



Strengthening strategies for renewable energy resources (RES) through educational analysis, participation, services, and regulation based on mixed methods

Bambang wido kristanto¹, Agus wibowo²

^{1,2}Sistem Komputer, Universitas Sains dan Teknologi Komputer Semarang, Indonesia

Email : Prayogo3@gmail.com¹ , agus.wibowo@stekom.ac.id²

Article Info

Article history:

Received June 10, 2025

Revised August 12, 2025

Accepted September 22, 2025

Keywords:

Battery Waste

Community Participation

Energy Literacy

Policy Reform

Renewable Energy

ABSTRACT

Indonesia has extraordinary resources and potential in developing renewable energy sources (RES), but various obstacles must be overcome in implementing RES. The purpose of this study is to analyze the gap in the application of RES. This gap includes energy knowledge, community participation, battery waste management, service quality, regulation, and legal policy. This study employs a mixed-methods approach, combining quantitative data collection through a structured questionnaire with qualitative data collection through in-depth interviews, focus group discussions, and policy analysis. The results show that 62% of people do not understand RES, 28% are involved in project planning, and 74% are unaware of SOP (standard operating procedures) regarding battery waste recycling. The results of the correlation analysis reveal a positive relationship between the level of knowledge and interest in RES ($R = 0.56$). Also, the developed community-based participation model includes initial involvement, transparency of information, and local incentives. These findings further strengthen the compatibility of the innovation diffusion theory, planned behavior theory, SERVQUAL, and the theory of public interest. This study will make a practical contribution through evidence-based strategies in increasing resilience, especially for policymakers and energy service providers. The impact of the policy aspects includes the need for large reforms, education, public campaigns, and the realization of battery waste management systems. This study also provides an opportunity for further study by expanding the geographical scope and related industrial sectors.

Corresponding Author:

Bambang wido kristanto

Universitas Sains dan Teknologi Komputer

Jl. Majapahit No. 605 Semarang

Email: join@stekom.ac.id



1. INTRODUCTION

In the global energy crisis and the challenges of climate change that occurred at this time, the transition of energy from fossil energy to Renewable Energy Sources/RES is a necessity. Indonesia is

a maritime country, and the islands have abundant natural resources, potentially very large in the development of renewable energy (Renewable Energy Sources/RES. Like solar power, wind, water, and biomass. However, the use of renewable energy in the national energy mix is still very low and is not by the targets set in the National Energy General Plan (RUEN). In 2025, the government targeted 23% of renewable energy in national energy, but until 2023, its contribution only reached around 12.3% according to data from the Ministry of Energy and Mineral Resources. This shows that there are still various structural and social obstacles that need to be resolved more effectively.

The discovery of important phenomena in the field is the low knowledge of the public about energy literacy. Based on a survey conducted in this study, 49% of respondents did not understand the benefits of RES, and only 21% of respondents had received information about RES. In addition, only 23% of respondents from the community were involved in the discussion and planning of the RES projects in their region. This reflects the lack of aspects of educational and communication strategies from related parties to the community. In addition, people who do not get information tend to be skeptical and pessimistic about the application and use of new technology, which becomes an obstacle.

The lack of community-based approaches and the unclear benefits of direct benefits of renewable energy projects results in low community participation, as well as the number of projects carried out by top-down methods, without deliberation and involvement of local communities, resulting in the emergence of social resistance which is an obstacle to the application of technology. In this case, it is very important to take a participatory approach to increase the sense of ownership and sustainability of the program. Previous research by Said et al. (2021) shows that involving the community from the planning stage can significantly increase the success of renewable energy projects.

One of the other concerns that is the main concern is the management system and handling of battery waste, especially lithium batteries and sulfuric acid (H₂SO₄) that are used as a storage of energy in the RES technology system. From the data collected, around 74% of respondents did not know the procedure for recycling used batteries. Until now, an absence of a standardized and adequate battery waste management system in Indonesia. This is one of the potential causes of increasing environmental pollution problems, which are contrary to the principle of renewable energy sustainability. Zeng et al. (2014) underline the need for a safe and integrated battery waste recycling system to avoid environmental pollution and build public trust in the application and use of new energy technology.

Community dissatisfaction with renewable energy services, in terms of supply reliability, technical service speed, and lack of guarantee of service quality to consumers. This negative perception causes people to be slower in accepting the application of new technology. According to Kumar & Hundal (2020), the SERVQUAL model shows that there is a striking difference between what is expected from the energy service provider compared to what occurs in the field. Studies conducted in various developing countries also found the same thing that happened in Indonesia, where service providers failed to meet user expectations consistently.

In the case of regulations and legal certainty, or regulations that support the implementation of RES, it is considered incomplete and weak. As well as the absence of policies that encourage the use of RES technology actively in various sectors, as a result. Consumers and investors who want to participate in the development of RES technology projects often feel pessimistic and are uncertain due to weaknesses in this aspect. For the sake of creating a more comfortable condition between investors, industry players, and consumers, it is necessary to increase regulations and legal certainty, or regulations that are flexible, effective, and focus on protection for all parties. As revealed by Hantke-Domas (2003), weak regulations can result in loss of protection for the public and inhibit market functions in vital sectors such as energy.

In international studies, the challenge of energy transition is not only a technical matter but is also a complex process of social and institutional transformation. Sovacool et al. (2015) revealed that to adopt clean energy, a need to take an interdisciplinary approach, which includes community behavior, policy design, and strengthening local institutions. This study adopted the T approach by combining the theory of diffusion of innovation (Rogers, 2003), the Theory of Planned Behavior (Ajzen, 1991),

SERVQUAL, and Public Interest Theory, to build a deep understanding of obstacles and potential for renewable energy development (RES) in Indonesia.

In the Theory of Diffusion of Innovations written by Rogers, E. M. (2003), it is explained that the spread of an innovation, such as renewable energy, is influenced by 5 factors: knowledge, persuasion, decision, implementation, and confirmation. In the context of implementing renewable energy technology in Indonesia, public interest and involvement often stop at the initial stage due to a lack of clear information and education. Al-Sallal, K. A., & Al-Sallal, A. M. (2021) show that public awareness of new energy technology is greatly influenced by the communication and socialization strategies employed. Pramudita, D., Kusuma, A., & Rachmawati, S. (2024) also explain that social media can be a good and effective educational tool to raise awareness among the younger generation about renewable energy. So, energy literacy is not just about technical knowledge, but also about strengthening social perceptions of the benefits and importance of implementing and using renewable energy technology.

Meanwhile, the Theory of Planned Behavior provides an understanding of the importance of attitudes, subjective norms, and behavioral controls that are felt in increasing community participation. Research conducted by Kumar & Anwar (2021) explains that community participation will increase if they know and see the concrete benefits of a program carried out, feel involved in the process, and have confidence in the effectiveness of the technology used. This makes an important foundation in designing a community-based approach that is more adaptive to the local context.

In connection with the management of waste and environmental sustainability, the commons theory put forward by Ostrom (1990) highlights the importance of collaboration to maintain mutual resources. Battery waste from an energy storage system is one example of a real challenge in this project. Without the involvement of the community, support for investors and industry players, as well as strict regulations, the problems regarding the handling of waste produced have the potential to damage the environment in the long run. Therefore, the development of a management system and the handling of collaboration-based waste are very important.

This study also found a gap between the expectations of the quality of energy provider services compared to the reality received by consumers. The SERVQUAL model, developed by Parasuram, A., Zeithaml, V. A., & Berry, L. L. (1988). It is one of the most popular ways used to assess the quality of energy services. According to this model, five dimensions form the basis for forming service quality: Tangibles, reliability, responsiveness, assurance, and empathy. Kumar, V., & Hundal, B. S. (2020). Also, use this model to assess the service of Solar Energy Company and find that there is a big difference between what customers expect with what they see.

In addition, there is a gap in macro policy at the level of implementation and micro policy gaps at the local level. National policy regarding renewable energy has not provided technical instruments, incentive mechanisms, or effective project management in the field. Kalpikajati & Hermawan (2022) emphasized that the lack of coordination between related institutions and the inconsistent policy will further worsen the existing obstacles. Therefore, the importance of vertical and horizontal integration lies in formulating and implementing policies.

By combining the results of the field with a literature review, it can be concluded that the development of renewable energy (RES) in Indonesia faces interrelated multidimensional and systemic challenges, which include constraints about the low level of energy literacy knowledge, lack of community participation, weak waste management systems, dissatisfaction with services, and policies that have not been fully implemented are some problems that need to be overcome simultaneously. Therefore, holistic, participatory, and evidence-based approaches are very necessary to accelerate the transition to clean energy.

Based on the results of the analysis of the gap and challenges that exist, this study aims to formulate a strategy to strengthen the implementation of renewable energy in Indonesia by prioritizing five main approaches: energy education, public participation, management of battery waste, improving service quality, and improving regulation. The design of this strategy is to integrate quantitative and qualitative data, so that it can reflect objectivity in the field and at the same time provide a more in-depth understanding contextually.

The approach that will be used in this study not only presents statistical information on the level of understanding or satisfaction of the public but also explores more deeply the perception and experience as a determining factor in the development and use of RES technology. It is hoped that the results of this study will serve as a foundation for policymakers, industry players, and the community

in building an inclusive, sustainable, and equitable energy system. In addition, this research also opens opportunities for further broad studies, which include geographical and sectoral aspects.

2. METHODOLOGY

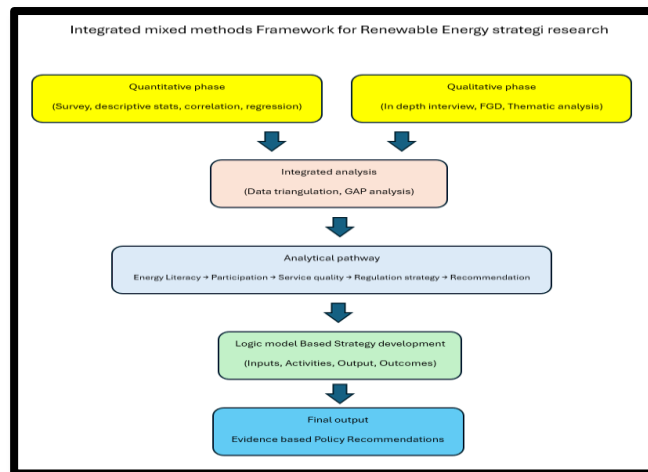
2.1 Type of research

The method used in this research is a mixed methods approach, combining quantitative and qualitative methods. This method was chosen because the issue to be studied is multidimensional and requires analysis in all aspects, numerical measurement, and contextual understanding. Involves social, technical, and policy aspects that cannot be explained by just one type of data. The mixed methods model applied is an exploratory sequential design, where quantitative data is collected first to identify general patterns, and then qualitative data is used to deepen understanding. This design aligns with the guidelines from Creswell & Plano Clark (2018), who recommend a mixed-methods approach for complex socio-technical issues. This method is suitable and relevant for addressing various obstacles in the implementation and application of renewable energy technology (RES) in Indonesia, by the findings of constraints and barriers in terms of low education, community participation, service quality, waste systems, and regulations.

Figure 1: Strategic Framework for Renewable Energy (RES)

2.2 Strategy Formulation Model / Algorithm

To formulate a reliable strategy for the implementation of renewable energy technology (RES), this research adopts a GAP Analysis approach combined with a logic model framework. The function of



GAP Analysis is to identify the gap between the current conditions and the ideal conditions in terms of energy literacy, public participation, battery waste management, service quality, as well as regulations and policies. Next, the results of this analysis are used as input in a logic model that includes input, activities, output, and expected outcomes. This approach will strengthen the evidence-based development strategy. (evidence-based strategy).

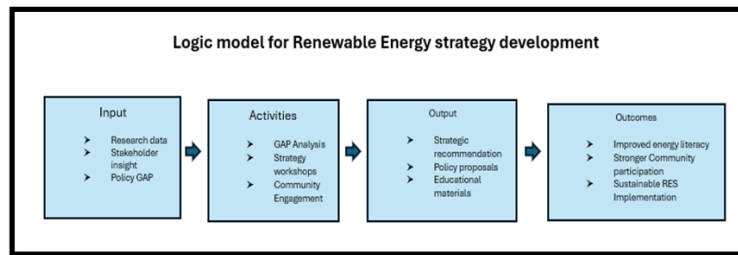


Figure 2: Model Chart for Renewable Energy Strategy Development.

2.3 Tools/software

Using SPSS (Statistical Package for the Social Sciences) version 25, Quantitative data analysis is conducted for descriptive statistical testing, Pearson correlation, and linear regression. Meanwhile, for qualitative data analysis, you can use NVivo 12 software, which is very helpful in the coding process and thematic analysis of in-depth interviews and FGDs (Focus Group Discussions). This software is very competent in grouping themes and visualizing relationships between categories, making it easier. For policy analysis, a content analysis approach can be used, which can be done using Microsoft Excel.

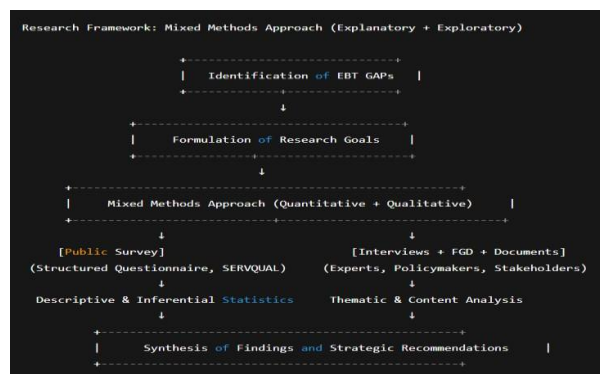
2.4 Data and Analysis Techniques

The data used includes two types, namely primary data and secondary data. Primary data were obtained by distributing questionnaires to the community members who are already using or are potential users of RES (n=250), as well as conducting in-depth interviews and focus group discussions (FGD) with project managers, government officials, and energy policy experts. Meanwhile, secondary data were collected from policy documents, official reports, and scientific journals. For quantitative analysis, correlation and regression tests can be conducted to explore the relationship between literacy, participation, and interest in adopting RES. As for qualitative data, thematic analysis is applied according to the Braun & Clarke (2006) guidelines, which focus on identifying patterns and meanings from the narratives conveyed by the informants.

2.5 Research Design / Framework

The design of this research adopts a mixed framework that combines quantitative and qualitative approaches in a single analysis flow. This model follows the integrative approach proposed by Ivankova, Creswell & Stick (2006), where the results from quantitative data are reinforced and deepened through qualitative findings. The framework is illustrated through the relationship between literacy → participation → service quality → regulation, → strategy recommendations. This flow is also complemented by a strategy matrix based on a logic model to produce more concrete policy recommendations.

Figure 3: Research framework mixed methods approach (Explanatory and Exploratory)



2.6 Validity and Reliability

To ensure that the instruments used are valid and reliable, construct validity tests and reliability tests using Cronbach's Alpha are conducted in the questionnaire. An instrument can be declared valid if the item-total correlation value is > 0.3 and if reliable, the Cronbach's Alpha (α) > 0.7 Sugiyono, 2018). And to validate qualitative data, one can apply triangulation of sources and methods by using a comparison between interview results, documents, and surveys. In addition, the need to use member-checking techniques to ensure that the interpretation of data is by what is conveyed by the informant

2.7 Research location

This research was conducted in several regions in Indonesia that have potential and relevance in the implementation of small to medium-scale renewable energy projects, including West Java Province, Central Java, and Yogyakarta. The selection of these locations was done purposively, based on criteria such as involvement in RES projects, data availability, and community participation variables. These areas can reflect urban and rural situations, allowing for limited generalization to the overall context of Indonesia.

3. RESULTS AND DISCUSSION

3.1 Testing

In this study, two main approaches were undertaken.

First, the testing used quantitative analysis employing data from structured questionnaires filled out by 250 respondents, both current users and potential users of Renewable Energy Sources (RES). All this data was then analysed using descriptive tests, Pearson correlation, and simple linear regression with the SPSS software.

Second, a qualitative approach was applied through in-depth interviews and focus group discussions (FGD), which were then analysed using NVivo 12 software for thematic analysis. In addition, a content analysis of energy policy documents was also conducted to evaluate the gap between regulations and their implementation.

3.2 Testing Results

The test results indicate that the level of public knowledge regarding energy literacy is still low. About 62% of respondents do not understand the benefits of renewable energy, and only 21% have ever received information and explanations from relevant institutions. The Pearson correlation test revealed a positive relationship between energy knowledge and interest in using Renewable Energy Sources (RES), with a value of $r = 0.56$. Additionally, the regression test confirms that energy literacy has a significant contribution to the interest in technology adoption, with a significance value of $p < 0.05$.

In terms of public participation, only 28% of respondents felt they had ever been involved in the planning or implementation of RES projects. The thematic analysis of qualitative data shows that. The top-down approach of the project, the lack of information transparency, and the absence of social incentives are factors contributing to the low public participation.

Other findings also show that 74% of respondents do not know the proper methods or the legal and competent institutions for handling battery waste recycling. This confirms that there is currently no structured waste management and disposal system for waste generated from battery-based energy storage technology at the local level. On the other hand, there is a low positive perception of the quality of RES services, especially in terms of reliability, technical response speed, and after-sales guarantee.

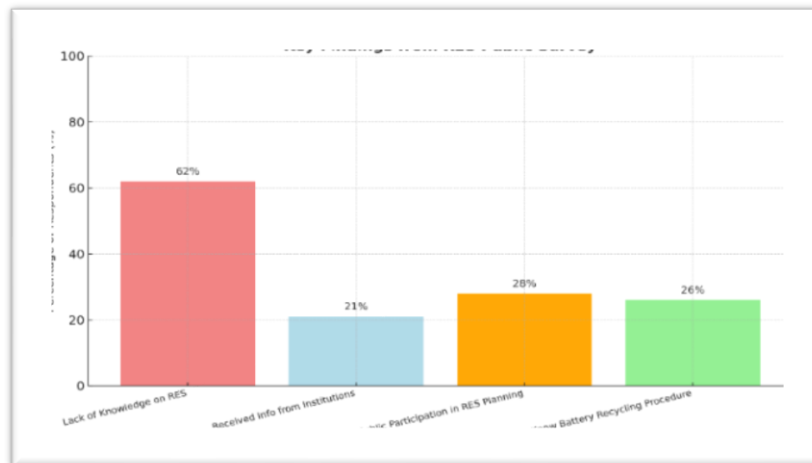


Figure 4: Key findings from the public survey on Renewable Energy Sources (RES)

Table 1: Correlation between Knowledge and Interest in Using Renewable Energy (RES)

Variable	Correlation Coefficient (r)	Description
Level of RES Knowledge	0.56	Positive correlation with interest in using RES
Participation in RES Projects	0.42	Moderate correlation with understanding of regulations

3.3 Interpretation of Results

These results reinforce the notion that the level of knowledge about energy literacy plays a crucial role in the successful adoption of Renewable Energy Sources (RES), starting from the initial Stages. According to the Diffusion of Innovation theory proposed by Rogers in 2003. People who do not understand how RES works and its benefits tend to feel pessimistic and even refuse to adopt this technology. These findings are also consistent with the research conducted by Park & Ohm (2014), which shows that the quality of knowledge about energy has a significant impact on the public's readiness to switch to clean energy sources.

The principles of the Theory of Planned Behaviour (Ajzen, 1991) have not been effectively applied in the RES project, resulting in low public participation, especially in building subjective norms and perceived behavioural control. The lack of public involvement in the planning process creates a social distance between the project and the community that will benefit from it, and ultimately can lead to failure in the implementation stage. Research by Sovacool et al. (2018) emphasizes that involving the community from the beginning is key to achieving a fair and sustainable energy transition.

3.4 Analysis Results

An in-depth analysis of the five dimensions of service based on the SERVQUAL model (Parasuraman et al., 1988) reveals a gap between expectations and reality. Interviews with RES users show that the technical services provided are not yet responsive, the warranty quality is low, and there is still a lack of professionalism. These findings align with the research conducted by Tomsic et al. (2019)

in Latin America, which emphasizes that perceptions of service quality significantly impact the success of implementing and using renewable energy systems and technologies sustainably.

In the context of battery waste management and handling, the lack of public knowledge and the absence of adequate recycling systems can pose new risks in terms of environmental friendliness.

Zeng et al. (2014) and Rachmadhani & Priyono (2023) emphasize the importance of recycling systems based on environmentally friendly technologies, such as hydrometallurgy. However, without support, regulatory clarity, and industry participation, these technical solutions are difficult to implement effectively.

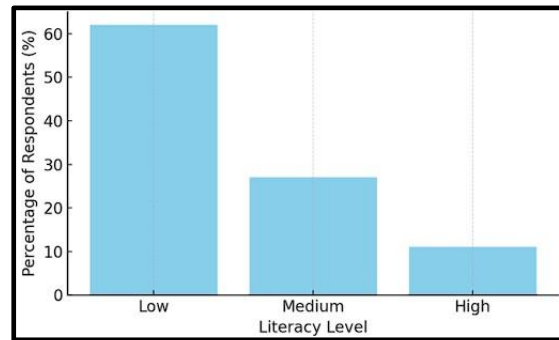


Figure 5: Distribution of Energy Literacy Level

Finally, from the policy perspective, document analysis shows that renewable energy regulations in Indonesia are still declarative and do not cover the technical aspects needed in their implementation. The absence of sanctions and incentives in aspects of regulation and policy makes this one of the main obstacles. This strengthens the theory of Public Interest Regulation (Hantke-Domas, 2003), which states that non-operational regulations will fail in protecting the public interest.

4. DISCUSSION

This study reveals that the application and use of new renewable energy RES in Indonesia faces many multi-dimensional challenges and obstacles, among others, due to the low understanding and knowledge of the public about energy, lack of direct participation by the community, managing battery waste that has not been handled optimally, the quality of services that are still inadequate and unsatisfactory, as well as the translation of regulations and legal certainty that is unclear. This finding shows that developing and applying RES technology not only relies on technological factors but must also involve the community, strengthen institutions, and have solid policy support.

Theoretically, the low knowledge of the public is strengthening the diffusion of innovation theory, Rogers (2003), which emphasizes the importance of the quality of education and understanding of the community in the early stages of the adoption process. In addition, there is still a lack of community participation in strengthening the theory of planned behavior Ajzen. (1991), which states that the intention to be involved is greatly influenced by social attitudes and norms. These results are in line with the results of previous studies, as are those of Kumar & Anwar (2021), which emphasized the importance of community involvement since the beginning of the implementation of the RES project

Furthermore, the problem of managing and handling battery waste also shows the need for an ongoing approach, according to the explanation. Of Zeng, X., Li, J., & Singh, N. (2014). This highlights the importance of formal and environmentally friendly recycling systems. On the other hand, regarding public perceptions of (RES) services that are unsatisfactory, especially in terms of reliability and speed of response. This is by the findings of the Kumar & Hundal study (2020), which emphasizes the importance of service quality to maintain the trust of users.

In terms of policy perspective and legal certainty, the RES regulations given are still not sufficient. This is in line with the policy cycle theory, Howlett & Ramesh (2003), which states that the policy will fail if it does not have a clear stage of implementation and evaluation. This study also strengthened the findings of Kalpikajati, S. Y., & Hermawan, S. (2022) about the weakness of legal certainty structures relating to the development and application of RES in Indonesia.

Also, theoretically, this study strengthens the interdisciplinary approach in the study of energy transitions by combining five main theories. And practically, the results obtained will be the basis for the government and the actors in the energy service provider in formulating a strategy for strengthening new renewable energy RES based on evidence. However, this research also has several limitations, including the scope of regions that are still limited, data based on perception, as well as the role of informants from inadequate industrial sectors.

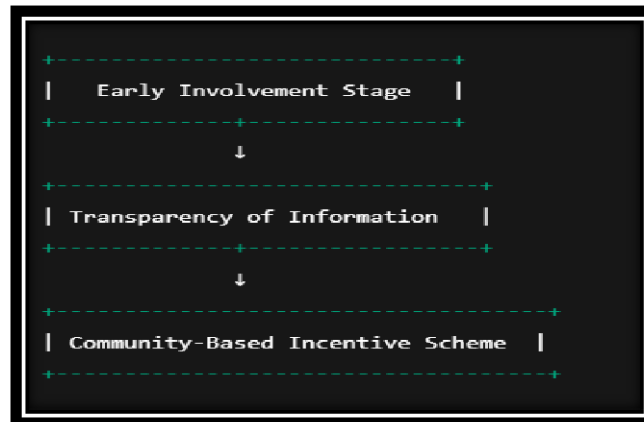


Figure 6: Conceptual Model of Community Participation Strengthening

5. CONCLUSION

This study concluded that the implementation of the development and application of renewable new energy technology (RES) in Indonesia faced a variety of quite complicated and systemic challenges, from things that are social, technical issues to the institutional sector. One of the factors that becomes the main obstacle is the very low level of public knowledge about energy, minimal public participation, an incompetent battery waste management system, and negative perceptions of the service quality provided by Energy providers, as well as weak regulations and legal certainty that have not been provided proportionally.

The survey results that were conducted showed that 62%, respondents, taken from various walks of life, did not understand the benefits of renewable energy, and only 21%. From the number of respondents who have received information from related institutions, as well as the very low level of community participation in rescue project planning, the survey results show several aspects, 28%, which prove that the participatory approach aspects are still less effective in the implementation of the RES Project. In addition, the problem of public awareness of the importance of battery waste management is also very minimal. From the survey results, only 26% of respondents who know the battery waste recycling procedures well, the gap will create new problems in the context of environmental pollution.

The aspect of service provided to consumers is one of the weaknesses, with numerous complaints from the public and dissatisfaction regarding the reliability of the energy supply, the lack of technical response, and the assurance of after-sales service. From a policy perspective, the existing regulations are considered merely declarative without any technical implementation mechanisms and clear incentives provided, resulting in a lack of interest from investors, industry players, and consumers to actively participate and support the development and adoption of renewable energy technology.

Theoretically, this study provides relevant information from various theoretical sources, such as the Diffusion of Innovation, Theory of Planned Behaviour, SERVQUAL, and Public Interest Theory, in terms of the development and implementation of RES technology in developing countries like Indonesia. The

mixed methods approach has proven to be very effective in providing a comprehensive picture of the gap between expectations, the policies provided, and the reality of implementation on the ground.

Table 2: Summary of Key Survey Indicators on RES Implementation:
Each bar represents a key survey result with the following data.

Indicator	Percentage (%)
Received RES Education	21%
Public Participation	28%
Know Battery Recycling Procedure	26%
Service Satisfaction (estimated)	30%

6. Recommendations for Further Study

a. Geographic and Social Expansion

Expansion of research to 3T areas (Underdeveloped, Frontier, and Outermost) to obtain a more nationally representative picture. By better understanding the geographical and social conditions in a multi-variate manner, to delve deeper into the local context in the adoption of New Renewable Energy (RES).

b. Micro and Macro Economic Analysis

Further studies should include a cost-benefit analysis of the implementation of RES at the household and community levels, as well as its impact on local economic resilience. And the need to conduct evaluations on the aspects of financing, availability of incentives, and project feasibility systematically.

1) Development of the index and readiness for adoption of technology RES

There is a need to create a RES adoption readiness index based on local indicators, such as energy literacy levels, regional regulatory readiness, public participation, and institutional capacity. This index will serve as a practical policy measurement tool.

2) Integration of Cross-Sector Perspectives

For further studies, it is necessary to synchronize the development of RES across sectors, including education, agriculture, tourism, and small industries. This is very important with the aim of building a sustainable and inclusive RES ecosystem across various sectors.

3) Longitudinal Evaluation

A need to conduct longitudinal studies to evaluate the dynamics of community perception, program Effectiveness, education intervention, and long-term policy impacts. This will provide a dynamic picture of the development of RES from time to time.

1) **International Comparison**

Conducting comparative studies with other countries (such as India, Vietnam, or Scandinavian countries) can provide policy inspiration and best practices that can be adopted and applied contextually. In Indonesia.

2) **Strengthening Institutional Studies and Governance**

The a need for a deeper study of how institutions coordinate with each other, and how to implement policies, as well as the extent of supervision of the RES, both at the central and regional levels. Because this will include analysis of project governance, budget transparency, and complaint mechanisms from the community.

6. REFERENCES

- Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behaviour and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Al-Sallal, K. A., & Al-Sallal, A. M. (2021). Public awareness and behaviour toward energy conservation in the UAE. *Energy Reports*, 7, 650–660. <https://doi.org/10.1016/j.egyr.2021.08.016>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.
- Hantke-Domas, M. (2003). The public interest theory of regulation: Non-existence or misinterpretation? *European Journal of Law and Economics*, 15(2), 165–194. <https://doi.org/10.1023/A:1021814416688>
- Howlett, M., & Ramesh, M. (2003). *Studying public policy: Policy cycles and policy subsystems* (2nd ed.). Oxford University Press.
- Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential explanatory design: From theory to practice. *Field Methods*, 18(1), 3–20. <https://doi.org/10.1177/1525822X05282260>
- Kalpikajati, S. Y., & Hermawan, S. (2022). Tantangan hukum dan kebijakan dalam pengembangan energi terbarukan di Indonesia. *Jurnal Hukum dan Kebijakan Energi*, 7(1), 45–59.
- Kumar, V., & Anwar, M. (2021). Role of community participation in renewable energy adoption: A behavioral analysis. *Energy Policy*, 156, 112419. <https://doi.org/10.1016/j.enpol.2021.112419>
- Kumar, V., & Hundal, B. S. (2020). Service quality gaps in solar energy companies: Application of SERVQUAL model. *Renewable and Sustainable Energy Reviews*, 133, 110315. <https://doi.org/10.1016/j.rser.2020.110315>
- Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.
- Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, 64(1), 12–40.
- Park, E., & Ohm, J. Y. (2014). Factors influencing the public intention to use renewable energy technologies in South Korea: Effects of the Fukushima nuclear accident. *Energy Policy*, 65, 198–211. <https://doi.org/10.1016/j.enpol.2013.10.037>
- Pramudita, D., Kusuma, A., & Rachmawati, S. (2024). The role of social media in renewable energy education among youth in Indonesia. *Jurnal Energi dan Masyarakat*, 12(1), 30–44.
- Rachmadhani, D., & Priyono, A. (2023). Pengelolaan limbah baterai berbasis teknologi hijau di Indonesia. *Jurnal Teknologi Lingkungan*, 24(1), 22–34.
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.
- Said, M., Firdaus, R., & Adiwibowo, S. (2021). Enhancing community engagement in renewable energy projects: A participatory model approach in Indonesia. *Energy Research & Social Science*, 80, 102239. <https://doi.org/10.1016/j.erss.2021.102239>

- Sovacool, B. K., Ryan, S. E., Stern, P. C., Janda, K., Rochlin, G., Spreng, D., Pasqualetti, M. J., Wilhite, H., & Lutzenhiser, L. (2015). Integrating social science in energy research. *Energy Research & Social Science*, 6, 95–99. <https://doi.org/10.1016/j.erss.2014.12.005>
- Sovacool, B. K., Turnheim, B., Hook, A., Brock, A., & Martiskainen, M. (2018). Ten recommendations for governing the transition to renewable energy. *Energy Policy*, 123, 1–9. <https://doi.org/10.1016/j.enpol.2018.08.019>
- Tomsic, Z., Debrezin, N., & Viskovic, A. (2019). Challenges and perceptions of renewable energy services in Latin America. *Renewable Energy*, 141, 697–706. <https://doi.org/10.1016/j.renene.2019.04.036>
- Zeng, X., Li, J., & Singh, N. (2014). Recycling of spent lithium-ion battery: A critical review. *Critical Reviews in Environmental Science and Technology*, 44(10), 1129–1165. <https://doi.org/10.1080/10643389.2013.763578>