 ISSN: 2548-9380 E-ISSN: 2549-2322

APPLICATION OF SUSTAINABLE PRINCIPLES IN TOWER BUILDINGS IN BALI

Editor's Request	Your Response	Review Submitted	Review Due
2025-03-22	2025-03-22	2025-03-24	2025-04-19

I Gusti Ngurah Putrawan, Ni Wayan Rustiarini
ignputrawan05@gmail.com, ketutsetiasapta@unmas.ac.id
Universitas Mahasaraswati, Jl. Kamboja No.11A, Dangin Puri Kangin, Kec. Denpasar Utara, Kota Denpasar, Bali 80233

Abstract

The study aims to examine the application of sustainable principles in tower development in Bali. With the increasing development of communication and tourism infrastructure, environmental sustainability has become a major challenge. This study uses a qualitative approach with a case study method on several towers that have implemented sustainability principles. The results of the study show that the use of environmentally friendly materials, energy efficiency, and harmony with local culture are the main factors in sustainable tower development in Bali. This study recommends improving regulations and incentives for companies that implement sustainable principles in infrastructure development. maximum 200 word abstract in English in italics with Times New Roman 10 point. Abstract should be clear, descriptive, and should provide a brief overview of the problem studied. Abstract topics include reasons for the selection or the importance of research topics, research methods and a summary of the results. Abstract should end with a comment about the importance of the results or conclusions brief.
Keywords: *sustainable, tower, efficiency, energy*

Abstrak

Penelitian bertujuan mengkaji penerapan prinsip berkelanjutan dalam pembangunan tower di Bali. Dengan meningkatnya pembangunan infrastruktur komunikasi dan pariwisata, keberlanjutan lingkungan menjadi tantangan utama. Studi ini menggunakan pendekatan kualitatif dengan metode studi kasus pada beberapa tower yang telah menerapkan prinsip keberlanjutan. Hasil penelitian menunjukkan bahwa pemanfaatan material ramah lingkungan, efisiensi energi, dan harmonisasi dengan budaya lokal merupakan faktor utama dalam pembangunan tower berkelanjutan di Bali. Studi ini merekomendasikan perbaikan regulasi dan insentif bagi perusahaan yang menerapkan prinsip berkelanjutan dalam pembangunan infrastruktur.
Kata kunci*: berkelanjutan, tower, efisiensi, energi*

INTRODUCTION

Infrastructure development, including telecommunication towers, in Bali continues to experience rapid growth along with the increasing need for digital connectivity. However, this expansion is not free from various challenges, especially in terms of environmental, social, and economic sustainability. Sustainable management is an increasingly relevant concept in the development process to ensure that negative impacts on the environment and local culture can be minimized. By adopting sustainability principles, tower development in Bali is expected to provide long-term benefits without damaging the balance of the existing ecosystem and empowering local workers. In addition, it is important to consider how this infrastructure can continue to develop in line with technological advances, without sacrificing environmental sustainability and the welfare of the local community. Therefore, a sustainability-oriented development approach must be a top priority for stakeholders, (Habibi et al. 2024). Commitment to maintaining a balance between technological innovation and environmental preservation is a key factor in ensuring the long-term benefits of this project. With proper regulation and strict supervision, this development can be a model for other regions in Indonesia. Sustainability is not just a concept, but a necessity that must be realized in every development policy, (Jamilu, Abdou, and Asif 2024).

One of the ongoing tower construction projects in Bali is the Turyapada Tower, located in Pegayaman Village, Buleleng Regency, at an altitude of 1,521 meters above sea level. Construction of this tower began in July 2022 and was initially targeted for completion in August 2023, but the completion target was postponed to December 2023. Although not yet fully completed, the Turyapada Tower is already striking and can be seen from a distance, marking its significant role in telecommunications and tourism infrastructure, (Gebhard et al. 2024). The Turyapada Tower has two main functions, namely as a telecommunications infrastructure and a tourist destination. Its existence is expected to have a positive impact not only on the digital sector, but also on local economic development. With the increasing dependence of the community on digital communication services, the presence of this tower is a strategic step in supporting digital transformation in Bali. In addition, the tourism potential offered by this tower can also provide added value to the tourism sector in the area. This potential can be maximized if supported by adequate facilities and effective promotion. Therefore, synergy between the government and the private sector in its management is crucial, (Makkawi et al. 2024).

From the telecommunications side, the top is used for terrestrial digital TV broadcast transmitters, cellular telecommunications, internet, and community radio communications. Its existence is expected to optimize digital TV broadcasts with coverage reaching 80 percent of the Buleleng, Jembrana, and Karangasem areas. Meanwhile, from the tourism side, this tower is equipped with various interesting facilities such as a planetarium, sky walk, restaurant, and glass bridge. There are also flower and fruit gardens, children's play areas, and outbound rides such as flying fox that can attract local and foreign tourists. With these facilities, the Turyapada Tower is not only a means of supporting communication, but also a leading tourist destination that contributes to increasing regional income. The existence of these supporting facilities is expected to increase tourist appeal and provide memorable experiences for visitors, (Tian et al. 2025). In addition, good facility management can have a wider economic impact by opening up business opportunities for the surrounding community, (Rosentreter et al. 2025). If further developed, this area has the potential to become a new tourism icon that attracts tourists from various circles, (Hafez et al. 2023). Careful planning and good management will determine the long-term success of this project.

In an effort to ensure optimal management, the Bali Provincial Government (Pemprov) is currently drafting a special regional regulation (perda) regarding the management of Turyapada Tower. This regulation regulates operational aspects, including entrance tickets, taxes, and tourism management and telecommunications infrastructure. The Regional Secretary (Sekda) of Bali, Dewa Made Indra, said that this regulation is currently under discussion and is expected to be submitted in early 2025. Currently, the public is allowed to visit the 115-meter-high tower for free, but after official management is implemented, regulations regarding access and utilization will be applied. With clear regulations, it is hoped that the management of this tower can run more effectively and transparently, (Salami et al. 2024). In addition, appropriate regulations can also ensure that the operation of this tower remains in line with the principles of sustainability. The policies designed must be able to balance economic needs and environmental protection. Transparency in fund management and flexible regulations to current developments are also important factors in the sustainability of this project.

Thus, the public can enjoy maximum benefits from the presence of this tower without causing excessive negative impacts. The construction process of the Turyapada Tower itself has experienced several delays from the initial target. The government has also imposed sanctions on the project management for the delay in accordance with applicable regulations, including daily penalty payments. However, the first phase of construction has now been completed and a soft launch will be carried out in the near future. With complete facilities that include educational, tourism, and telecommunications functions, it is hoped that this tower can contribute greatly to the development of the digital sector and tourism in Bali, while maintaining the principle of sustainability in its management, (Niza et al. 2024). The delay of this project is also an important lesson for the government and contractors to be able to increase efficiency in planning and executing similar projects in the future. Anticipating various risks and obstacles from an early stage can help reduce the possibility of project delays that are detrimental to various parties. Therefore, increasing coordination between various stakeholders is an important factor in ensuring the success of infrastructure projects like this. With a comprehensive evaluation, similar projects in the future can be more efficient and avoid similar obstacles.

Sustainability in infrastructure development is an important aspect that must be considered, especially in areas that have high cultural and environmental values such as Bali. The principle of sustainable development involves various approaches that aim to reduce negative impacts on the environment, maximize resource efficiency, and improve the welfare of the surrounding community. With the construction of telecommunication towers that consider aspects of sustainability, it is hoped that a balance can be created between technological development and environmental preservation. In addition, the implementation of effective sustainability policies can provide assurance that the development carried out is not only economically profitable, but also has a positive impact on environmental sustainability. A science and technology-based approach to managing resources is also key to creating environmentally friendly and sustainable infrastructure, (F. W. Yu, Ho, and Wong 2025). Collaboration between government, academics, and the community in the application of green technology can help ensure that this project remains oriented towards the principles of sustainability.

METHOD

This research with a case study of the Turyapada Tower in Bali focuses on examining the principles of sustainable architecture applied to the building, therefore the type of method used is a qualitative descriptive research method. Through this method, it is hoped that it can dig up a deep understanding of the application of sustainable management in the construction and management of the Turyapada Tower and help analyze the social, economic, and environmental impacts on local workers and the tourism sector.

Qualitative research is a study that aims to explore and analyze a research object in depth with several methods of data collection including interviews and observations, (Li, Tsavdaridis, and Katenbayeva 2024). The Descriptive-Analytical Method allows researchers to describe the conditions of the Turyapada Tower construction, the policies implemented, and their impact on the community and the surrounding environment and analyze qualitative data from various sources, such as interviews, observations, and document studies related to tower management regulations.

The data that has been collected can later be re-analyzed descriptively and narratively in order to find and determine the results of the research, (Moshood et al. 2024). The object in the form of a tower located in Bali was chosen as a case study object because the tower is related to the research topic, namely the characteristics and concepts of buildings that apply the concept of sustainable architecture.

RESULT AND DISCUSSION

The results of the study show that several towers in Bali have implemented sustainable principles in various aspects, such as the use of environmentally friendly materials, energy efficiency through solar panels, and architectural designs that are in harmony with local culture. The use of materials with a low carbon footprint, such as recycled steel and environmentally friendly concrete, helps reduce the environmental impact of the construction process,(H. Yu et al. 2024) . In addition, the implementation of a solar panel system as an alternative energy source has been shown to reduce dependence on conventional electricity and reduce carbon emissions. This system not only helps in energy savings but also increases the operational efficiency of the tower in the long term. Furthermore, innovations in energy storage technology have also begun to be implemented to ensure a more stable electricity supply.

Other efforts made include the use of energy-efficient LED lighting and natural ventilation-based cooling systems to reduce electricity consumption. Thus, the concept of sustainability is increasingly becoming a major concern in the development of modern telecommunications infrastructure in Bali. Along with technological developments, this strategy is increasingly being optimized to ensure more effective and efficient sustainability, both in terms of the environment and operations. In terms of architecture, several towers have adopted designs that respect Balinese cultural values, such as the use of traditional ornaments and integration with the surrounding natural landscape. This approach not only maintains the aesthetics of the environment but also increases social acceptance of tower construction, (Ko et al. 2018). Adapting the design to local character can reduce community resistance to new infrastructure development.

Typical Balinese ornaments, such as wood carvings and paras stone, are often used to create harmony with surrounding buildings. In addition, the use of vegetation as a tower camouflage element is also applied to minimize the striking visual impact,(Abou Ibrahim et al. 2025) . The use of natural

colors and structures that do not contrast too much with the surrounding environment are strategies applied to maintain visual harmony. With an approach that is sensitive to local culture and ecology, tower construction can be more accepted by the community and is not considered a disturbance to the aesthetics of the environment. This also reflects the industry's commitment to the principle of sustainable development that considers not only technical aspects but also social and cultural aspects. However, there are still a number of challenges in implementing sustainable principles.

One of the main obstacles is the weak regulation governing sustainability standards in tower construction. Existing regulations are often not specific enough in regulating the use of sustainable materials or environmentally friendly technologies. The absence of clear standards has led to inconsistencies in the application of sustainability principles in various tower construction projects. Some companies may prefer cheaper solutions to environmentally friendly ones because there is no binding legal obligation, (Bonilla et al. 2025). In addition, the lack of incentives from the government is also a factor that hinders the implementation of green technology in this industry. In some cases, the initial cost of adopting sustainable technology is considered too high, so many developers prefer conventional solutions. Therefore, a more stringent policy is needed so that sustainability principles can be applied comprehensively. Stricter regulations will help ensure that tower construction is not only economically profitable but also environmentally friendly. In addition to the regulatory aspect, public and stakeholder awareness of the importance of sustainable development is still relatively low. Some people only assess tower construction from an economic perspective, without considering the long-term environmental and social impacts.

In fact, environmentally unfriendly infrastructure can contribute to the degradation of local ecosystems and increase carbon emissions. Less informed communities often only see immediate benefits, such as increased connectivity and economic opportunities, without considering the long-term consequences, (Lucchi et al. 2024). Therefore, public education is key to raising awareness of the importance of sustainable development. Socialization programs and environmental awareness campaigns can help introduce the concept of sustainability and encourage the public to be more active in monitoring development in their area. With increased understanding, it is hoped that the public can be more critical in assessing development projects and encouraging the implementation of more environmentally friendly policies. Collaboration between the government, academics, and the private sector can also help accelerate the transformation towards sustainability.

Furthermore, coordination between local governments, telecommunications companies, and the community is still less than optimal. Difficulties in obtaining development permits often hinder the adoption of green technology because they are considered to increase initial investment costs. Several projects that want to adopt renewable energy systems often face complex bureaucratic obstacles. In addition, the lack of communication between stakeholders causes many decisions to be made without considering the overall sustainability impact. Telecommunication companies are often more oriented towards business efficiency, while the government focuses more on administrative aspects without considering the overall environmental impact. Therefore, a closer cooperation mechanism is needed to ensure that the interests of all parties can be accommodated in sustainable tower development planning. With a more collaborative approach, bureaucratic obstacles can be minimized so that the implementation of environmentally friendly solutions can run more effectively.

Increasing industry awareness of sustainability is also crucial in driving change. Telecommunication companies must be more proactive in adopting green policies as part of their corporate social responsibility. Some concrete steps that can be taken include investing in research and development of environmentally friendly technologies, increasing operational efficiency, and implementing better waste management systems. By implementing this approach, companies not only contribute to environmental preservation but can also improve their reputation in the eyes of the public and investors.

Support from the international community can also play a role in accelerating the implementation of sustainability policies in tower construction in Bali. Global standards on green infrastructure can be used as a reference in formulating stricter local regulations. In addition, partnerships with international organizations can help in terms of technology transfer and providing funding for sustainable projects. With cross-border collaboration, the implementation of sustainability principles can be further strengthened and provide a wider positive impact.

Overall, although there have been efforts to implement sustainable principles in tower construction in Bali, improvements are still needed in terms of regulations, public education, and stronger policy support to ensure that this infrastructure development is truly in line with sustainable development goals. To encourage sustainable tower construction in Bali, stricter and more targeted policies are needed, both in the form of regulations and economic incentives. Local governments need to set clear sustainability standards in the tower construction licensing process, including the obligation to use environmentally friendly materials, energy efficiency, and designs that respect local culture. With more specific standards, the industry can more easily adapt to sustainability demands without creating uncertainty in the infrastructure development process. Stricter regulations will also encourage companies to be more active in implementing green solutions and integrating social and cultural aspects into their tower designs.

This study shows that the implementation of environmentally friendly technology in the construction of telecommunications towers in Bali has experienced significant development, especially in the use of low-carbon materials and renewable energy systems. This is in line with the findings of (Salins et al. 2024) which show that strict regulations in developed countries, such as Germany and Sweden, encourage telecommunications companies to be more innovative in developing energy-efficient solutions. In these countries, incentive policies for companies that implement green technology have proven effective in increasing energy efficiency while reducing environmental impacts.

Meanwhile, research (Bao et al. 2024) on the development of telecommunications towers in India shows that although the country faces economic challenges in implementing green technology, the public-private partnership strategy has accelerated the transition to sustainable infrastructure. This model is different from that found in this study. In addition, research (Onyszkiewicz and Sadowski 2022) on telecommunications towers in several developing countries shows that the main obstacle in adopting green technology is the high initial investment cost. This is also found in this study, where some operators are still reluctant to switch to renewable energy solutions due to the large initial investment. However, previous studies have also shown that in the long term, the use of green energy actually saves more operational costs, which is in line with the results of this study.

On the other hand, research (Alsehaimi et al. 2024) revealed that Indonesia has begun to adopt a policy of using more environmentally friendly local materials in tower construction. The results of this study support these findings, especially in the application of materials with a low carbon footprint such as recycled steel and environmentally friendly concrete which have been shown to reduce the environmental impact of the construction process. Furthermore, research (van Erp et al. 2023) shows that the integration of solar energy systems in telecommunications towers provides great benefits in reducing dependence on conventional electricity. The results of this study found similarities in the application of this technology in Bali, although in Japan, the success of implementation is highly dependent on government subsidies, which is still a challenge in Indonesia.

This study also found that architectural design that takes into account local cultural aspects can increase public acceptance of tower construction. This is similar to the findings of research (Barber, Alves, and Lima 2024), which shows that the integration of cultural elements in infrastructure design can reduce social resistance to tower construction. In Bali, the use of traditional ornaments and vegetation as tower camouflage elements has been an effective strategy in increasing aesthetics and public acceptance.

In terms of regulation, this study found that weak sustainability standards and minimal incentives from the government are the main obstacles to the implementation of green technology in the telecommunications sector. This finding is in line with the study (Lefebvre et al. 2025) which shows that inconsistent regulations can hinder innovation and adoption of sustainable solutions in the telecommunications industry.

Overall, the results of this study confirm that the success of implementing green technology in tower construction is highly dependent on government policies, industry readiness, and public awareness. Previous studies in developed countries have shown that strict incentive and regulatory policies can accelerate the adoption of sustainable technology, while in developing countries, economic challenges and immature regulations are still the main obstacles. Therefore, a collaborative strategy is needed between the government, industry, and society to accelerate the transformation of telecommunications infrastructure towards more effective sustainability.

CONCLUSION AND RECOMMENDATION

The implementation of sustainable principles in tower construction in Bali still faces various challenges, but has shown positive developments, especially in terms of the use of environmentally friendly materials, energy efficiency, and architectural design that is in harmony with local culture. However, obstacles in implementing regulations, lack of public awareness, and minimal supervision of infrastructure development are still the main obstacles.

To increase the effectiveness of the implementation of sustainable principles, stricter and more specific regulatory improvements are needed, including technical standards for environmentally friendly tower construction and incentive mechanisms for companies that implement them. In addition, public education needs to be improved to build awareness of the importance of sustainable development and its impacts on the environment and society. Stricter supervision from the authorities is also needed to ensure that tower construction meets the established sustainability standards.

Further studies are recommended to explore innovative methods in more environmentally friendly tower construction, such as the use of more sustainable alternative materials, optimization of renewable energy, and a design approach that is more adaptive to the surrounding environment. Thus, future research can provide further contributions in creating sustainable infrastructure development policies and practices in Bali and other regions.

REFERENCES

Abou Ibrahim, Rima, Oumaima Imghoure, Pierre Tittelein, Naoual Belouaggadia, Fadi Hage Chehade, Nassim Sebaibi, Stéphane Lassue, and Laurent Zalewski. 2025. “Application of Ventilated Solar Façades to Enhance the Energy Efficiency of Buildings: A Comprehensive Review.” *Energy Reports*. Elsevier Ltd. https://doi.org/10.1016/j.egyr.2024.12.051.

Alsehaimi, Abdullah, Ahsan Waqar, Khaled A. Alrasheed, Abdulrahman S. Bageis, Hamad Almujibah, Omrane Benjeddou, and Abdul Mateen Khan. 2024. “Building a Sustainable Future: BIM’s Role in Construction, Logistics, and Supply Chain Management.” *Ain Shams Engineering Journal*, December. https://doi.org/10.1016/j.asej.2024.103103.

Bao, Yuxin, M. K. Leung, Dicken Poon, and Changying Xiang. 2024. “Integrating Vertical Farm into Low-Carbon High-Rise Building in High-Density Context: A Design Case Study in Hong Kong.” *Journal of Building Engineering* 96 (November). https://doi.org/10.1016/j.jobe.2024.110472.

Barber, Hunter, Victor Alves, and Fernando V. Lima. 2024. “Synergistic Cotreatment of Cooling Tower Blowdown and Produced Waters: Techno-Economic, Sustainability, and Optimization Systems Analyses.” *Desalination and Water Treatment* 320 (October):100779. https://doi.org/10.1016/j.dwt.2024.100779.

Bonilla, J., B. Ortega-Delgado, D. C. Alarcón-Padilla, J. Fernández-Reche, and P. Palenzuela. 2025. “Development of a Novel Tool to Simulate Solar Thermal Cogeneration Plants Using Small-Capacity Tower Plants.” *Energy Conversion and Management* 324 (January). https://doi.org/10.1016/j.enconman.2024.119285.

Erp, Tim van, Cecilia Haskins, Wayne Visser, Holger Kohl, and Niels Gorm Maly Rytter. 2023. “Designing Sustainable Innovations in Manufacturing: A Systems Engineering Approach.” *Sustainable Production and Consumption* 37 (May):96–111. https://doi.org/10.1016/j.spc.2023.02.007.

Gebhard, Lukas, Jaime Mata-Falcón, Rebecca Ammann, Nadine Preßmair, Benjamin Kromoser, Costantino Menna, Abtin Baghdadi, et al. 2024. “Enhancing Structural Efficiency with Digital Concrete – Principles, Opportunities and Case Studies.” *Cement and Concrete Research* 185 (November). https://doi.org/10.1016/j.cemconres.2024.107645.

Habibi, Alireza, Richard Buswell, Mohamed Osmani, and Mohamadmahdi Aziminezhad. 2024. "Sustainability Principles in 3D Concrete Printing: Analysing Trends, Classifying Strategies, and Future Directions." *Journal of Building Engineering*. Elsevier Ltd. https://doi.org/10.1016/j.jobe.2024.111354.

Jamilu, Garkuwa, Adel Abdou, and Muhammad Asif. 2024. "Dynamic Facades for Sustainable Buildings: A Review of Classification, Applications, Prospects and Challenges." *Energy Reports* 11 (June):5999–6014. https://doi.org/10.1016/j.egyr.2024.05.047.

Ko, Nathanael, Manuel Lorenz, Rafael Horn, Hannes Krieg, and Michael Baumann. 2018. "Sustainability Assessment of Concentrated Solar Power (CSP) Tower Plants - Integrating LCA, LCC and LCWE in One Framework." In *Procedia CIRP*, 69:395–400. Elsevier B.V. https://doi.org/10.1016/j.procir.2017.11.049.

Lefebvre, Xavier, Vaishali Ashok, Dominique Claveau-Mallet, Etienne Robert, and Emilie Bedard. 2025. "Data-Driven Cooling Tower Optimization: A Comprehensive Analysis of Energy Savings Using Microsand Filtration." *Applied Thermal Engineering* 258 (January). https://doi.org/10.1016/j.applthermaleng.2024.124736.

Li, Zhengyao, Konstantinos Daniel Tsavdaridis, and Assel Katenbayeva. 2024. "Reusable Timber Modular Buildings, Material Circularity and Automation: The Role of Inter-Locking Connections." *Journal of Building Engineering* 98 (December). https://doi.org/10.1016/j.jobe.2024.110965.

Lucchi, Elena, Francesca Turati, Benedetta Colombo, and Eva Schito. 2024. "Climate-Responsive Design Practices: A Transdisciplinary Methodology for Achieving Sustainable Development Goals in Cultural and Natural Heritage." *Journal of Cleaner Production* 457 (June). https://doi.org/10.1016/j.jclepro.2024.142431.

Makkawi, Yassir, Mihad Ibrahim, Nihal Yasir, and Omar Moussa. 2024. "Solar-Thermal Conversion of Biomass: Principles of Solar Concentrators/Reactors, Reported Studies, and Prospects for Large-Scale Implementation." *Fuel Processing Technology*. Elsevier B.V. https://doi.org/10.1016/j.fuproc.2024.108139.

Moshood, Taofeeq D., Gusman Nawanir, Chia Kuang LEE, and Muhammad Ashraf Fauzi. 2024. "Toward Sustainability and Resilience with Industry 4.0 and Industry 5.0." *Sustainable Futures* 8 (December):100349. https://doi.org/10.1016/j.sftr.2024.100349.

Niza, Iasmin Lourenço, Ana Maria Bueno, Manuel Gameiro da Silva, and Evandro Eduardo Broday. 2024. "Air Quality and Ventilation: Exploring Solutions for Healthy and Sustainable Urban Environments in Times of Climate Change." *Results in Engineering*. Elsevier B.V. https://doi.org/10.1016/j.rineng.2024.103157.

Onyszkiewicz, Jakub, and Kajetan Sadowski. 2022. "Proposals for the Revitalization of Prefabricated Building Facades in Terms of the Principles of Sustainable Development and Social Participation." *Journal of Building Engineering* 46 (April). https://doi.org/10.1016/j.jobe.2021.103713.

Rosentreter, H., C. Scope, T. Oddoy, A. Lerch, and J. Meier-Haack. 2025. "Monovalent Selective Ion Exchange Membranes: A Review on Preparation Processes, Applications, Performance Criteria and Sustainability Aspects." *Desalination*. Elsevier B.V. https://doi.org/10.1016/j.desal.2024.118412.

Salami, Babatunde Abiodun, Ashraf A. Bahraq, Mohd Moin ul Haq, Opeyemi A. Ojelade, Ridwan Taiwo, Sarmed Wahab, Adeshina Adewale Adewumi, and Mohammed Ibrahim. 2024.

"Polymer-Enhanced Concrete: A Comprehensive Review of Innovations and Pathways for Resilient and Sustainable Materials." *Next Materials* 4 (July):100225. https://doi.org/10.1016/j.nxmate.2024.100225.

Salins, Sampath Suranjan, Shiva Kumar, A. Ganesha, and S. V.Kota Reddy. 2024. "Machine Learning-Based Optimization and Performance Analysis of Cooling Towers." *Journal of Building Engineering* 96 (November). https://doi.org/10.1016/j.jobe.2024.110415.

Tian, Haonan, Mohsen N. Soltani, Baran Yeter, and Diego E. Galván-Pozos. 2025. "Design of a Novel Tower Damping System for Semi-Submersible Floating Offshore Wind Turbines Considering Fatigue and Ultimate Limit States." *Ocean Engineering* 320 (March). https://doi.org/10.1016/j.oceaneng.2025.120343.

Yu, Fu Wing, Wai Tung Ho, and Chak Fung Jeff Wong. 2025. "Sustainable Subtropical Hotel Operations: A Time Series Analysis of Waste Heat Recovery Potential." *Environmental Challenges* 18 (April). https://doi.org/10.1016/j.envc.2025.101091.

Yu, Haoxuan, Bodong Wen, Izni Zahidi, Chow Ming Fai, and Dag Øivind Madsen. 2024. "China's Green Building Revolution: Path to Sustainable Urban Futures." *Results in Engineering* 23 (September). https://doi.org/10.1016/j.rineng.2024.102430.