

Technologies and Materials for Renewable Energy, Environment & Sustainability

Literature Review: Affordable and Green Energy for Agricultural Communities

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Literature Review: Affordable and Green Energy for Agricultural Communities

Silva-Aguilar Anderson ^{1,a)}, Mendoza-Chate Joaquin ^{1,b)}, Saavedra-Cagallaza Sandro ^{1,c)}, and Jonathan R.F. ^{1,d)}

¹*Facultad de Ingeniería y Arquitectura, Universidad Autónoma del Perú, Lima 15842, Perú.*

^{a)} asilvaa@autonoma.edu.pe

^{b)} jmendoza2@autonoma.edu.pe

^{c)} ssaavedrac@autonoma.edu.pe

^{d)} Corresponding author: srojasfl@autonoma.edu.pe

Abstract. Access to affordable, renewable energy is essential for sustainable development and improving quality of life, especially in rural and agricultural communities. By 2030, the aim is to reduce dependence on fossil fuels and improve health, given that in rural areas 48% of households suffer from respiratory diseases due to the use of these fuels. Reason why, in this research, an analysis of literature on affordable and ecological energy for agricultural communities will be carried out, for which Rayyan was used where with our titles 2,045 publications were found from the database such as Scopus, IEEE Xplore and ScienceDirect in which has been leaked. However, energy generation and consumption continue to cause environmental and social problems due to dependence on unsustainable sources and the increase in natural disasters. The transition to clean energy, such as solar, biomass and wind, can reduce costs and CO2 emissions. Microgrids, supported by artificial intelligence, represent a key to innovation, allowing rural communities more efficient access to energy. Collaboration between the community and the private and government sectors is crucial to the success of these projects. The research bases its data on reliable databases such as Scopus, IEEE Xplore and ScienceDirect, and uses bibliometric analyzes to understand the current energy context and propose sustainable solutions that contribute to the Sustainable Development Goals (SDGs).

Keywords: energy, ecological, agricultural, affordable energy, farming communities.

INTRODUCTION

Renewable energy is an urgent need for vulnerable and growing communities that currently lack access to reliable and sustainable energy, which hinders economic and social development [1]. The IEA (International Energy Agency) report, in its 2020 edition, reported that about one billion two hundred million people do not have reliable energy, which hinders development. Renewable energy (RE) is crucial to address fossil energy shortages and climate disruption, which aligns with the United Nations SDG 7, which seeks universal access to sustainable electricity by 2030 [2]. A recent study showed that villages with new access to electricity show a significant increase in small industries, suggesting that the potential of small industries can become an intermediate mechanism in which electricity contributes positively to poverty reduction [3]. However, attempts to provide energy to people in these communities often face system sustainability issues. Common causes of challenges are inadequate energy system design, technological gaps, and operational difficulties [4]. Long-term sustainable actions are needed to solve the challenges we face today. A sustainable energy system can be defined as a cost-effective, reliable, and environmentally friendly energy system that effectively uses local resources and networks [5]. Rural electrification in developing communities remains a significant challenge. Energy is a primary source for increasing quality of life and fostering economic development; however, dependence on fossil fuels creates environmental problems [6]. Although rural electrification has the potential to decrease poverty and enrich the quality of life [7], it faces technical and financial challenges that must be addressed to ensure its economic viability and promote its adoption in these communities [8].

METHODOLOGY

This process begins with the identification phase, where 1,666 records of potentially relevant studies were located, coming from 02 databases, Science Direct and IEEE, which are recognized and reliable in the student and scientific

field. Both articles and documents found were downloaded and uploaded to the Rayyan program, which helped us debug duplicate records and others considered irrelevant. In this debugging stage, 24 duplicate records were removed, along with another 469 records that were discarded for reasons of another type of focus related to the research topic, resulting in a total elimination of 493 records review.

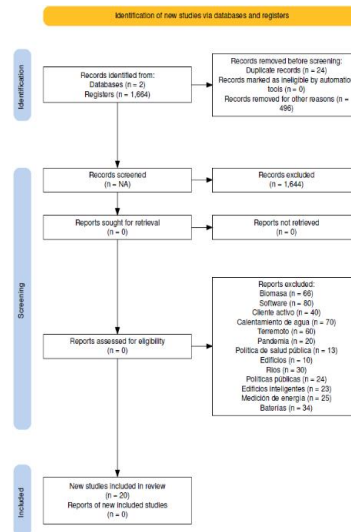


FIGURE 1. Execution of a prism for the selection of selected documents.

In this stage, multiple documents were excluded due to their focus on topics irrelevant to the research's specific purpose. Among the excluded topics, we have biomass (66 records), software (80 records), global warming (70 records), pandemic (20 records), public health policy (13 records), and other topics such as smart buildings and energy measurement, with a total of 16 exclusion categories. The execution of the entire procedure is observed in the PRISMA flowchart; see Figure 1. This reflects an exhaustive selection process, ensuring that only the most relevant studies aligned with the research topic were considered, eliminating those that addressed unrelated issues or did not provide direct value to the review objectives. Finally, in the inclusion phase, it was determined that 20 studies met all the inclusion criteria (see Table 1) and were integrated into the final systematic.

Table 1. List of documents analyzed.

N°	Original title	Author(s)	Year	Country	Link
1	Integrated sustainability assessment framework for geothermal energy technologies: A literature review and a new proposal of sustainability indicators for Mexico	Solano-Olivares et al.	2024	Mexico	Link
2	John B. Goodenough's pioneering contributions towards advancements in photo-rechargeable lithium batteries	Singh et al.	2024	EE, UU	Link
3	Energy access sustainability criteria definition for Colombian rural areas	Montalvo-Navarrete et al.	2024	Colombia	Link
4	Sustainability in practice: Analyzing environmental, social and governance practices in leading Latin American organizations' reports	Hluszko et al.	2024	Brazil	Link
5	Securing energy sovereignty: A review of key barriers and opportunities for energy-producing Native nations in the United States	Raimi et al.	2024	EE. UU	Link

6	Global strategies for a low-carbon future: Lessons from the US, China, and EU's pursuit of carbon neutrality	Evro et al.	2024	EE. UU	Link
7	Biofuels versus climate change: Exploring potentials and challenges in the energy transition	Rial, Rafael Cardoso.	2024	Brazil	Link
8	Techno-economic Analysis of Hybrid Energy System Connected to an Unreliable Grid: A Case Study of a Rural Community in Nigeria	S. A. Adetoro et al.	2022	Nigeria	Link
9	Key Elements to Create Renewable Energy Communities (REC)	G. C. Lazaroiu, M. Roscia.	2023	Canada	Link
10	Is dynamic energy sharing really necessary? The case study of collective renewable self-consumers in Croatia	M. Gržanić, T. Capuder.	2023	United Arab Emirates	Link
11	Energy Management Framework for Transactive Energy Communities	N. Mendes et al.	2024	Portugal	Link
12	Optimal dispatch for the US Virgin Islands to increase renewable rates in Saint Croix	D. V. Pombo et al.	2023	EE. UU	Link
13	Technical-economic impact of the deployment of renewable energy communities: an Italian case study	M. A. Bucarelli et al.	2023	Italy	Link
14	Case study of microgeneration for energy supply in remote island communities	S. Badamshina et al.	2024	Russia	Link
15	The energy community is part of the smart city	I. Ciobanu et al.	2023	Romania	Link
16	Key elements to create renewable energy communities (CER)	G. C. Lazaroiu, M. Roscia.	2023	Canada	Link
17	Optimal operation of battery storage systems in renewable energy communities	P. De Juan-Vela, A. Alic, V. Trovato.	2023	France	Link
18	Renewable energy communities: an innovative application for a small Italian mountain municipality	G. E. Dino et al.	2024	Kosovo	Link
19	Solar photovoltaic recycling strategies	Ngagoum Ndalloka et al.	2024	EE. UU	Link
20	Anticipating future photovoltaic waste generation in China: Navigating challenges and exploring prospective recycling solutions	Wang et al.	2024	China	Link

RESULTS AND DISCUSSION

Figure 2 shows the number of publications by country selected from our databases on renewable energy in vulnerable communities, with data from Science Direct and IEEE sources. We can see that the United States significantly leads with five publications (33.3% of the total), indicating a considerable interest in this area, probably due to its focus on energy transition and innovation in sustainable technologies for rural communities [29]. Brazil and Canada have two publications each (13.3% each), reflecting a notable commitment to the trend and challenges in renewable energy research [30]. Other countries such as China, Colombia, France, and Italy present one publication (6.7% each), suggesting a more limited participation than the leaders, although demonstrating a global interest in the topic. This distribution could reflect differences in the focus and priority each country gives to applied renewable energy research. This distribution of publications reflects differences in each country's priority for renewable energy research in rural areas. While some countries, such as the United States, invest more heavily, others show a more moderate interest, possibly due to resource limitations or a focus on other research topics. However, the fact that there are publications from multiple countries highlights the relevance of this topic at a global level. Figure 3 shows the number of documents published on renewable energies in vulnerable areas of our selected databases, distributed by

year in various academic sources, such as Science Direct and IEEE. A notable growth in publications can be observed over time: in 2022 only 1 publication was recorded, while in 2023 the number increased to 7 and, finally, in 2024 it reached 12 publications. Likewise, the selection of reliable and updated sources is crucial to guarantee the validity and relevance of our research [34]. This increase suggests a growing interest in renewable energy research applied to vulnerable contexts, possibly driven by the urgent need for sustainable solutions that benefit these communities [35].

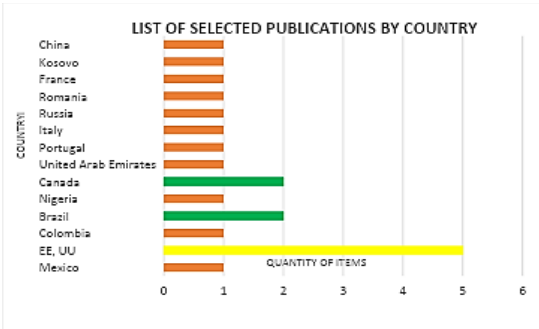


FIGURE 2. List of publications from countries selected for research.

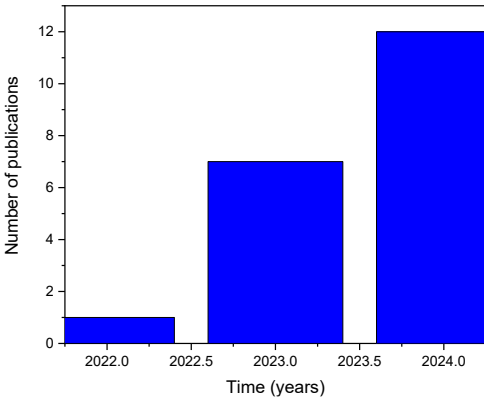


FIGURE 3. Publication year of the documents acquired for research.

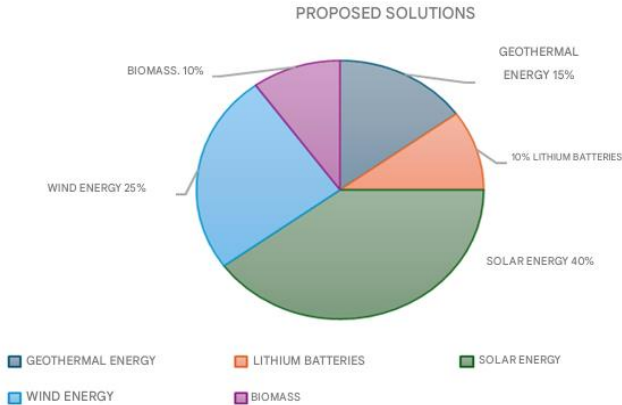


FIGURE 4. Proposed solutions obtained from research.

Figure 4 shows the proportions of different types of renewable energy proposed in a set of 20 selected research projects. The objective of these solutions is to reduce environmental pollution and promote sustainable development.

As can be seen, solar energy (40%) is the most prominent option, indicating its relevance in research as a primary source for developing communities due to its abundance and ease of implementation in remote areas [36], followed by wind energy (25%), which is a key renewable energy source to reduce dependence on fossil fuels and mitigate climate change [37]. Both renewable energy sources are the main solutions in the research based on their unique benefits and practical feasibility.

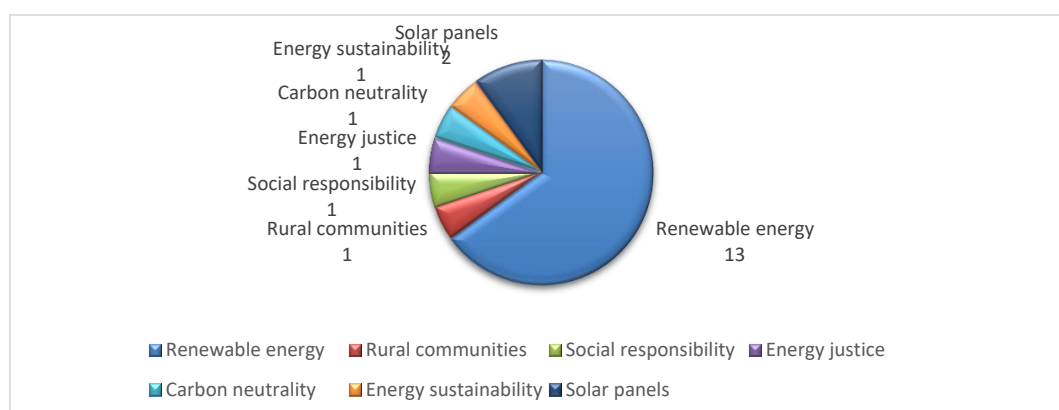


FIGURE 5. Keywords for searching for information for research.

Figure 5 shows the keywords used in our search for documents on renewable energy in vulnerable areas. The most frequent keyword is "Renewable energy", found in 13 documents, reflecting its relevance in this field of study. It is followed by "Solar panels" with 2 documents, highlighting the interest in this specific technology. Other terms such as "Energy sustainability", "Carbon neutrality", "Energy justice", "Social responsibility" and "Rural communities" appear in 1 document each, indicating the diversity of topics and approaches that accompany research on renewable energy. This variety of keywords suggests that the interest in renewable energy in rural areas covers not only technical aspects but also social and environmental issues that complement the search for sustainable solutions to reduce dependence on fossil fuels [38].

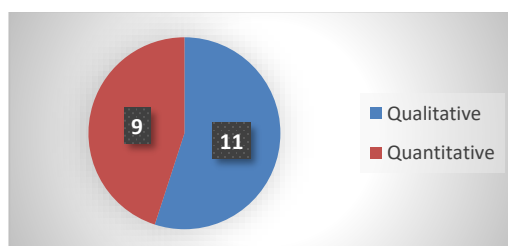


FIGURE 6. Type of data obtained for research.

Figure 6 shows that of the 20 documents selected for the research, they present a combination of methodological approaches, both quantitative and qualitative. The combination of approaches allows obtaining a more complete and in-depth view of the object of study, by integrating numerical and interpretive data [39]. As shown, 9 of these documents contain quantitative data, while 11 documents focus on a qualitative approach. The inclusion of both types of approaches ensures a more realistic and detailed understanding of the aspects invested and also increases the validity and reliability of the research results [40].

This research highlights the importance of renewable energies as a viable solution to improve living conditions in developing communities. The results obtained show that technologies such as solar and wind energy are the most widely used, representing 40% and 25% respectively. This is due to their accessibility, ease of implementation, and effectiveness in remote areas, making them ideal options for these communities. In addition, these energies not only help reduce dependence on fossil fuels but also offer economic and social benefits, such as job creation and the revitalization of local economies. An important point identified in the research is the barriers that hinder the

implementation of these technologies. These include economic problems, lack of adequate infrastructure, cultural resistance, and the absence of specific public policies. These barriers not only limit access to renewable energies but also complicate their long-term acceptance and sustainability. This reinforces the need to design strategies that address these challenges, such as the creation of favorable policies, financing programs, awareness campaigns, and alliances between public and private sectors. Another interesting aspect is the growing trend in research on renewable energies for vulnerable communities. In the last three years, publications related to this topic have increased significantly, from 1 in 2022 to 12 in 2024. This growth reflects an increasing interest in finding sustainable solutions to energy problems in vulnerable contexts. However, it was also observed that most publications come from countries such as the United States, which highlights an uneven distribution in research. This suggests the need for greater international collaboration to ensure that the benefits of these technologies reach more regions. Finally, the research highlights that renewable energies not only represent an environmental solution but also a tool for social and economic development. Renewable technologies not only help reduce carbon emissions but also have the potential to transform communities by offering a reliable and sustainable source of energy. Despite the challenges identified, the comprehensive approach of this study allows us to conclude that, with the right strategies, these technologies can be a fundamental pillar for improving the quality of life in developing communities and promoting a more equitable future.

CONCLUSION

In conclusion, the analysis of publications on renewable energy in vulnerable communities reveals a growing interest in this area, reflected in the quantity and diversity of studies. The United States leads the production of research, probably due to its focus on energy transition and the development of sustainable technologies. Other countries such as Brazil, Canada, and China contribute, although to a lesser extent, demonstrating that interest in renewable energy is a global phenomenon. Regarding the types of publications, international conferences are the most frequent medium, suggesting that researchers value interaction and exchanging ideas in a collaborative environment; however, journal articles remain crucial to building a solid scientific knowledge base. The increase in the number of publications in recent years reflects a growing urgency for sustainable solutions for vulnerable areas, especially considering the context of climate change and the energy crisis. Furthermore, the prevalence of English as the main language of these investigations highlights the authors' intention to reach a global audience, allowing these studies to have a greater impact and recognition. The variety of keywords employed, from technical terms to social aspects, shows a holistic perspective in this field of study, covering not only technological advances but also ethical and social considerations. Finally, the combination of qualitative and quantitative methodological approaches in the research allows for a comprehensive understanding of the impact and possibilities of renewable energy in vulnerable communities, offering a solid basis for future investments

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