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Review Article

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A Review of Renewable Energy Infrastructure Trends Literature: A Case Study of Shopping Mall, Pasar Gedhe Klaten, Indonesia

Ari Nuriana [a], Muhammad Ikhsan Setiawan [a,*], Sulidar Fitri [b,c] and Grida Saktian Laksito [d]

[a] Department of Civil Engineering, Faculty of Engineering, Universitas Narotama, Klampis Ngasem, Kec. Sukolilo, 60117 Surabaya, Jawa Timur, Indonesia.
[b] Department of Informatics, Faculty of Informatics and Computing, Universiti Sultan Zainal Abidin, 21300 Kuala Terengganu, Malaysia.
[c] Department of Information Technology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Tasikmalaya, 46196 Tasikmalaya, Jawa Barat, Indonesia.
[d] Department of Economics, Faculty of Business, Economics and Social Development, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.
* Correspondence: ikhsan.setiawan@narotama.ac.id (M.I.S.)

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Abstract

The trajectory of literature concerning renewable energy infrastructure has evolved substantially in recent decades, reflecting the escalating significance of renewable energy sources within the broader context of the global energy scene. A noticeable shift towards integrating renewable energy infrastructure into shopping malls has emerged in recent years, marking a broader movement towards sustainability and environmental accountability within the commercial sector. Historically, shopping malls have been significant energy consumers, heavily reliant on conventional sources like fossil fuels to meet their lighting, heating, and cooling needs. Yet, escalating concerns over climate change and energy expenses have increasingly prompted mall developers and operators to adopt renewable energy solutions. By incorporating solar panels, wind turbines, and geothermal systems, shopping malls can substantially diminish their carbon footprint, reduce energy costs, and bolster their environmental standing. Furthermore, this inclination aligns with corporate social responsibility efforts, as malls strive to underscore their dedication to sustainability and attract environmentally conscious patrons. Bolstered by governmental incentives and regulatory frameworks encouraging renewable energy adoption, the trajectory of renewable energy infrastructure in shopping malls in Pasar Gedhe Klaten, Indonesia, is anticipated to persist, delivering both environmental benefits and economic gains for stakeholders.

1. Introduction

The trend of renewable energy infrastructure literature has evolved significantly over the past few decades, mirroring the growing importance of renewable energy sources in the global energy landscape (McCabe et al., 2018). This literature encompasses various topics, including technological advancements, policy frameworks, economic analysis, environmental impacts, and societal implications associated with developing and deploying renewable energy infrastructure (Dincer, 2000). In the early stages of research, the focus was primarily on the technical aspects of renewable energy technologies such as solar photovoltaics, wind turbines, hydroelectric power, geothermal energy, and biomass. Researchers explored ways to improve efficiency, reduce costs, and overcome technical challenges associated with integrating renewable energy into existing power grids.

As renewable energy gained momentum as a viable alternative to fossil fuels, attention shifted towards understanding the policy and regulatory frameworks necessary to support its widespread adoption. Scholars began examining the role of government incentives, feed-in tariffs, renewable portfolio standards, and carbon

pricing mechanisms in stimulating investment in renewable energy infrastructure. Additionally, there has been a growing emphasis on international cooperation and agreements to address climate change through the promotion of renewable energy deployment.

Economic analysis has also been a key area of research within the literature on renewable energy infrastructure. Studies have investigated the cost competitiveness of renewable energy technologies compared to conventional energy sources and the potential economic benefits associated with job creation, energy security, and reduced dependence on fossil fuel imports (Heal, 2010).

Environmental considerations have significantly shaped the discourse around renewable energy infrastructure (Johansson, 2013). Researchers have examined the environmental impacts of renewable energy technologies throughout their life cycles, including land use, water consumption, wildlife impacts, and greenhouse gas emissions. Moreover, increasing interest has been in exploring the potential synergies between renewable energy deployment and efforts to mitigate climate change and biodiversity loss.

In recent years, the literature on renewable energy infrastructure has expanded to encompass broader societal and geopolitical dimensions (Gielen et al., 2019; Stein, 2013). Scholars have investigated the social acceptance of renewable energy projects, the role of community engagement in decision-making processes, and the implications of renewable energy transitions for energy justice and equity. Moreover, there has been growing recognition of the geopolitical implications of the shift towards renewable energy, including changes in global energy markets, geopolitical alliances, and energy security considerations.

Overall, the trend of renewable energy infrastructure literature reflects the multifaceted nature of the transition towards a more sustainable and resilient energy system. As renewable energy technologies mature and become increasingly integrated into mainstream energy systems, the literature will likely continue to evolve to address emerging challenges and opportunities in this dynamic field (Breyer et al., 2022; Grübler et al., 1999; Shackley & Green, 2007).

In recent years, there has been a notable trend towards integrating renewable energy infrastructure into shopping malls, reflecting a shift towards sustainability and environmental responsibility within the commercial sector. Traditionally, shopping malls have been significant consumers of energy, relying heavily on conventional sources such as fossil fuels to power lighting, heating, and cooling systems (Omer, 2008a, 2008b, 2009). However, with increasing concerns about climate change and rising energy costs, mall developers and operators increasingly turn to renewable energy solutions. By incorporating solar panels, wind turbines, and geothermal systems, shopping malls can significantly reduce their carbon footprint, lower energy expenses, and enhance their environmental credentials.

Moreover, this trend aligns with corporate social responsibility initiatives, as malls seek to demonstrate their commitment to sustainability and appeal to environmentally conscious consumers. Supported by government incentives and regulatory frameworks promoting renewable energy adoption, the trend of renewable energy infrastructure in shopping malls is expected to grow, offering both environmental benefits and economic advantages for stakeholders.

The trend of Renewable Energy Infrastructure in a shopping mall at Pasar Gedhe Klaten, Central Java, Indonesia, with 462 panels PV, a total of 207,9 KWP, each panel 450 WP. Pasar Gede Klaten is an area with high activity intensity, serving as the central trading hub of Klaten City with various activities to meet the needs of the entire population in the urban and surrounding areas of Klaten. It is also located near densely populated residential areas, workplaces, and other activities. Therefore, support is needed in Pasar Gede Klaten to facilitate various urban community activities, including the electrical installation system.

Figure 1. Pasar Gedhe Solar Panels Infrastructure

Travelators and escalators are among the components that serve the needs of visitors. The electrical system bears a significant load, with a total electrical load in Pasar Gede Klaten reaching 345 KVA. For reducing the electricity consumption at Pasar Gede Klaten, it is possible to utilize a Solar Power Generation System that can work optimally by harnessing the extensive roof space of Pasar Gede Klaten. The construction is carried out in two phases: in 2020-2021 for zones C and D, and in 2021-2023 for zone A, while zone B is scheduled for 2022-2023. The total budget for the market construction amounts to IDR 93.5 billion from

the national budget (APBN). The total number of traders in the market reaches 1,166 people. The electricity generated from the solar power plant (PLTS) can save expenditures for PLN electricity taxes by approximately 30 percent to 40 percent.

2. Literature Review

A literature review of a green shopping mall that incorporates solar energy involves the use of solar power systems to generate electricity and promote sustainability Allouhi & Rehman (2023), Barchi et al. (2018), Biryuzova & Glukhanov (2022), Duncan et al. (2015), Fariza et al. (2020), Jing et al. (2017) Liu & He (2023), Stensson (2010), Su & Yue (2021), Zhao et al., (2023), and Zorzi et al. (2019)

A study by Allouhi & Rehman (2023) investigated using a comprehensive analysis of grid-connected hybrid renewable energy systems explicitly tailored for supermarkets, incorporating electric vehicle (EV) charging platforms. Their study addresses a crucial intersection of sustainability, energy efficiency, and transportation electrification within the commercial sector. Their study navigates through an intricate landscape of renewable energy technologies, energy storage systems, and EV charging infrastructure, providing valuable insights into such integrated systems' optimization and sensitivity analyses. Also, their study demonstrates a commendable integration of theoretical models, simulation tools, and real-world data to validate the proposed methodologies and evaluate the feasibility of grid-connected hybrid renewable energy systems in practical settings. Including case studies or numerical examples based on real-world supermarket scenarios would further enrich the study, providing concrete illustrations of the proposed methodologies and facilitating broader applicability and adoption by stakeholders in the commercial sector.

Barchi et al. (2018) studied innovative and timely exploration into the potential transformation of shopping centers into renewable energy hubs. The study proposes a paradigm shift towards sustainability, energy resilience, and flexibility within the commercial sector by leveraging renewable energy sources and advanced energy management technologies. The study navigates through various renewable energy technologies, energy storage systems, and grid integration strategies, offering valuable insights into renewable malls' design, operation, and optimization. Moreover, this study showcases a commendable integration of theoretical frameworks, simulation tools, and practical case studies to illustrate the transformative potential of renewable malls in real-world settings. Including case studies or pilot projects highlighting successful implementations of renewable malls would further enhance the study, providing concrete examples and lessons learned for stakeholders in the commercial and energy sectors. Additionally, the study could benefit from discussing the potential barriers and strategies for overcoming challenges related to financing, stakeholder engagement, and regulatory frameworks in transitioning towards renewable malls.

Biryuzova & Glukhanov (2022) focused on enhancing the performance of internal heating systems within shopping centers. By addressing the critical issues of energy efficiency and reliability, the study provides valuable insights into optimizing heating infrastructure, a crucial aspect of sustainability and operational cost reduction for commercial complexes. The study navigates through a range of technical solutions, operational strategies, and case study analysis, presenting a comprehensive approach to improving the performance of internal heating systems in shopping centers.

This study uses a detailed analysis of the challenges and opportunities associated with internal heating systems, particularly within the context of shopping centers. The study adeptly explores various factors impacting system efficiency and reliability, including equipment selection, control strategies, maintenance practices, and thermal comfort requirements. By incorporating a case study approach, the study offers practical insights and lessons learned from real-world implementations, enhancing the relevance and applicability of the proposed solutions to stakeholders in the commercial sector.

Moreover, this study showcases a commendable integration of theoretical frameworks, simulation tools, and practical examples to illustrate the effectiveness of proposed interventions in enhancing the efficiency and reliability of internal heating systems. Including quantitative analyses, such as energy performance assessments or economic evaluations, would further strengthen the study, providing empirical evidence to support the proposed recommendations and justify investment decisions for system improvements. Additionally, discussing the potential environmental and economic benefits of improved heating system efficiency, such as reduced carbon emissions and operational costs, could enhance the study's impact and relevance.

This study offers practical guidance and actionable recommendations for optimizing internal heating systems in shopping centers, ultimately leading to enhanced energy efficiency, operational reliability, and cost savings. As stakeholders increasingly prioritize sustainability and resilience in building operations, the insights provided in this study are timely and pertinent, serving as a valuable resource for practitioners, facility managers, and policymakers in the commercial sector.

Jing et al. (2017) studied an electricity utilization management system tailored specifically for shopping malls. By addressing the critical energy management issue within commercial complexes, the study offers valuable insights into optimizing electricity usage, reducing energy costs, and enhancing sustainability. The study navigates through various aspects of energy

utilization, monitoring, and control, providing a systematic approach to improving the efficiency and performance of electricity systems in shopping malls.

The study identifies factors influencing energy consumption patterns, including lighting, HVAC systems, escalators, elevators, and tenant operations. By proposing an integrated management system, the study offers a holistic solution to monitor, analyze, and optimize electricity usage, enabling cost-effective energy management strategies and sustainable operations within shopping malls.

Moreover, the study showcases a commendable integration of theoretical frameworks, technological solutions, and practical examples to illustrate the effectiveness of the proposed electricity utilization management system. Including case studies or pilot projects demonstrating successful implementations of similar systems would further enrich the study, providing concrete illustrations and best practices for stakeholders in the commercial sector. Additionally, discussing the management system's potential economic and environmental benefits, such as reduced energy expenses and carbon emissions, could enhance the study's impact and relevance.

Liu & He (2023) comprehensively explored an innovative approach to fire safety system design tailored specifically for shopping malls. By integrating programmable logic controllers (PLC) and variable-frequency drives (VFD), the study aims to enhance the effectiveness and efficiency of fire exhaust systems, critical components for ensuring occupant safety and minimizing property damage in the event of a fire. The study navigates various aspects of system design, control logic, and operational considerations, offering valuable insights into optimizing fire safety infrastructure within commercial complexes.

This study lies in its detailed analysis of the proposed fire exhaust system design's technical principles and operational functionalities. The study elucidates the advantages of PLC and VFD technologies, such as enhanced control flexibility, precise operation, and real-time monitoring capabilities. By leveraging these technologies, the study proposes an integrated approach to fire safety management, enabling proactive detection, rapid response, and efficient evacuation procedures in shopping malls.

Moreover, the study showcases a commendable integration of theoretical concepts, engineering methodologies, and practical examples to illustrate the feasibility and effectiveness of the proposed design. Including simulation results, case studies, or field tests demonstrating the performance of the PLC and VFD-based fire exhaust system would further enrich the study, providing empirical evidence and validation of the proposed methodologies. Additionally, discussing the system's potential benefits, such as improved safety outcomes, reduced property damage, and regulatory compliance, could enhance the study's impact and relevance.

Stensson (2010) examined energy utilization and indoor climate management within shopping malls, focusing on enhancing energy efficiency. The study aims to identify opportunities for optimizing energy performance while maintaining occupant comfort and well-being by analyzing energy consumption patterns, building systems, and indoor environmental quality. The study navigates through various aspects of energy management, HVAC systems, and indoor climate control, providing valuable insights into strategies for improving energy efficiency in commercial complexes.

This study analyzed the relationship between energy use and indoor climate conditions within shopping malls. The study adeptly explores factors influencing energy consumption, such as lighting, heating, ventilation, air conditioning, and occupant behavior, while also considering the impact of these factors on indoor air quality, thermal comfort, and overall occupant satisfaction. Adopting a holistic approach, the study offers a nuanced understanding of the complex interplay between energy efficiency and indoor environmental quality in commercial buildings.

Moreover, the study showcases a commendable integration of theoretical frameworks, empirical research, and practical examples to illustrate effective strategies for enhancing energy efficiency while maintaining indoor comfort levels. Including case studies, energy performance assessments, or simulation results demonstrating successful energy-saving initiatives implemented in shopping malls would further enrich the study, providing concrete illustrations and best practices for stakeholders in the commercial sector. Additionally, discussing the potential economic and environmental benefits of improved energy efficiency, such as reduced operating costs and carbon emissions, could enhance the study's impact and relevance.

Su & Yue (2021) integrated smart car park storage systems to optimize power management within shopping malls. The study aims to enhance energy efficiency, grid stability, and renewable energy utilization in commercial complexes by leveraging innovative technologies and intelligent control strategies. The study navigates through various aspects of power management, energy storage systems, and smart grid integration, providing valuable insights into the design, operation, and benefits of incorporating smart car park storage solutions in shopping malls. Also, this study examines the role of energy storage in balancing supply and demand, peak shaving, load shifting, and grid ancillary services, particularly within the context of shopping mall environments. By proposing an integrated approach to power management, the study offers a holistic solution to optimize energy utilization and enhance the resilience of shopping mall operations.

Moreover, the study showcases a commendable integration of theoretical concepts, simulation models,

and practical examples to illustrate the effectiveness of the proposed power management strategies. Including case studies or pilot projects demonstrating successful implementations of smart car park storage systems in shopping malls would further enrich the study, providing concrete illustrations and real-world insights for stakeholders in the commercial sector. Additionally, discussing the potential economic and environmental benefits of smart power management, such as reduced electricity costs, carbon emissions, and grid congestion, could enhance the study's impact and relevance.

Zhao et al. (2023) analyzed the influence of market structure on renewable energy development within the context of a regional electricity market in China. By employing simulation techniques, the study aims to elucidate the impact of different market structures on the integration and growth of renewable energy sources, such as wind and solar, within the electricity market. The study navigates various aspects of market design, policy frameworks, and renewable energy deployment strategies, providing valuable insights into the interplay between market structures and renewable energy development. Their study examines market concentration, regulatory frameworks, pricing mechanisms, and market power, highlighting their implications for renewable energy penetration and market competitiveness. By employing simulation modelling, the study offers a quantitative assessment of the effects of different market structures on key performance indicators, such as renewable energy capacity, generation mix, and electricity prices.

Moreover, the study showcases a commendable integration of theoretical frameworks, empirical data, and simulation results to support its findings and conclusions. The inclusion of sensitivity analyses or scenario simulations considering various market conditions and policy scenarios would further enrich the study, providing insights into the robustness and generalizability of the results. Additionally, discussing the broader implications of the findings for renewable energy policy and market design in China and other regions could enhance the study's impact and relevance.

Zorzi et al. (2019) studied strategic planning of energy sources, focusing on enterprises' adoption of renewable energies. By addressing the critical issue of energy sourcing, the study aims to provide a framework for enterprises to assess, prioritize, and integrate renewable energy sources into their energy portfolios. The study navigates various aspects of energy planning, renewable energy technologies, and decision-making processes, offering valuable insights into strategies for enhancing sustainability and resilience within enterprises.

Also, this study examines factors such as resource availability, technology maturity, regulatory frameworks, financial considerations, and organizational objectives, highlighting their implications for energy source planning. The study offers practical guidance for enterprises seeking to transition towards more sustainable and cost-effective energy sources by proposing a systematic approach to assess the feasibility and suitability of renewable energy options.

Moreover, the study showcases a commendable integration of theoretical frameworks, case studies, and practical examples to illustrate the application of the proposed energy source planning framework. The inclusion of real-world case studies demonstrating successful implementations of renewable energy projects by enterprises would further enrich the study, providing concrete illustrations and best practices for stakeholders in the business sector. Additionally, discussing the potential economic, environmental, and social benefits of renewable energy adoption for enterprises could enhance the study's impact and relevance.

3. Materials and Methods

The methodology for bibliographic analysis involves a systematic approach to identifying, collecting, and analyzing relevant literature within a specific research domain. A comprehensive search strategy is developed, incorporating relevant keywords and search terms to retrieve literature from academic databases, library catalogs, and other sources. Inclusion and exclusion criteria guide the selection process, ensuring that only literature meeting predefined criteria is included for analysis. Once the literature is retrieved, screening procedures are implemented to assess the relevance of titles and abstracts, followed by the retrieval of full-text articles for further evaluation.

Subsequently, data extraction is conducted to capture essential metadata and relevant information from the selected literature. This may include authorship details, publication year, journal/book titles, abstracts, keywords, and other pertinent data. Analysis techniques such as thematic content analysis, citation analysis, and quality assessment are then employed to identify patterns, trends, and insights within the literature. The findings are synthesized and interpreted to address the research question or objectives, with attention to identifying gaps, contradictions, and areas for future research. Finally, the results are reported clearly and structured, providing a comprehensive overview of the literature and its implications for the research topic.

A bibliographic database that provides abstracts and citations for academic journal articles. When you search Scopus, the search results typically include information about academic publications that match your query. Here's a general overview of how you can analyze search results in Scopus:

1) Refine Search Results: After performing a search, you may need to refine your results based on criteria such as publication date, document type, source type, and more. This helps you narrow down the results to find the most relevant articles.

2) Viewing Article Information: Clicking on a specific article title in the search results will take you to the detailed view of that article. The abstract, authors, keywords, publication details, and citation information are here.
3) Citation Analysis: Scopus provides citation information for each article, including the number of times other articles have cited it. This can indicate the impact and influence of a particular paper in the academic community.
4) Author and Affiliation Information: In the search results, you can view information about authors and their affiliations. This can be useful for identifying experts in a specific field or institution.
5) Export and Save: Scopus allows you to export search results in different formats (e.g., CSV, Excel) for further analysis or to save for future reference.
6) Advanced Search: Utilize the advanced search features to create more specific queries. You can combine keywords, use Boolean operators, and set specific search parameters to tailor your search.
7) Set Alerts: You can set up alerts to receive notifications when new articles that match your search criteria are added to the database; (8) Journal Metrics: Scopus provides metrics for journals, including their impact factor, CiteScore, and SJR (SCImago Journal Rank). These metrics can help you assess the quality and influence of a journal.
8) Graphs and Visualizations: Some versions of Scopus provide visualizations and graphs that show trends in research topics, citations, and collaborations.

4. Results and Discussions

In recent years, integrating renewable energy infrastructure has emerged as a pivotal strategy for enhancing sustainability and reducing environmental impact across various sectors.

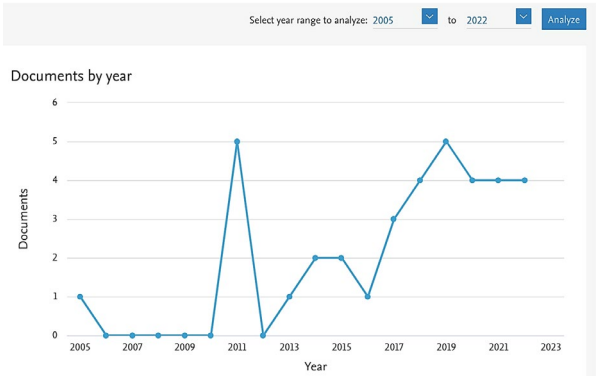

Figure 2. Trend of shopping mall renewable energy retrieved from Scopus database.

This review delves into the trends and developments in the renewable energy infrastructure literature, specifically focusing on shopping malls. As a significant energy consumer, a shopping mall presents an intriguing case study for exploring the adoption of renewable energy solutions. This review centers on Pasar Gedhe Klaten, a prominent shopping mall in Indonesia, as a case study to examine the implications, challenges, and opportunities associated with integrating renewable energy infrastructure within commercial complexes.

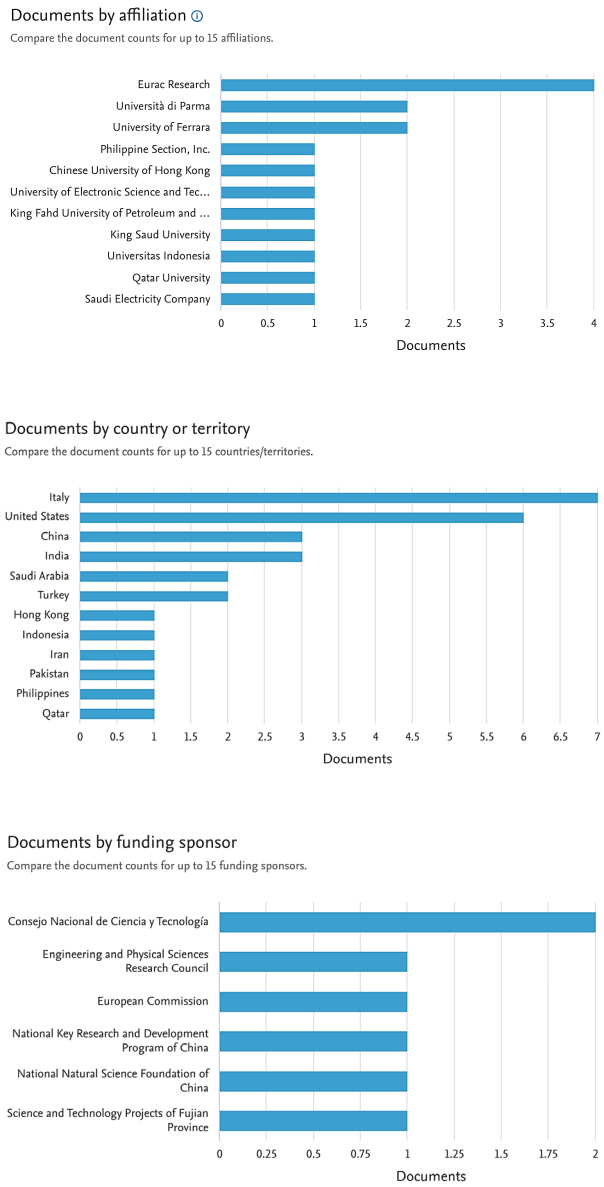

Figure 3. Trend of shopping mall renewable energy articles by affiliations, countries and funding sponsors from Scopus database.

By analyzing the existing literature, this review aims to provide insights into the trends, best practices, and potential pathways for implementing renewable energy solutions in shopping malls, with implications for sustainability, environmental responsibility, and energy efficiency.

5. Conclusions

In conclusion, this review of the literature on renewable energy infrastructure trends, focusing on the case study of Pasar Gedhe Klaten shopping mall in Indonesia, highlights the significant developments and opportunities in integrating renewable energy solutions within commercial complexes. The analysis reveals a growing global trend towards sustainability and environmental responsibility, driving the adoption of renewable energy technologies in shopping malls. Pasar Gedhe Klaten is a pertinent case study demonstrating the potential benefits of implementing renewable energy infrastructure in commercial settings.

The review underscores the importance of addressing environmental concerns, reducing carbon footprints, and mitigating energy costs by deploying solar panels, wind turbines, and other renewable energy systems. Moreover, it emphasizes the role of government incentives, regulatory frameworks, and corporate social responsibility initiatives in promoting renewable energy adoption among shopping malls. However, the analysis also identifies challenges such as initial investment costs, technological limitations, and policy barriers that must be addressed to accelerate the transition towards renewable energy in commercial complexes like Pasar Gedhe Klaten.

Further research and practical implementation are warranted to explore innovative approaches, overcome barriers, and maximize the benefits of renewable energy infrastructure in shopping malls. By leveraging renewable energy solutions effectively, Pasar Gedhe Klaten and similar commercial establishments can reduce their environmental impact and enhance their resilience, sustainability, and competitiveness in the evolving energy landscape.

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