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DEVELOPMENT AND ACTUALIZATION OF RENEWABLE ENERGY: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT
This article presents a systematic literature review on the development, challenges, and opportunities of renewable energy in the global context up to 2025. The review focuses on five major themes: capacity expansion, storage and flexibility technologies, policy and market frameworks, system innovation, and socio-ecological aspects. Literature sources were collected from peer-reviewed journals (2015–2025) and official reports from international organizations such as IRENA, REN21, Ember, and IEA. The findings show a record-breaking increase in renewable capacity—582 GW in 2024 alone, with solar and wind dominating the growth—raising the global share of low-carbon electricity to 40.9%. However, this expansion remains insufficient to achieve the COP28 target of tripling renewable capacity to 11 TW by 2030. Key barriers include limited large-scale storage deployment, regulatory uncertainties, recycling issues in wind turbine blades, and inadequate political commitments. On the other hand, emerging opportunities such as decentralized energy communities, circular economy integration, and artificial intelligence-driven energy systems demonstrate promising directions for sustainable development. The study concludes that achieving global climate goals requires accelerating renewable capacity deployment, advancing storage solutions, fostering inclusive energy policies, and integrating technological innovation with socio-ecological considerations.

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INTRODUCTION

Transition going to energy renewable has enter stage crucial . In 2024, the portion energy low carbon (including nuclear and renewable) reached 40.9% of generation global electricity (Graham E. & Fulghum, N., 2025). Addition capacity energy renewable globally rising significant — up to 740 GW new in 2024 (Reuters, 2025); (IRENA, 2025) noted an increase of 582 GW alone in 2024 with a total capacity installed reach 4,443 GW (IRENA, 2025). This reflects the momentum that has not yet been Once There is previously.

However, even though number growth impressive, achievement This Still Far from the COP28 target: capacity tripling up to 11 TW by 2030— while projection moment This only reach around 7.4 TW (Guardian, 2025). In context this, is required understanding comprehensive to development technology, policy, and global challenges.

Mitigating global warming requires the rapid adoption of renewable energy (RE) systems across all sectors of the global economy. A crucial step for such adoption is assessing their social, economic, and environmental impacts. By reviewing 369 studies, this paper identifies and synthesizes the various social, economic, and environmental aspects of RE technology adoption that have been studied over the past decade. The review identifies barriers and enablers common to various countries, as well as those for which study results and/or local contexts are contradictory.

Renewable energy (RE) has a positive and significant effect on the Sustainable Development, indicating that a unit increase in renewable energy utilization results in a 0.052 % enhancement of the actualization of sustainable development. Additionally, access to clean fuels and technologies for cooking demonstrates both a positive and significant impact on sustainable development, highlighting the importance of clean energy access in improving living standards and health outcomes (Luan, Y., et al., 2025).

The review demonstrated the great variety of impacts that renewable energy deployments can have on human and ecological communities and how influential the specifics of a given community are on the positive and negative impacts that eventuate," said Bjorn Sturmberg, co-author. Governments, and all stakeholders, need to carefully consider the local context of developments and engage sincerely with locals and representative of the local ecology.

An interesting finding from the review was the correlation between support for renewable energy (RE) and a demographic of younger, highly educated people. The findings further revealed that younger people were more willing to pay for RE and were generally more optimistic about the positive aspects of RE.

Key Social Trends

Trust was the most mentioned social driver reflecting its key importance, independent of the type of economy. Trust was seen to play a crucial role, particularly in relation to building and maintaining community participation and community ownership of renewable energy assets.

The literature review elicited numerous aspects of successful projects, these include: understanding the local context, attending to the affective component of the local community, fostering a local champion, frequent and direct communication that mitigates against uncertainties and engages with perceived problems and active community participation. Social acceptance was also shown to increase in response to a degree of community co-ownership.

Visual encroachment and close proximity were found to be barriers to RE deployment. A well-studied aspect of RE was the relative proximity of RE installations to stakeholders. Generally, the closer the proximity of RE developments to stakeholders was found to correlate with lower acceptance.

Key Economic Trends

The two major economic drivers of RE deployments were high quality of institutional governance and RE subsidies. Conversely fossil fuels were advantaged through the absence of taxes or environmental prices particularly on pollution. In the majority of the literature the importance of institutional governance was identified through shortcomings in governance. Regarding technological costs, the most remarkable changes have occurred for solar PV and wind.

A barrier to renewable energy adoption is the ongoing support and subsidisation of fossil fuel use by national governments. Studies found opposition to removing these subsidies was particularly pronounced in fossil fuel producing countries such as South Africa, the Gulf States and Kazakhstan.

Environmental Impacts

Sensitivity towards environmental concerns and climate change in particular was a major driver for support for RE. In developed economies, environmental concerns were predominantly found to be drivers for social acceptance of RE. Interestingly, very few of the papers mentioned the well-known global benefits of renewable energy such as carbon emissions and particulate matter. In recent years, there has been an increased amount of literature mentioning that place attachment should be investigated rather than just pure visibility impacts of renewable energy projects.

Place attachment refers to the deep emotional and social bonds individuals and communities form with their environment. Place attachment shapes their sense of identity and belonging. These connections influence public attitudes towards renewable energy projects, as people may resist developments that they perceive as disrupting valued landscapes, community ties, or cultural heritage. Understanding and integrating place attachment into energy planning can foster social cohesion, enhance community participation, and improve acceptance of renewable energy projects.

Among social issues, trust and the quality of institutional governance are increasingly prominent in research and are key drivers of RE adoption. The review

also reveals growing interest in place attachment, but with contradictory findings regarding its negative or positive impacts. Among economic issues, the review found broad agreement that, regardless of the type of economy, countries continue to prioritize economic growth through expanded production and innovation in fossil fuels.

Effective policies can drive innovation, reduce financial barriers, and create favorable market conditions that encourage the deployment of these technologies. Regulatory frameworks play a crucial role in establishing technical standards, ensuring grid reliability, and protecting consumer interests. They also provide the necessary legal and institutional support for integrating renewable energy systems into existing infrastructure, thereby promoting sustainability and energy resilience (Agupugo et al., 2024).

Review impact environment find that studies about implementation energy renewable tend focus on impact negative local, ignoring positive global benefits, such as mitigation change climate, in general implicit, and only There is A little studies about impact environment energy renewable in countries develop.

Two identified gaps by review This as challenges that need to be overcome studied in the future is investigate benefit collocation energy renewable in countries develop and overcome lack of representation perspective and participation Ethnic group Original in study and implementation energy renewable.

METHODS

Study This use method *Systematic Literature Review* (SLR) for analyze developments, challenges, and opportunity energy renewable in global scale. Approach This chosen Because capable give description comprehensive about condition latest as well as trend relevant research, with emphasize traceability, transparency, and repeatability of the search process literature. The SLR method refers to on framework PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*), which includes four stages Main: Identification, Screening, Eligibility and Inclusion (Moher, 2009).

Search Process Literature with gather databases used : Scopus, Web of Science, ScienceDirect, MDPI, SpringerLink , and report institution international (IRENA, REN21, Ember, IEA, IPCC). With keywords search: *"renewable energy" OR "clean energy" OR "green energy"* , *"solar energy" OR "wind energy" OR "bioenergy" OR "hydropower"* , " *policy" OR "storage technology" OR "flexibility" OR "AI in energy"* . Keywords combined using Boolean operators (AND/OR) to narrow down results search.

Criteria Inclusions taken in article journal, review, proceedings conference, and report official organization international. Relevant studies with topic energy renewable, policy energy, technology storage, innovation system, as well as aspect socio-ecological. For criteria exclusion: article duplicate, focused study on energy

fossil or nuclear without relatedness direct with energy renewable, non-renewable articles have quantitative data and analysis clear policy.

Stages Selection Literature through identification beginning produced ±1,200 publications. Screening title & abstract leaving 350 relevant articles. Evaluation eligibility (full-text screening) reduce amount to 125 articles, after check availability text full and relevance content. Stage inclusion end produced 85 peer-reviewed articles and 10 reports official internationally used in analysis. This process depicted in the flowchart PRISMA Flow Diagram, which explains amount article on each stage selection.

Analysis Techniques through Analysis Quantitative: compilation of capacity data installed, growth annual share energy renewable, as well as indicator policy. Analysis Qualitative: synthesis narrative from studies policies, challenges socio-economic, as well as innovation technology. Approach Techniques Thematic: literature grouped to in five themes main namely: growth capacity, technology storage & flexibility, policy and regulation, innovation system energy, and aspect socio-ecological.

For ensure validity, only source scientific reputable used. Reliability strengthened with transparency of the selection process, documentation results search, and use PRISMA framework as standard international.

RESULTS AND DISCUSSION

On In 2024, the world recorded addition capacity energy renewable as big as 585 GW, reaching a total capacity of installed around 4,448 GW, which is record growth annual with increase 15.1% compared to year previously (IRENA, 2025). Contribution dominant come from energy solar — contribute 452 GW or around 77% of the total additional renewable — and energy wind, which contributes 113 GW. Second sector This together represent 96.6% of total growth capacity new in the sector renewable (Shahan, Zachary. 2025).

In a way geographically, Asia leads with donate around 64% from addition capacity global renewables, especially from China who installed around 64% of the global total (IRENA, 2025). On the other hand others, for achieve the COP28 target , namely capacity tripling renewable become more from 11 TW in 2030, the level expansion annual must increase become around 16.6%, whereas in a way current moment This Still be under number (IRENA, 2025).

Challenge Network and Flexibility System, Growth capacity energy rapidly renewable it turns out confronted with constraint infrastructure. In Spain, more from 80% of network nodes electricity reported Already reach point saturated, so that make things difficult addition generator new without sacrifice stability And efficiency system (Reuters, 2025). This show the need investment big in capacity transmission and planning strategic so that energy renewable can integrated with Good (Child, et al. 2018).

Along with increasing power renewable nature intermittency, technology storage becomes crucial. In Japan, investment on system storage energy battery

(BESS) has reach more from USD 2.6 billion since December 2023, including project 1 GWh battery in Fukushima (Reuters, 2025). However, regulations new limiting capacity and duration storage invite concern to eligibility economy investment term long.

Temporary that, in England, the company like Invinity Energy Systems develop vanadium-based flow batteries that offer storage energy during 6–8 hours, more safe and durable compared to lithium-ion batteries, although cost initially more high. Global demand for storage is estimated will increase until 1,500 GWh in 2027 (Jolly, Jasper. 2025).

Integration Storage in Infrastructure Energy Traditional can we see in india also explore integration solution storage with infrastructure energy conventional. They planning a BESS pilot at the power plant coal for absorb surplus energy sun at noon day and let it go moment request high. NTPC has release tender for 1.7 GW of batteries in 11 coal-fired power plants as part from initiative This (Sethuraman N.R, 2025).

In terms of global inequality in utilization energy renewable, potential solar in Africa is very big, the contradiction is contribution capacity renewable continent This only 1.5% of the global total. Challenges like access limited electricity (approx. 600 million people still without electricity) inhibits transition inclusive energy. African governments are targeting improvement capacity until 300 GW by 2030, with potential reach 90% energy renewable in 2050 (Magome, M. 2025).

In a study also explains the existence of the presence of a significant long run relationship between economic growth, renewable energy, emissions of GHG and gross fixed capital formation. On the economic pillar of sustainability, the findings indicate that renewable energy and real gross fixed capital formation exert positive and significant impacts on long run growth of SSA countries. Furthermore, the environmental pillar of sustainability results show that real GDP and real gross fixed capital formation exert positive and significant impacts on emissions of GHG while renewable energy exerts negative and significant impact on emissions of GHG (Riti et al., 2022).

Tables

Table 1. Findings Latest And The implications

Theme	Findings Latest	Implications
Growth Capacity	Record 585 GW addition; total ~4.45 TW renewable; still Not yet achieve the 2030 tripling target	Need acceleration capacity more carry on
Infrastructure Network	Saturated nodes in Spain, communication integration weak	Need investment transmission And grid modernization
Storage Energy	Investment big in Japan, UK flow battery innovation	Storage essential For grid stability and RE integration
Hybrid Integration	BESS pilot at Indian coal-fired power plant	Strategy adaptive For transition energy in a way gradually
Regional Inequality	Africa still low his contribution even though potential tall	Need support technical And financial For scalability

Figures

Figure 1. Principles to Ensure the Energy Transition Is in Harmony with Nature (IRENA, 2025)

CONCLUSION

Growth energy renewable very fast, but Not yet enough — capacity renewable increase significant, but the global target is still far. Needs technology storage and flexibility very urge for addressing intermittency. Policy and incentive fiscal (as in India) is proven effective, but needed collaboration more wide between government and sector private sector. Innovation in system energy (decentralized, AI) opens opportunity new for efficiency and adaptation factors socio-ecological and economy circular the more important, demanding approach holistic in implementation and RE development.

Several regions have pioneered effective policy and regulatory models that can serve as benchmarks. For instance, the European Union's Clean Energy for All Europeans package provides comprehensive regulations to promote renewable energy and energy storage. Similarly, the United States has implemented various federal and state-level policies that support the deployment of microgrids and energy storage systems. In conclusion, well-designed policy and regulatory frameworks are instrumental in overcoming the barriers to renewable energy microgrids and energy storage adoption. By providing financial incentives, establishing technical standards, and mandating renewable energy integration, these frameworks create a conducive environment for the growth of sustainable energy systems, ultimately contributing to global energy transition goals (Agupugo et al., 2024).

From the conclusion on can recommended some important points namely: Improvement integration policy and infrastructure cross sector and country; Acceleration implementation technology storage advanced with appropriate incentives; Open model development and community inclusive energy; and Research advanced on design system circular For *lifecycle* RE technology. By setting clear goals and providing necessary resources, policies not only stimulate innovation but also help in addressing the challenges and barriers faced by the renewable energy sector.

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