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نحو مباني صافية صفرية الطاقة من أجل الاستدامة

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Towards Net Zero Energy Buildings for Sustainability

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المخلص

تلعب المباني ذات صافي الطاقة الصفرية (NZE) دورًا حاسمًا في تحقيق أهداف التنمية المستدامة (SDG) وإنشاء مناطق سكنية صديقة للبيئة. تم تصميم هذه المباني لتوليد نفس القدر الذي تستهلكه من الطاقة، مما يؤدي إلى توازن صافي لاستهلاك الطاقة من الشبكة بمقدار صفر. ومن خلال دمج التقنيات المبتكرة ومبادئ التصميم المستدام، تقلل مباني NZE من بصمتها الكربونية وتساهم في تحقيق مستقبل أكثر استدامة. وقد تم عرض النتيجة المكتسبة ومناقشتها. لقد اكتسب مفهوم المباني ذات الطاقة الصفرية (NZEBS) اهتمامًا كبيرًا في السنوات الأخيرة كاستراتيجية حاسمة لتحقيق الاستدامة في البيئة المبنية. تم تصميم NZEBS لإنتاج نفس القدر من الطاقة الذي تستهلكه، مما يؤدي إلى رصيد طاقة صافي قدره صفر خلال فترة محددة.

الكلمات المفتاحية: الطاقة الصفرية، أهداف التنمية المستدامة، البصمة الكربونية

Abstract

Net Zero Energy (NZE) buildings play a crucial role in meeting the Sustainable Development Goals (SDG) and creating environmentally friendly residential areas. These buildings are designed to generate as much energy as they consume, resulting in a net balance of zero energy consumption from the grid. By integrating innovative technologies and sustainable design principles, NZE buildings minimize their carbon footprint and contribute to a more sustainable future. The acquired result has been presented and discussed. The concept of Net Zero Energy Buildings (NZEBS) has gained significant attention in recent years as a crucial strategy for achieving sustainability in the built environment. NZEBS are designed to produce as much energy as they consume, resulting in a net energy balance of zero over a specified period.

Keywords: NZE, SDG, carbon footprint.

Introduction

Net Zero Energy Buildings (NZEBS) are a notion that has developed as a hope for the future as the world struggles with climate change and the pressing need to transition to a sustainable future. [1]. The integration operation of NZEB is considered as a solution in the building sector to overcome problems such as environmental

protection, energy saving, Carbon Dioxide (CO₂) emission reduction, and environmental protection [2]. Net Zero Energy building is conducted in various countries such as Australia even when the electricity production is enough renewable energy is running [3]. These innovative structures represent a paradigm shift in the construction industry, offering a sustainable solution that effectively addresses the growing concerns of energy consumption and environmental impact [4]. The exploration concept of Net Zero Energy buildings is presented along with how they contribute to meeting sustainable development goals and creating a healthier environment [5]. In residential areas, NZE buildings offer numerous benefits [4].

Firstly, they significantly reduce Greenhouse Gas (GHG) emissions by utilizing renewable energy sources (RESs) such as solar panels, wind turbines, or geothermal systems to meet their energy needs [6]. This reduces reliance on fossil fuels and helps combat climate change [7]. Although the initial investment in constructing a Net Zero Energy building may be higher, the long-term benefits outweigh the costs [8]

Secondly, NZE buildings prioritize energy efficiency through advanced insulation, high-performance windows, and efficient appliances [9]. These measures optimize energy consumption and reduce overall energy demand, resulting in lower energy costs for residents [10].

Thirdly, NZE buildings promote a healthy and comfortable living environment [11]. They prioritize natural lighting, proper ventilation, and indoor air quality control. Additionally, they often incorporate green spaces, such as rooftop gardens or vertical gardens, which enhance biodiversity and provide residents with access to nature [2]. Based on stochastic renewable energy integrated sources, optimal energy management of the energy hub is conducted [12]. Consequently, to the previous study, nature-inspired metaheuristic algorithms were conducted in the state-of-the-art to minimize the total cost of the energy hub and reduce pollutant emission, and fuel consumption. The eco house systems aim to achieve NZE through some technologies and strategies as discussed in the literature such as RES, energy efficiency appliances, sustainable building materials, energy monitoring, and others.

NZEB evaluation's main goal is to measure NZEB's effects on the environment and energy [2]. The main contribution of this study is to achieve an eco-house system depending of renewable sources to run home appliances. The remaining sections in the article are classified into 5 Sections. Section II discusses the methods and materials. Section III tabulated the benefits of NZE. Section IV listed the essential challenges of NZE. the NZE challenges are placed. The summary discussion is positioned in Section V. Eventually, the conclusion and references close the article.

Method and materials

During a specified time frame, usually a year, net-zero-energy buildings are made to create as much energy as they need.. By leveraging advanced technologies, energy-efficient design principles, and renewable energy sources as shown in Figure 1, these buildings minimize their carbon footprint and reduce reliance on fossil fuels [13]. Their methods include optimizing insulation, using energy-efficient lighting and ventilation, and generating clean energy on-site through the use of renewable energy systems like solar, wind, or geothermal energy [14]. Figure 2 demonstrates the General concept of Net Zero Emission that allows achieving NZEB [2].

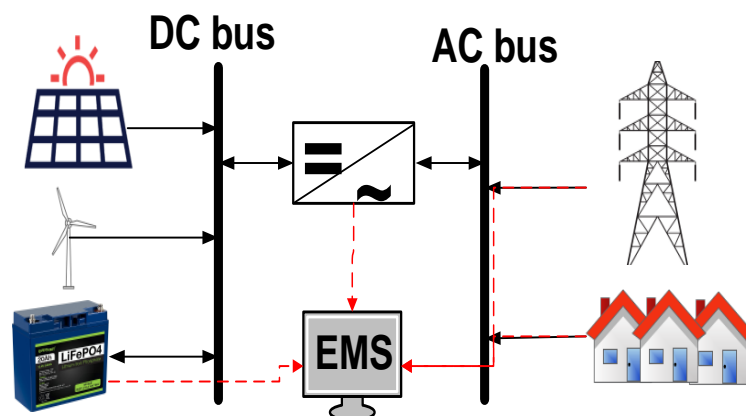


Figure 1:Proposed system

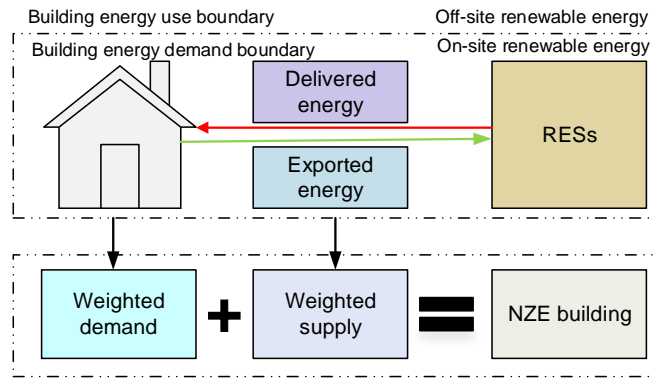


Figure 2: General concept of Net Zero Emission.

Based on the International Energy Agency (IEA), various scenarios were presented in the literature as illustrated in Figure 3. Furthermore, integrating various renewable energy sources could help the NZEB technique which allows for achieving economic residential system that indicates as (an ECO house).

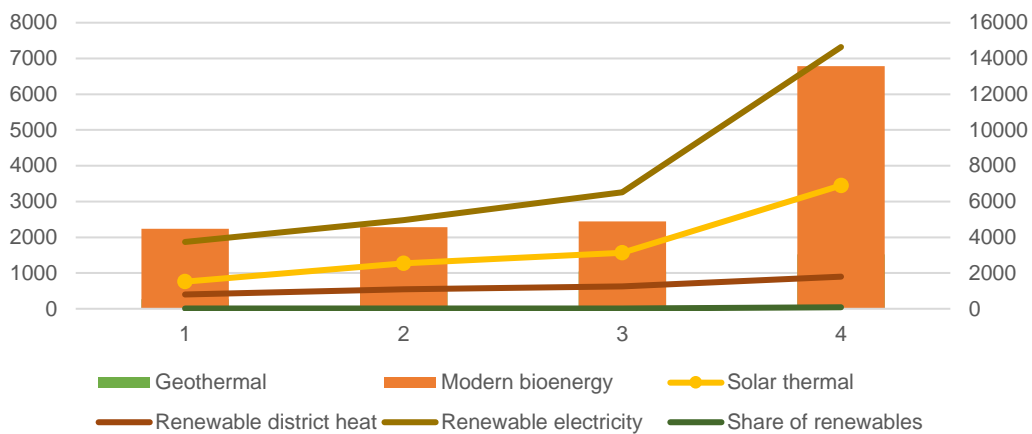


Figure 3: Modern renewable energy use for buildings-related heating by source, and share of total heat consumption in buildings, in the Net Zero Scenario, 2011-2030 [15].

Globally, several countries implies the NZEB in order to minimize the use of energy operation in the period of 2000-2022 as demonstrated in Figure 3. Eco houses are designed to have as little of an impact on the environment as possible, save homeowners money on energy, and produce more sustainable and healthy living environments. Reducing energy use, protecting natural resources, and fostering a healthy living environment are the main objectives of an eco-house.

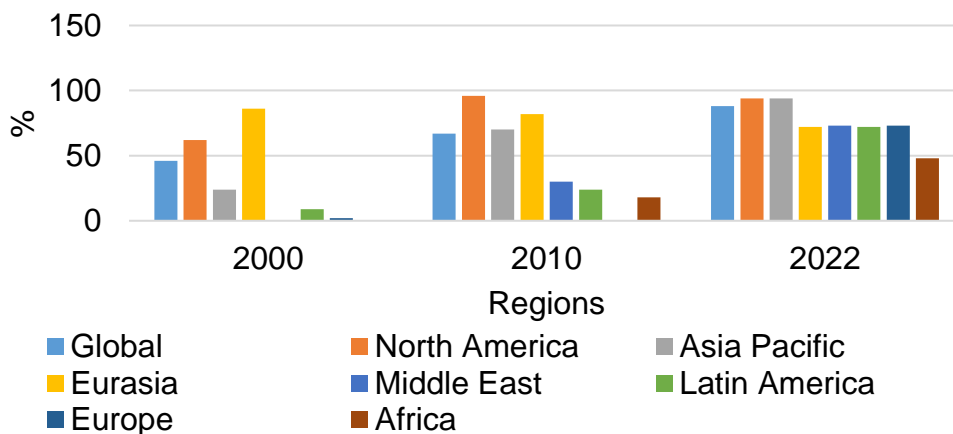


Figure 4: Residential space cooling consumption covered by minimum energy performance standards by region, 2000-2022 [16].

In the net zero scenario, Figure 4 displays the clean energy investment by sector in emerging markets and developing economies.

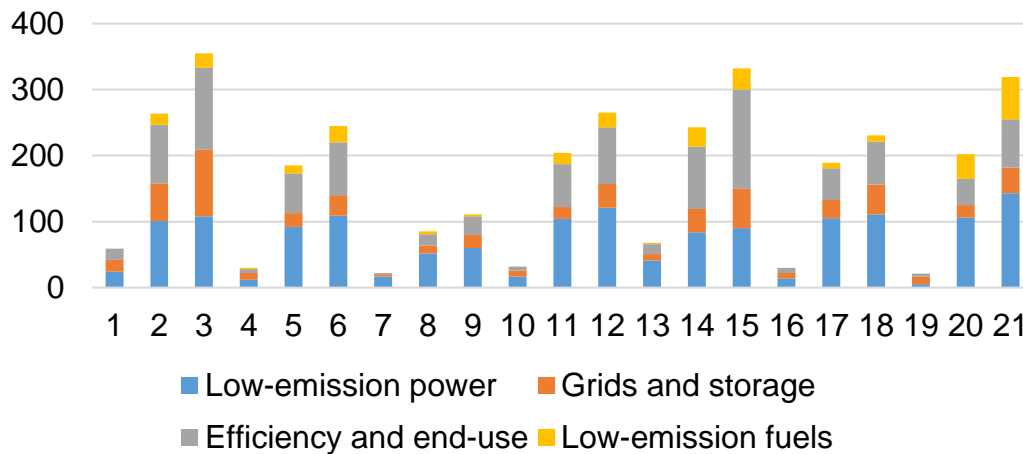


Figure 5: Clean energy investment by sector in emerging markets.

In the microgrid operation systems in the NZEB is considered. A construction form intended to reduce its environmental impact and promote sustainability is called an eco-house, sometimes referred to as a green house or eco-friendly house. Reducing energy use, preserving resources, and fostering a healthy atmosphere are the main objectives of an eco-house.



Figure 6: ECO house

According to some key features associated with an eco-house achieving energy efficiency by designing a system could reduce the amount of energy needed for heating, cooling, and lighting. Additionally, integrating renewable energy sources to reduce the dependency on fossil fuels.

Challenges and the Path Forward

While Net Zero Energy buildings offer tremendous potential, several challenges need to be addressed for widespread adoption [17].

1. High upfront costs.
2. Limited availability of skilled professionals and technologies.
3. Governments, industry leaders, and researchers must collaborate to overcome these obstacles by providing financial incentives, promoting research and development, and establishing favorable regulations and standards.

Key Benefits of Net Zero Energy Buildings

The main key advantages of considering NZEB in our daily life are tabulated in Table I. Additionally, to the aforementioned advantages of NZEB, renewables energy supply by technology in the net zero scenario in the period of 2010-2030 and illustrated in Figure 7.

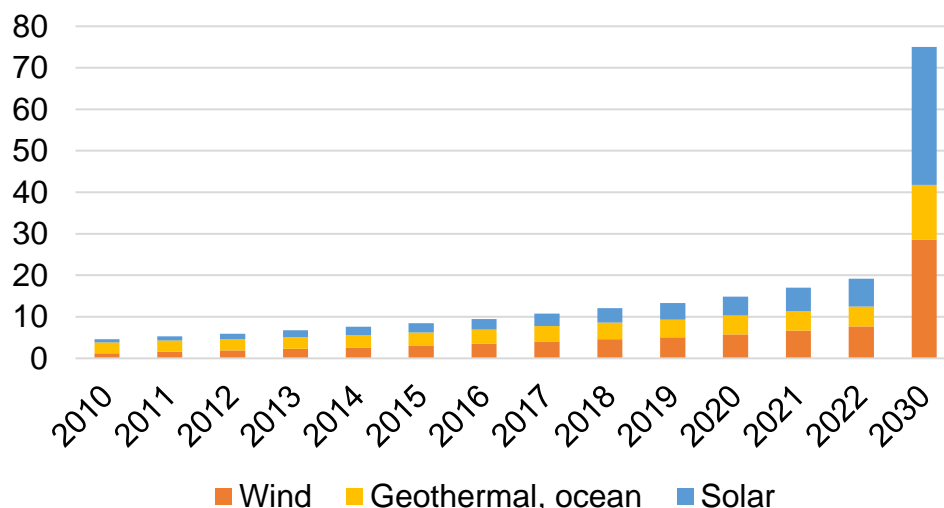


Figure 7: Renewables energy supply by technology in the net zero scenario.

Table 1: Key benefits of net zero energy buildings [5], [18].

Key Benefits of NZEB	Feature
Environmental Preservation	<ul style="list-style-type: none"> • NZEB significantly reduce GHG emissions • Help combat climate change and air pollution relying on RESs • Minimize the reliance on fossil fuels as the major contributors to CO₂ emissions and depletion of natural resources.
Energy Independence	<ul style="list-style-type: none"> • Lower the reliance on external energy sources, • Provide greater energy security and resilience. generating their own energy • They are less vulnerable to fluctuations in energy prices and grid failures, ensuring a reliable and stable energy supply.
Cost Savings	<ul style="list-style-type: none"> • These buildings have lower energy bills due to reduced energy consumption and the ability to sell excess energy back to the grid. • Over time, the savings in energy costs can offset the initial investment.
Health and Well-being	<ul style="list-style-type: none"> • NZEB prioritize occupant comfort and well-being. • Reducing the risk of respiratory problems and allergies. • Promotes a healthier and more productive indoor environment by enhancing indoor air quality
Leadership in Sustainable Development	<ul style="list-style-type: none"> • NZEB serve as beacons of sustainability • Inspiring others and demonstrating the feasibility and effectiveness of sustainable construction practices. • Contribute to the achievement of global sustainable development goals.

Results and Discussion

Based on the proposed diagram in Fig 1, the output power from the renewables has been illustrated in Fig 8 (a and b), respectively. As presented, the produced peak power is almost 6 kW in the utilized sources.

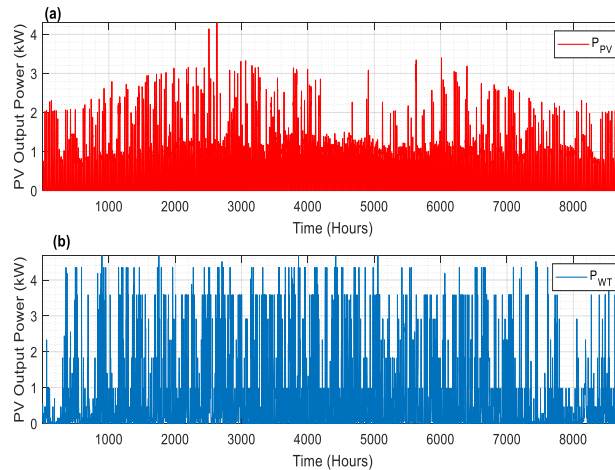


Figure 8: Output power from integrated renewable sources.

In terms of energy comparison, the comparison of the energy in order to meet the main objective of this study which is meeting Net Zero Energy Buildings by showing the first 700 hours (a month). Figure 9 presented the lower energy consumption along with higher energy generators in terms of kWh. Besides, the cumulative of the NZEB balance is shown decreases.

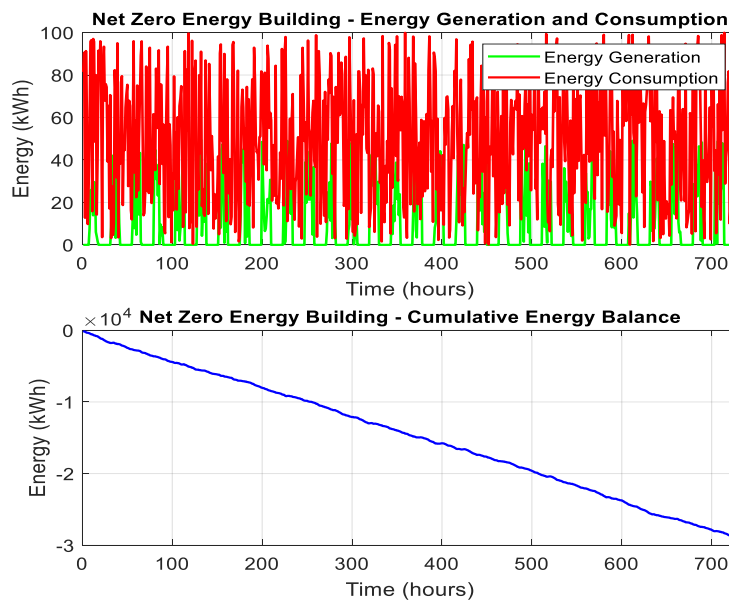


Figure 9: Breakdown of Energy generator and consumption.

Conclusion

Net Zero Energy buildings represent an indispensable component of sustainable development and a crucial step towards mitigating climate change. By harnessing renewable energy, maximizing energy efficiency, and reducing environmental impact, these buildings offer a path to a greener and more resilient future. As the world comes together to combat climate change, embracing Net Zero Energy buildings is a vital strategy in creating a sustainable environment for generations to come.

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