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RENEWABLE ENERGY TRANSITION AND ITS IMPACT ON ENVIRONMENTAL HEALTH AND AIR QUALITY IN URBAN AREAS OF BANTEN PROVINCE

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Abstract

The transition to renewable energy is one of the main strategies for reducing air pollution and improving environmental health in urban areas. Banten Province, as a region with high industrial and transportation activity, faces air quality issues that impact public health. This research aims to analyze the impact of the renewable energy transition on air quality and environmental health in urban areas of Banten Province. The research uses a quantitative approach with descriptive and explanatory designs. Data were obtained from secondary air quality data including parameters PM2.5, NOx, SO_2, CO, and O_3, as well as primary data from a community survey regarding environmental health conditions. Data analysis was performed using descriptive statistics and regression models to test the relationship between renewable energy use, emission reduction, and health impacts. The research results indicate that increased utilization of renewable energy significantly impacts the reduction of air pollutant concentrations. The decrease in air pollution quality is associated with a reduced risk of respiratory and cardiovascular diseases in urban populations. This research concludes that the transition to renewable energy plays an important role in improving air quality and environmental health in urban areas of Banten Province, and therefore needs to be supported by sustainable policies and implementation.

Keywords: Renewable Energy Transition, Environmental Health, Air Quality

INTRODUCTION

The transition to renewable energy is becoming a strategic issue at the global level as awareness of climate change and environmental degradation

increases. The world's dependence on fossil fuels has led to a significant increase in greenhouse gas emissions. This condition is driving various countries to shift their energy systems toward cleaner and more sustainable energy sources (Sayigh, 2023). International organizations such as the United Nations and the International Energy Agency are actively promoting the global energy transition agenda. The main goal of this transition is to reduce carbon emissions while maintaining environmental sustainability (Mohammed & Messaoud, 2024). Thus, the energy transition is not only an energy issue, but also a health and human quality of life issue.

At the national level, Indonesia has set a commitment to reduce greenhouse gas emissions thru various sustainable energy policies. The Indonesian government aims to increase the renewable energy mix in the National Energy Master Plan. This policy aligns with efforts to achieve low-carbon development and a green economy (Rahman et al., 2022). However, the implementation of energy transition in Indonesia still faces various structural and technical challenges. Reliance on coal and fossil fuels is still quite high, especially in the power generation and transportation sectors. This condition has a direct impact on environmental quality, particularly in urban areas.

Banten Province is one of Indonesia's strategic regions experiencing rapid industrial growth and urbanization. Industrial, transportation, and residential activities in the Banten urban area contribute to increasing energy demand. Most of this energy demand is still met from fossil fuel sources. As a result, air pollutant emissions in Banten's urban areas tend to increase. Several cities in Banten show a significant decline in air quality. This makes Banten a relevant area to study in the context of energy transition and environmental quality.

Air quality issues in Banten's urban areas are becoming an increasingly serious environmental concern. Air pollution comes from various sources, such as motor vehicles, manufacturing industries, and fossil fuel power plants. Pollutants such as PM2.5, PM10, NO_2, SO_2, and CO often exceed safe limits. Long-term exposure to air pollutants can degrade the quality of the environment. Additionally, geographical conditions and population density exacerbate the impact of air pollution in urban areas. Therefore, air quality becomes an important indicator in assessing the success of sustainable development.

The use of fossil fuels is closely linked to the degradation of air quality and environmental health. The burning of fossil fuels produces harmful

emissions that have a direct impact on ecosystems and human health. Air-polluted environments risk lowering the quality of soil, water, and biodiversity (Ge, 2023). Additionally, air pollution accelerates the degradation of the urban environment. This condition indicates that energy issues cannot be separated from environmental health problems (Yalew, 2022). Therefore, the energy transition becomes a strategic solution in reducing pressure on the environment.

From an environmental health perspective, poor air quality has a significant impact on the health of urban populations. Air pollution increases the risk of respiratory and cardiovascular diseases, as well as other health disorders. Vulnerable groups such as children, the elderly, and those with chronic illnesses are the most affected. The health burden of air pollution also increases social and economic costs (Lin et al., 2024). Thus, improving air quality becomes an important part of efforts to enhance community well-being. The transition to renewable energy has the potential to provide dual benefits for the environment and health.

Based on these conditions, a comprehensive study is needed on the transition to renewable energy and its impact on environmental health and air quality in urban areas of Banten Province. This research is important to identify the extent to which the energy transition can contribute to improving air quality. Additionally, this study can provide insights into the relationship between energy policy and environmental health conditions. The research findings are expected to serve as a basis for evidence-based policy formulation. Local governments and stakeholders can utilize the findings of this research as a reference for decision-making. Thus, this research has strong academic and practical relevance.

RESEARCH METHOD

This research uses quantitative research with a descriptive-analytical and explanatory research design. This design was chosen to analyze the relationship between renewable energy transition, air quality, and environmental health in the urban areas of Banten Province. The research location includes several cities in Banten Province that have high industrial and transportation activity. The research was conducted within a specific timeframe, adjusted based on the availability of air quality data and the implementation of field surveys. The study population includes the urban environmental conditions and the community residing in the research area. The research sample includes air quality data collection points and community

groups selected as survey respondents using appropriate sampling techniques.

Data collection techniques were carried out thru primary and secondary data. Secondary data were obtained from air quality images, reports from relevant agencies, and official air quality monitoring station data. Primary data were collected thru questionnaire surveys, interviews, and field observations to obtain information related to public perception and environmental conditions. The research instruments consisted of structured questionnaires, interview guidelines, and observation sheets that were adapted to the research variables. Data analysis techniques use descriptive statistics to describe air quality and environmental health conditions, as well as regression models and spatial analysis to test relationships between variables. The validity and reliability of the instrument were tested to ensure the accuracy and consistency of the data used (Creswell, 2009; Creswell & Creswell, 2017).

RESULT AND DISCUSSION

Status of Renewable Energy Transition in Urban Areas of Banten Province

Renewable energy policies and regulations in Banten Province are part of the national energy policy that emphasizes increasing the clean energy mix. The Banten regional government supports the implementation of renewable energy thru regional development planning and environmental sectoral policies. This regulation aims to encourage a reduction in dependence on fossil fuels, particularly in urban areas. Additionally, renewable energy policies are also linked to emission reduction targets and improved environmental quality. However, the implementation of this policy still requires inter-agency synchronization (Chhaparwal & Goyal, 2024). This is important so that the policies formulated can be effective and sustainable.

At the urban level, renewable energy policies in Banten are beginning to be directed toward the electricity, transportation, and building sectors. The development of rooftop solar power plants is a major focus of the local government. In addition, energy efficiency efforts are also included in sustainable city development policies. The government encourages the participation of the private sector and the public in the utilization of renewable energy. Incentive policies and licensing ease are supporting instruments in this process (Briggs et al., 2022). Nevertheless, the utilization rate of renewable energy is still relatively limited.

The implementation of renewable energy technology in the urban areas of Banten shows gradual progress. The most widely adopted technology is solar energy, particularly in office buildings and public facilities. Some industrial areas are also beginning to utilize renewable energy as an alternative energy source (Kamran et al., 2023). Additionally, the use of energy-efficient lighting and energy management systems is beginning to be implemented in urban areas. However, the adoption of this technology is not yet uniform across all areas of the city. Implementation gaps are still evident between the downtown area and the suburbs.

Community participation in the adoption of renewable energy in urban Banten is still considered moderate. Some people are starting to realize the economic and environmental benefits of renewable energy. However, the level of renewable energy literacy remains a major challenge. The lack of information and education has led to the public not being fully interested in switching from conventional energy (Stock, 2023). Additionally, the relatively high initial investment cost is also a hindering factor. Therefore, more intensive education and socialization strategies are needed (Hampl, 2022).

The main obstacles to the transition to renewable energy in urban Banten come from technical and economic aspects. Limited supporting infrastructure is a significant constraint. Additionally, long-standing reliance on fossil fuels makes the process of changing the energy system difficult. Funding aspects are also a challenge, especially for the community and small business owners. Regulations that are not fully operational at the local level also slow down implementation (Hampl, 2022). These obstacles require a comprehensive policy approach.

On the other hand, Banten Province has great potential for renewable energy development. The potential for solar energy in urban areas is quite high considering the abundant sunlight intensity. Additionally, the increasing efficiency of renewable energy technology development opens up opportunities for wider adoption. National policy support is also a driving factor for regions to accelerate the energy transition. Private sector and investor involvement can strengthen the development of renewable energy (Schipfer et al., 2022). With good synergy, this opportunity can be optimally utilized.

The status of renewable energy transition in urban areas of Banten Province is still in the development stage. Existing policies and implementation show a positive direction, but are not yet fully optimal. Structural and social barriers still need to be overcome thru adaptive policies.

On the other hand, the available opportunities offer hope for accelerating the energy transition (Cain, 2024). The roles of the government, community, and private sector are key to success. With the right strategy, the transition to renewable energy can contribute to improving the quality of the urban environment in Banten.

Impact of Energy Transition on Air Quality

The transition to renewable energy has direct implications for changes in air quality in urban areas. Reducing the use of fossil fuels has the potential to lower emissions of harmful air pollutants. Air quality parameters such as PM2.5, NOx, SO_2, CO, and O_3 are often used to assess the level of urban air pollution. These pollutants generally come from the burning of fossil fuels in the transportation and industrial sectors. With the increasing utilization of renewable energy, major emission sources can be significantly suppressed (Chen et al., 2022). Therefore, energy transition is becoming one of the main strategies in controlling air pollution.

Changes in PM2.5 concentration are an important indicator in assessing the impact of the energy transition. These fine particles are very dangerous because they can enter the respiratory tract and bloodstream. The use of fossil fuels, particularly coal and oil, is a major contributor to PM2.5 in urban areas. The transition to renewable energy, such as solar power and clean electricity, has the potential to reduce the formation of these particulates. Decreasing PM2.5 concentrations has a positive impact on public health (Gallardo et al., 2024). Thus, renewable energy significantly contributes to improving air quality.

Beside PM2.5, NOx and SO_2 parameters also change with the energy transition. Gas NOx and SO_2 are largely produced from the combustion of fossil fuels in power plants and motor vehicles. Increased use of renewable energy can reduce emissions of these gasses. A decrease in NOx contributes to a reduction in the formation of tropospheric ozone (Cheng et al., 2024). Meanwhile, the decrease in SO_2 reduces the risk of acid rain and environmental disruption. This condition demonstrates the close link between the energy system and air quality.

Carbon monoxide and ozone parameters are also affected by changes in energy sources. Carbon monoxide is primarily produced from the incomplete combustion of fossil fuels. The transition to electric vehicles and clean energy can reduce CO concentrations in urban air (Wang & Liu, 2025). Meanwhile, ozone is a secondary pollutant formed from the chemical

reactions of other pollutants. Reducing NOx emissions and volatile organic compounds also lowers ozone formation (Kilinc-Ata & Çamkaya, 2025). Thus, renewable energy plays an indirect role in controlling urban ozone.

A comparison of air quality conditions before and after the adoption of renewable energy shows an improving trend in some urban areas. Before the energy transition, air pollution levels tended to be higher due to the dominance of fossil fuels. After the implementation of renewable energy, some air quality parameters showed a decrease in concentration. This change reflects the effectiveness of clean energy policies in reducing emissions (Adebayo et al., 2024). However, the impact of air quality improvements is gradual and takes time. Therefore, long-term evaluation is essential.

The influence of energy sources on emissions is clearly seen in the comparison between fossil fuels and renewable energy. Fossil fuels produce high gas and particulate emissions during combustion. Conversely, renewable energy generates significantly lower or even zero emissions during the operational phase. This difference has a direct impact on urban air quality. The larger the share of renewable energy, the lower the level of air pollution (Chen et al., 2022). This confirms the importance of changing the energy structure in controlling emissions.

Overall, the transition to renewable energy has a positive impact on air quality in urban areas. The decrease in various pollutant parameters indicates the potential of clean energy in creating a healthier environment. Nevertheless, optimal results require policy consistency and cross-sectoral support. Other factors such as vehicle growth and industrial activity also need to be controlled. With an integrated approach, the energy transition can be a long-term solution. This effort is expected to improve air quality and the quality of life for urban residents.

Implications for Environmental Health

Air pollution in urban areas has significant implications for environmental and public health. Short-term and long-term exposure to air pollutants can decrease the quality of life for urban residents. Pollution parameters such as PM2.5, NO_2, and SO_2 are known to have a direct impact on the respiratory system. This condition is further exacerbated by population density and high transportation activity. Environmental health is an important indicator in assessing the impact of urban development (Hwang & Venter, 2025). Therefore, air pollution control is an integral part of efforts to improve public health.

Respiratory diseases are the most common health impact associated with air pollution. Exposure to fine particulate matter can trigger asthma, bronchitis, and acute respiratory infections. Children and the elderly are the most vulnerable groups to these impacts (Ilyas et al., 2024). Additionally, air pollution also increases the incidence of allergies and respiratory tract irritation. The increase in respiratory disease cases contributes to the public health burden (Yurtkuran, 2025). This demonstrates a strong relationship between air quality and environmental health.

Beside respiratory diseases, air pollution also affects cardiovascular diseases. Harmful particulate matter and gasses can enter the bloodstream. This condition increases the risk of heart disease, hypertension, and stroke. Long-term exposure to air pollution has been proven to increase premature mortality rates. The economic burden of cardiovascular disease is also increasing (Ahmad et al., 2023). Thus, air pollution control becomes a priority in environmental health policy.

Health Risk Assessment is used to assess the level of health risk due to exposure to air pollution. This method measures the relationship between pollutant concentration and its impact on human health. Risk assessment includes hazard identification, exposure analysis, and risk characterization. The results of risk estimation provide an overview of the level of health threat in a region. This information is important for identifying vulnerable groups and prioritizing interventions (Wei et al., 2023). Thus, Health Risk Assessment becomes an important tool in environmental policy decision-making.

The application of Health Risk Assessment also helps evaluate the benefits of the renewable energy transition on environmental health. The decrease in pollutant concentration due to clean energy can lower the level of public health risk. This analysis allows for a comparison of risks before and after the implementation of renewable energy. The results of the risk assessment can be used to strengthen the argument for sustainable energy policies (Jabarullah et al., n.d.). Additionally, this approach supports evidence-based health planning. Therefore, health risk estimation becomes an important component of this research.

Public perception and knowledge of air quality also influence responses to environmental issues. People with a good understanding tend to be more concerned about the impact of air pollution. This awareness can drive more environmentally friendly behavior change. However, the level of knowledge about pollution sources and renewable energy still varies. Lack of information

can hinder public participation in the energy transition (Alharthi et al., 2022). Therefore, environmental education becomes an important need.

Thus, the implications of air pollution on environmental health highlight the urgency of transitioning to renewable energy. Improving air quality can reduce the risk of disease and enhance public well-being. The environmental health approach allows for a more comprehensive impact analysis. Community support based on good knowledge is a key factor for success. Synergy between energy, health, and environmental education policies is essential. Thus, the transition to renewable energy has the potential to provide long-term benefits for urban environmental health.

CONCLUSION

The transition to renewable energy in urban areas of Banten Province shows significant potential for improving air quality and environmental health. The shift from fossil fuels to renewable energy contributes to a decrease in air pollutant emissions such as PM2.5, NOx, SO_2, and CO. This improvement in air quality directly impacts a reduction in the risk of public health problems, particularly respiratory and cardiovascular diseases. Although the implementation of renewable energy is still in the development stage, policy direction and technology adoption show a positive trend. Challenges such as limited infrastructure, funding, and energy literacy still require serious attention. However, opportunities for renewable energy development in Banten remain wide open, supported by national policy and the available resource potential.

Overall, the transition to renewable energy is an important strategy for achieving a healthier and more sustainable urban environment in Banten Province. The positive impact on air quality and environmental health confirms that energy policy cannot be separated from health and environmental policies. The success of the energy transition requires synergy between local governments, the private sector, and the community. Increased public education and strengthened regulations are key to accelerating the adoption of renewable energy. Additionally, data-driven evaluation and environmental health approaches need to be continuously developed. With an integrated approach, the transition to renewable energy can provide long-term benefits for the quality of life of urban communities in Banten.

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