World Bank Publications.