

## Integration of Renewable Energy Education in the Paradigm of Harmony and Sustainability: A Systematic Literature Study

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### Abstract

This research aims to analyze the integration of renewable energy education in the paradigm of harmony and sustainability through conceptual and empirical studies that develop in the academic literature. This type of research is a systematic literature study with a search of scientific articles in reputable databases published in the range of 2015–2025. A total of 17 articles that met the inclusion criteria were analyzed to identify approaches, integration models, and their implications for the formation of ecological and sustainability awareness. The analysis technique used is content analysis to categorize themes, curriculum integration patterns, pedagogical strategies, and value orientation that support harmony between humans, the environment, and clean energy technology. The results of the analysis show that the integration of renewable energy education is effective when implemented in an interdisciplinary, project-based, and contextual manner with sustainability values, so as to be able to increase energy literacy, pro-environmental attitudes, and social responsibility of students. The focus of the scientific contribution of this research is to offer an integrative conceptual framework that places renewable energy education as a strategic instrument in building a paradigm of ecological harmony and sustainable development in the education sector. These findings are expected to be a reference for the development of education curricula and policies that are responsive to the challenges of the global energy and environmental crisis.

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## INTRODUCTION

Global developments in the 21st century are characterized by increasing energy needs along with population growth and technological developments. Dependence on fossil energy over the past few decades has triggered various environmental problems, such as greenhouse gas emissions, global warming, and ecosystem degradation. This condition encourages the need for a transition to a more environmentally friendly and sustainable energy source. Renewable energy, such as solar, wind, water, and biomass, is considered to have great potential in supporting energy sustainability because of its renewable nature and minimal negative impact on the environment (Irena, 2022).

Previous studies have highlighted the important role of the energy crisis and global climate change in driving countries to switch towards sustainable use of renewable energy.

Hoque in the context of Education shows that this effort is realized through the integration of energy and sustainability issues into the curriculum as part of Education for Sustainable Development (ESD). Education has a strategic role in shaping ecological awareness, social responsibility, and environmentally friendly behavior in the younger generation. Therefore, renewable energy education is not only oriented towards the transfer of technological knowledge, but also on the formation of sustainable values, attitudes, and ethics (Hoque et al., 2022).

A number of studies in the last five years have shown that the integration of ESD in learning is able to improve environmental literacy, systems thinking skills, and student participation in sustainability actions. Recent studies (2020–2025) emphasize the importance of interdisciplinary approaches, project-based learning, and local contexts in renewable energy education. Other

research also highlights the need to strengthen the value and cultural dimensions of sustainability education so that it is not merely technocratic, but forms a holistic awareness of the relationship between humans and nature

In the context of sustainable development, education has an important role in shaping the awareness, knowledge, and attitudes of the younger generation towards the use of clean energy. Renewable energy education not only aims to increase understanding of energy technology, but also instill the values of environmental concern and social responsibility. The integration of renewable energy education in the learning process can provide real experiences to students through theoretical and practical approaches so that they are able to form an innovative and environmentally friendly mindset (Muljono et al., 2025).

It was also stated by UNESCO that in supporting the energy transition, the education sector has a strategic role in building energy awareness and literacy in the community. Renewable energy education not only focuses on mastering technological concepts, but also plays a role in instilling the value of concern for the environment and social responsibility. Through the integration of renewable energy materials in the curriculum, students can gain a comprehensive understanding of the importance of energy conservation and sustainable management of natural resources (UNESCO, 2017).

The paradigm of harmony and sustainability emphasizes the importance of a balance between the use of natural resources and environmental preservation and social welfare. This approach requires synergy between ecological, social, and economic aspects in every development process. The transition to a sustainable energy system requires not only technological innovation, but also a change in people's mindset that can be shaped through education. Sustainability-oriented education is believed to be able to produce a generation that has ecological awareness, technological skills, and the ability to face the challenges of the energy crisis and climate change (Tilbury, 2011).

The integration of renewable energy education in the paradigm of harmony and sustainability is a strategic step to form human resources who are adaptive to technological developments and care about environmental sustainability. Through integrated learning, students are expected not only to understand the concept of renewable energy theoretically, but

also to be able to apply this knowledge in their daily lives. Thus, renewable energy education can contribute to supporting sustainable development and creating a balance between energy needs and environmental sustainability in the future.

Nevertheless, although much research discusses ESD and renewable energy education, most still focuses on aspects of curriculum, pedagogy, and environmental literacy. There have not been many studies that specifically examine the integration of renewable energy education in the paradigm of harmony, especially those based on religious values, spiritual ethics, and the balance of human relationships with God, others, and nature. In fact, the harmony paradigm has great potential in strengthening the moral and cultural foundation for sustainability practices, especially in religious and multicultural societies.

Some previous research has shown that values-based approaches and local wisdom can increase the internalization of pro-environmental attitudes more deeply than cognitive approaches alone. However, these studies generally have not explicitly linked renewable energy education to an integrative conceptual framework of harmony and sustainability. Thus, there is a research gap related to how renewable energy education can be conceptually integrated in a harmonious paradigm that includes ecological, social, and spiritual dimensions.

Based on these gaps, a comprehensive study is needed that synthesizes the findings of the latest research to build a conceptual framework for the integration of renewable energy education in the paradigm of harmony and sustainability. The systematic literature review approach allows for an in-depth analysis of research trends, integration models, as well as theoretical contributions that have been developed in recent years.

This study aims to conceptually analyze the integration of renewable energy education in the paradigm of harmony and sustainability through a systematic literature study. The results of the research are expected to provide a scientific contribution in the form of an integrative conceptual framework that can be a reference for curriculum development, learning strategies, and educational policies oriented towards sustainability and ecological harmony.

## **METHODS**

This study uses a qualitative approach with the type of systematic literature review. The qualitative approach was chosen because this research aims to conceptually analyze the

integration of renewable energy education in the paradigm of harmony and sustainability through an in-depth interpretation of various relevant scientific sources. This approach allows researchers to comprehensively understand phenomena based on theoretical synthesis and previous research findings (Creswell, 2007).

The research design used is a systematic literature review with reference to the stages of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). This method is carried out through the process of identification, selection, feasibility, and inclusion of relevant literature in order to obtain a valid and systematic research synthesis (Snyder, 2019).

Research data was obtained from secondary sources in the form of scientific journal articles, academic books, reports from international institutions, and education policy documents related to renewable energy education and sustainable development. Literature searches are carried out through scientific databases such as Google Scholar, Garuda, Scopus, and international institution publications such as UNESCO and the International Renewable Energy Agency (Irena, 2022).

The data collection technique is carried out through literature documentation. This process involves several stages, namely: (1) Identification of literature relevant to the research topic, (2) Literature selection based on relevance, source credibility, and year of publication, and (3) Literature grouping based on research themes, such as renewable energy education, sustainability, and environmental harmony paradigms. Literature documentation techniques are used to obtain conceptual data that support systematic and structured research analysis (Bowen, 2009).

Data analysis was carried out using content analysis techniques. This technique is carried out by studying, interpreting, and connecting various concepts contained in the collected literature. Content analysis allows researchers to identify patterns, relationships between concepts, and develop a framework of thought regarding the integration of renewable energy education in the paradigm of harmony and sustainability (Krippendorff, 2018).

The data analysis process is carried out through several stages, namely data reduction, data presentation, and conclusion drawn. Data reduction is carried out by selecting information relevant to the focus of the research, while the presentation of data is carried out through

conceptual grouping and theoretical synthesis. The last stage is the drawing of conclusions based on the interpretation of the results of the literature analysis that has been carried out.

Literature search was carried out systematically in the range of 2015–2025 by utilizing reputable databases, including *Google Scholar*, *Scopus*, and *Garuda/Sinta*. From the initial search process, a number of articles were obtained which were then strictly selected using the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) procedure. A total of 17 articles were determined to meet the inclusion criteria and were analyzed in depth in this study. The inclusion criteria applied include: (1) articles published in the range of 2015–2025; (2) discussing the theme of renewable energy education, *Education for Sustainable Development* (ESD), or sustainability paradigm; (3) indexed in national and international reputable databases; and (4) available in full text version. In contrast, exclusion criteria include articles that are not thematically relevant, articles without a *peer-review process*, as well as publications that are not fully accessible.

*Procedure Screening* It is carried out through three stages. First, the identification stage, which is the search for articles based on keywords such as *Renewable Energy Education*, *Sustainability Paradigm*, and *ecological awareness*. Second, the screening stage (*Screening*), where titles and abstracts are selected based on relevance to the focus of the research. Third, the inclusion stage, which is the determination of the final article that meets all the criteria that have been determined. Data validation is carried out through triangulation of sources by comparing findings between articles to ensure consistency and credibility of the synthesis results (Snyder, 2019).

## DISCUSSION

### Harmonious Paradigm in Education

The paradigm of harmony in education emphasizes balance and integration between the various dimensions of learning: moral, cognitive, emotional, social, and human-environment values. This paradigm not only places knowledge as content, but also as *attitudes and actions* that are harmonious in real life. For example, the concept of harmony in Islamic educational philosophy emphasizes the balance between spirit, intellect, and body so that the individual grows holistically and plays the role of a responsible caliph on earth. This approach is relevant when the integration of

moral values and scientific knowledge is seen as mutually enriching, not separate (Wijayanti et al., 2024).

The author in this case relates relevance in the curriculum, in the context of curriculum integration, the harmonious paradigm opens up opportunities to compile learning materials that do not divide disciplines, but link academic competence with ethical and social values. For example, the *Education for Sustainable Development (ESD)* approach emphasizes the integration of sustainability themes into all subjects, not just as a separate addition to content.

As for related ideas, *Betty Chan* In the case study of education, it is shown that the harmonious value of cultural traditions (e.g. the value of *A* from Chinese philosophy) can be used as an educational basis for sustainable development because it combines human-environment and human-human relations in a balanced manner (Chan et al., 2009).

The paradigm of harmony and sustainability is a development approach that emphasizes a balance between the use of natural resources, human welfare, and environmental sustainability. This paradigm places humans as part of an ecosystem that must maintain harmony between development needs and environmental sustainability. In the context of energy, this paradigm demands a transformation of the energy system towards the use of environmentally friendly and sustainable energy sources (UNESCO, 2017).

The harmonious paradigm emphasizes the harmonious relationship between humans and nature. The uncontrolled use of energy, especially fossil energy, has caused various environmental problems such as global warming, air pollution, and ecosystem damage. Therefore, the development and utilization of renewable energy is one of the strategic steps in maintaining this balance. Renewable energy has more environmentally friendly characteristics because it produces lower carbon emissions than conventional energy, so it is able to support environmental conservation efforts (Irena, 2022).

Meanwhile, the sustainability paradigm emphasizes meeting the needs of the current generation without reducing the ability of future generations to meet their needs. The concept of sustainability includes three main dimensions, namely environmental, social, and economic dimensions. The use of renewable energy can support these three dimensions by reducing environmental impacts, improving community

welfare through job creation, and strengthening national energy security (Shukla et al., 2022).

Although (UNESCO, 2017) emphasizing integration *Education for Sustainable Development (ESD)* curricularly, this approach is considered to still tend to be normative and has not fully encouraged epistemological transformation in energy learning. (Tilbury, 2011) complements this perspective by emphasizing that true sustainability can only be achieved through a comprehensive change in values and life orientation, not just the addition of curriculum content. The harmony paradigm offered in this study expands the framework of ESD by integrating ethical, spiritual, and cultural dimensions in the relationship between humans and nature.

In this study, the integration of renewable energy education is an important means in instilling the value of harmony and sustainability in students. Education has a strategic role in shaping ecological awareness, environmental care attitudes, and clean energy technology skills. Through an integrated learning process, students not only gain a theoretical understanding of renewable energy, but are also able to develop environmentally friendly behaviors in daily life (Nations, 2015).

The results of the study show that renewable energy education can strengthen students' understanding of the relationship between human activities and environmental sustainability. The integration of renewable energy materials in the curriculum also encourages the development of a critical and innovative mindset in facing the challenges of the global energy crisis. Thus, the paradigm of harmony and sustainability is not only a theoretical concept, but can be realized through the implementation of education oriented towards sustainable development.

In addition, this paradigm also encourages collaboration between various parties, such as the government, educational institutions, the community, and the industrial sector in supporting the sustainable energy transition. Renewable energy education can be a bridge in building community collective awareness of the importance of maintaining a balance between development and environmental sustainability. With the integration of renewable energy education in the paradigm of harmony and sustainability, it is hoped that a generation can be formed that has ecological awareness, social responsibility, and innovative capabilities in

developing environmentally friendly energy.

### **Concept of Sustainability and Sustainable Development**

Education for sustainable development is essential to prepare the next generation to tackle environmental issues and commit to sustainability. By incorporating sustainable practices into formal and informal education systems, awareness and skills needed for societal transformation can be enhanced. This method emphasizes how important a dynamic education system, which encompasses various aspects, such as resource management, gender equality, and civic education, to foster a broader understanding of sustainability (Cahyono et al., 2024).

The concept of the relationship between nature and humans in Islam views the earth as a place of civilization, testing and responsibility. Humans are given the privilege as caliphs to maintain and utilize nature in a balanced manner. In this view, Islam emphasizes the importance of sustainable action and wise management. Man as a representative of Allah gives human consequences to nature to serve Allah, also in the context of *hifdzun nafs* or maintaining the continuity of life proportionately and not exceeding the limits (Al An'am: 141-142). Uncontrolled exploitation of nature that damages the survival of future generations is an act of violating God's law as well as an act of disobedience, because humans are only given the task of maintaining it, not controlling it (Sumiati & Rahtikawati, 2024).

Based on the synthesis of 17 analyzed literature, this study proposes a conceptual model of the integration of renewable energy education that relies on three interrelated dimensions. The first dimension is the cognitive dimension, which includes reinforcement *literacy* students' energy through an in-depth understanding of the characteristics, potentials, and limitations of various renewable energy sources, ranging from solar, wind, to geothermal energy (Falcone, 2023). The second dimension is the affective dimension, which is oriented towards the internalization of ecological awareness and the formation of sustainability ethics as the foundation of students' behavior in responding to the global energy crisis (Hoque et al., 2022). The third dimension is the practical dimension, which is realized through the direct involvement of students in the implementation of clean energy technology in the school environment as an authentic and contextual learning space (Surya et al., 2026).

These three dimensions do not stand alone, but form a unit that is integrative and mutually supportive. Mastery of cognitive aspects is a prerequisite for the formation of deep affective awareness, while this affective awareness in turn encourages planned practical actions based on green technology. This model conceptually goes beyond the technocratic approach that has dominated the discourse of energy education, because it places values, attitudes, and behaviors at the core of the learning transformation process (Muljono et al., 2025). Thus, this three-dimensional model can be a frame of reference for curriculum developers in designing renewable energy learning that is holistic, relevant, and has a long-term impact on students and the surrounding environment (Saputra et al., 2025).

### **Integration of Renewable Energy Education in the Curriculum**

Renewable energy issues are part of the global agenda *Sustainable Development Goals (SDGs)*, especially SDG 7 (*Affordable and Clean Energy*) and SDG 4 (*Quality Education*). The integration of renewable energy education helps students understand the needs of the energy transition, environmental impact, and sustainable technology solutions. According to *Martinez-Borreguero*, the integration of energy and sustainability concepts in the curriculum can be done by mapping energy content to various subjects—e.g. Science for its physical principles, social studies for energy policy implications, and technology for the development of practical solutions. This research also emphasizes the need for an interdisciplinary approach so that students understand energy issues comprehensively (Martinez et al., 2024). Examples of learning practices such as experiment-based projects, solar panel simulations, wind turbines, or energy efficiency studies in the context of school communities can stimulate students' active participation, encourage practical understanding and strengthen critical thinking competencies (Warastuti et al., 2025).

The integration of renewable energy education in the paradigm of harmony and sustainability is an educational approach that places clean energy as part of efforts to create a balance between human needs, environmental sustainability, and socio-economic sustainability. Renewable energy education not only emphasizes the mastery of technical knowledge regarding alternative energy sources, but also builds ecological awareness, environmental ethical

values, and skills to support sustainable development.

### 1. The Role of Renewable Energy Education in Realizing Sustainability

The results of the study show that renewable energy education has a strategic contribution in supporting the Sustainable Development Goals (SDGs), especially related to clean energy and quality education. Education that integrates renewable energy issues helps students understand the impact of fossil energy use on climate change and encourages the development of environmentally friendly technology-based solutions. UNESCO emphasizes that education for sustainable development (ESD) aims to equip students with knowledge, skills, values, and attitudes that support the creation of a sustainable future (Altassan, 2023). These findings are in line with the study (Altassan, 2023) which indicates that the integration of the system *Solar Photovoltaic* (PV) in the environment of educational institutions not only contributes to operational energy efficiency, but also functions as an experiential learning medium that simultaneously forms environmentally friendly behavior in students. Through the direct involvement of students in the maintenance of solar energy systems, the management of recycled water, and the use of organic waste as natural fertilizers, educational institutions have the potential to transform into *Micro-Ecosystem* which incubates the generation of environmental care holistically. Furthermore, this approach has been proven to be able to align the goals of environmental conservation with the improvement of the quality of education synergism, thus affirming the strategic position of schools as the main agents of change in accelerating the clean energy transition at the community level.

In addition, renewable energy learning allows students to develop a multidisciplinary understanding that combines science, technology, economics, and social aspects. This approach can improve critical thinking and problem-solving skills for global energy issues. Through curriculum integration, students can understand the relationship between energy consumption, climate change, and individual and collective responsibility in maintaining environmental sustainability.

### 2. Integration of Harmonious Paradigms in Renewable Energy Education

The harmonious paradigm emphasizes the

importance of balance between humans and nature. In the context of renewable energy education, this paradigm is realized through the development of a curriculum that integrates ecological values, environmental ethics, and awareness of the limitations of natural resources. Harmony-based education emphasizes that energy use must be done wisely so as not to damage the ecosystem and the balance of nature (UNESCO, 2017).

The implementation of the harmony paradigm can be carried out through contextual learning that relates renewable energy materials to students' daily lives. This approach helps students understand the importance of the energy transition as part of efforts to maintain ecological balance and resource sustainability. Harmony-based education also plays a role in shaping eco-friendly behavior and collective awareness of ecological responsibility. In a broader perspective, (Harahap & Uthman, 2024) emphasized that environmental education plays a role as *Catalyst* fundamental in building a harmonious relationship between humans and their ecosystems. Their systematic review reveals that the massive environmental degradation triggered by the dominance of economic interests over ecological considerations can be significantly mitigated through the internalization of environmental knowledge into the formal education curriculum. The integration of ecological knowledge curricular has been proven to be able to grow a generation that not only has *Ecological Literacy* comprehensive, but also the capacity to balance economic development priorities with the imperative of environmental sustainability wisely. Thus, the paradigm of harmony in renewable energy education obtains a solid empirical foundation that the transformation of human-nature relations can only be realized if environmental education is positioned not as an additional subject, but as the epistemological foundation of the entire learning process.

### 3. Integration of Renewable Energy Education as a Social Transformation Strategy

The integration of renewable energy education in the sustainability paradigm also serves as a social transformation strategy towards an energy-conscious and sustainability-oriented society. Education has an important role in shaping the mindset of the young generation to be able to adapt to the development of clean energy technology.

Studies show that the application of renewable energy technologies in educational settings, such as the use of solar panels in schools, not only helps reduce fossil energy consumption but also becomes a practical learning tool for students. Solar energy application programs in educational institutions can increase students' understanding of clean energy technology while fostering environmental awareness and energy efficiency (Surya et al., 2026).

In addition to providing educational benefits, the integration of renewable energy education also contributes to sustainable economic development by encouraging technological innovation, job creation in the green energy sector, and the development of future workforce competencies. Education that emphasizes the integration of renewable energy can strengthen people's readiness to face the global energy transition. The dimension of social transformation is empirically strengthened by the study (Chou et al., 2023) which through bibliometric analysis of 6,794 scientific articles managed to identify a significant positive correlation between the adoption of renewable energy and economic growth indicators such as increased *Gross Domestic Product* (GDP), industrial productivity, and the acceleration of technological innovation. The findings imply that the transition to a sustainable energy system is not just an ecological imperative, but also a prospective economic development strategy, especially in regions with an abundance of renewable energy resources. In the context of education, a deep understanding of the nexus between renewable energy and sustainable economic growth needs to be internalized to students so that they are able to consolidate their ecological orientation with a vision of productive and equitable development. Furthermore, the integration of the economic-ecological dimension in the renewable energy curriculum will shape a generation that is not only environmentally conscious, but also has strategic competence in driving green economic transformation (*Green Economy Transformation*) at the local and national levels.

#### 4. Challenges and Opportunities for Renewable Energy Education Integration

Despite having great potential, the integration of renewable energy education still faces various challenges, such as limited educational resources, lack of educators who

have competence in the field of renewable energy, and the lack of learning facilities based on clean energy technology. However, the development of sustainable education policies and increasing global attention to the issue of climate change open up a great opportunity to strengthen the integration of renewable energy education in the formal and non-formal education systems (UNESCO, 2017). One of the main challenges in integrating renewable energy education is resistance to changes in curriculum and teaching practices. Some educators may feel uncomfortable with new methods or lack knowledge about renewable energy. Therefore, ongoing professional training and development for educators is essential (Manegtto et al., 2025). Strengthening the curriculum, improving the competence of educators, and developing project-based and experimental learning are strategies that can support the effective implementation of renewable energy education. Thus, renewable energy education can play a key role in building a society oriented towards harmony and sustainability (Aida et al., 2025).

Renewable energy is energy obtained from naturally renewable sources in a relatively short period of time. These energy sources include solar, wind, water, biomass, and geothermal. The use of renewable energy is essential to reduce dependence on fossil fuels, which lead to greenhouse gas emissions and other negative impacts on the environment (Falcone, 2023). Based on results *Content Analysis* Regarding the 17 articles studied, three dominant themes were found in the integration of renewable energy education, namely: (1) strengthening energy literacy, (2) forming ecological awareness, and (3) social transformation based on green technology. These three themes are the common thread that connects all the descriptions in the following discussion.

One of the hallmarks of renewable energy is its ability to be generated continuously without reducing the availability of resources. For example, solar energy can be harnessed throughout the year as long as there is sunlight, while wind energy can be generated as long as there is wind movement. This is in contrast to fossil fuels which, once exploited, will run out and take millions of years to rebuild (Manegtto et al., 2025). It is also explained in the Qur'an Surah al-A'raf: 56 which affirms that Allah

created the heavens, the earth, and all their contents in balance, and forbids humans to do damage after Allah has repaired them. This is an important basis in the paradigm of sustainability and environmental harmony, including in the use of renewable energy. According to recent research, the use of renewable energy can help significantly reduce carbon dioxide emissions and support the achievement of sustainability goals at various levels, both locally and globally (Saputra et al., 2025).

Renewable energy sources consist of several types, namely (a) Solar Energy, which utilizes sunlight to generate electricity or heat. Solar panel technology has developed rapidly, enabling more efficient use of solar energy. Next is (b) Wind Energy, which is energy obtained from wind flow by converting the kinetic energy of the wind into electrical energy. This energy source is very effective in areas that have high wind speeds. Then there is (c) Hydropower, which generates energy from flowing water, usually through dams that drive turbines to produce electricity. Hydropower is one of the most widely used renewable energy sources in many countries. In addition, there is (d) Biomass, which is energy derived from organic materials such as plant and animal waste that are used as energy sources. The utilization process can involve direct combustion or conversion into liquid and gaseous fuels. Finally, (e) Geothermal Energy, which utilizes heat from the earth to generate electricity or for heating purposes, and is commonly found in areas with high geological activity.

The integration of renewable energy education has gained a solid normative foothold in the Islamic scientific tradition, especially through the concept of *Khilafah Fil Argh* which places humans as the bearers of the mandate to manage the earth responsibly and justly. In this perspective, the use of renewable energy is not just a technological choice, but a moral obligation that comes from ethics *Trust* which is attached to each individual as a servant as well as God's representative on earth (Saputra et al., 2025). On the contrary, the exploitation of fossil energy that results in massive ecosystem damage can be categorized as a manifestation *Facade*, which is a form of destruction that is expressly prohibited in QS. Al-A'raf: 56. Therefore, Islamic educational institutions have a strategic responsibility to integrate these ecotheological values into the

curriculum in an explicit, systematic, and measurable manner rather than just symbolic ornaments in learning (UNESCO, 2017).

Strengthening the spiritual dimension in renewable energy education also has direct implications for the institutional management of Islamic education. Islamic educational institutions such as madrassas and pesantren have great potential as laboratories of sustainability values that integrate local wisdom with clean energy technology, considering that both institutions have a strong community base and a value orientation inherent in the daily lives of students and students (Hoque et al., 2022). This approach will strengthen *Positioning* Islamic education is not only a printer of a moral generation, but also as a sustainable transformation agent that is responsive to the challenges of the energy crisis and global climate change. Thus, Islamic education management needs to proactively formulate curriculum policies that accommodate the integration of ecological values based on *Worldview* Islam comprehensively (Irena, 2022).

Beyond technical obstacles of an operational nature, the integration of renewable energy education is faced with much more complex and systemic structural challenges. The state's dependence on the fossil energy subsidy regime creates policy disincentives that indirectly slow down the acceleration of the energy transition, including in the national education ecosystem (IRENA, 2022). The gap in technology infrastructure between schools in urban areas and schools in the Frontier, Outermost, and Disadvantaged 3T areas further exacerbates implementation inequalities *Education for Sustainable Development* in Indonesia, where access to clean energy learning tools is still very limited (Manegtto et al., 2025). This condition is exacerbated by the lack of educators who have cross-disciplinary competencies in the field of renewable energy and sustainability pedagogy at the same time (Falcone, 2023).

This edition outlines the challenges and opportunities in transformative learning and teaching for sustainable development in education. This edition covers education for sustainable development, technology, and management for transformative learning and teaching. Original research articles and reviews are accepted in this Special Edition. Research areas include new technologies, education, management, quality, professional development, transformative learning and teaching, and sustainable development (Dagli & Altinay, 2025).

Nonetheless, a number of strategic opportunities are wide open to encourage this acceleration of integration. The implementation of the independent curriculum that emphasizes project-based and contextual learning actually opens up a space that is very conducive to strengthening renewable energy education at all levels of formal education in Indonesia. In addition, the National Energy General Plan (RUEN), which targets to increase the renewable energy mix to 23% by 2025, should be a momentum for the education sector to contribute through strengthening students' energy literacy (Shukla et al., 2022). The recommended transformation strategies include cross-sectoral collaboration between governments, educational institutions, and the green energy industry, as well as the development of contextual learning modules that are adaptive to Indonesia's geographical and cultural diversity, especially to reach educational communities in the 3T region that have been marginalized from the mainstream of sustainability education innovation (Nations, 2015).

In line with the framework, (Khalil, 2024) In their comprehensive study of the integration of green energy in modern electricity systems, it emphasizes that the main challenges in implementation *Renewable Energy Sources* (RESs) are sourced from the inherent variability of renewable energy sources and the complexity of grid integration (*Grid Integration*). Its pedagogical implications are very relevant for the Indonesian educational context, where students need to be equipped not only with a conceptual understanding of renewable energy, but also with technical literacy related to energy storage mechanisms (*Energy Storage*), optimization algorithms, and system control strategies that allow the integration of renewable energy to run efficiently and sustainably. Strengthening this technical dimension is becoming increasingly crucial given the projected increase in the national renewable energy mix that is ambitious, which demands the availability of educated human resources capable of bridging the gap between theoretical technological advances and real-world implementation of energy solutions. Therefore, the renewable energy education curriculum needs to accommodate a multidisciplinary approach that integrates technical competence with ecological awareness and social responsibility in a balanced manner.

## CONCLUSION

A systematic review of 17 reputable literature reveals that the integration of renewable energy education in the paradigm of harmony and sustainability is a strategic approach that has proven effective in shaping ecological awareness, energy literacy, and social responsibility of students. Based on the results of *the content analysis*, three dominant themes were found that consistently appeared in the literature, namely strengthening energy literacy, internalizing ecological awareness, and social transformation based on green technology. These findings indicate that renewable energy education implemented in an interdisciplinary, contextual, and project-based manner is able to produce more meaningful and sustainable learning outcomes than conventional approaches that are purely technocratic. Thus, curriculum integration that combines cognitive, affective, and practical aspects is inevitable in responding to the challenges of the energy crisis and global climate change.

This research provides a conceptual contribution in the form of a three-dimensional integration model of cognitive, affective, and practical that offers a holistic framework beyond the conventional ESD approach which has been considered too normative. The proposed harmonious paradigm expands the *framework of Education for Sustainable Development* by adding ethical, spiritual, and cultural dimensions in human-nature relations, especially through the concept of *caliph fil ardh*, *amanah*, and *façade* in the perspective of Islamic education. This conceptual framework places renewable energy education not just as an instrument for technology knowledge transfer, but as a vehicle for the formation of a sustainability *worldview* based on moral values and local wisdom.

Practically, the findings of this study imply the need to reorient the national curriculum policy that explicitly accommodates renewable energy education as a mandatory component of the Independent Curriculum, especially for schools and madrasas at all levels of formal education. The government needs to encourage cross-sectoral collaboration between educational institutions, the green energy industry, and local communities to address technology access gaps, especially in 3T areas that are still marginalized. Improving the competence of educators through continuous training based on *Education for Sustainable Development* is also an urgent priority so that implementation at the classroom level can run effectively and impactfully. With strong policy

synergy and a holistic learning approach, renewable energy education can be the main instrument in realizing an adaptive, innovative, and committed Indonesian generation to ecological sustainability and social harmony in the future.

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