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Sustainable Residential Towers with a Coexistence Approach to Solar Energy and Green Design

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ABSTRACT

This research examines sustainable residential towers through a coexistence approach to solar energy and green design. Given the environmental challenges and the growing need for sustainable living spaces in large cities, this study analyzes case studies of residential towers that utilize solar energy technologies and green design principles. The research methodology involves a case study approach that includes the evaluation of design, energy efficiency, environmental impacts, and the quality of life of the residents of these towers. In this context, several successful projects from different countries were selected and their characteristics analyzed. The results indicate that the integration of solar energy with green design not only helps reduce energy consumption and operational costs but also enhances the quality of life for residents and creates sustainable social spaces. Furthermore, this research identifies the challenges and opportunities related to the implementation of such designs and offers recommendations for developing effective policies and strategies aimed at promoting sustainable construction.

1. Introduction

Recently, many rerearches have been attempting to provide a sustainable society in various fields, such as society, economy, and the environment. As sustainability is emphasized, architecture that is publicly and socially responsible has been gaining much interest. In turn, this has caused the role of public architecture to be greater than ever, due to its existence being tied to the public [1]. This is because sustainability is linked to public values. Therefore, research into sustainable public space can be an important way to secure the sustainability of the cities [2], For a city to endure, it is most important to meet geographical and environmental conditions, as the sustainability of contemporary cities has gained emphasis, interest in architecture has increased, due to its social and public responsibility. Since sustainability is linked to public values, research on sustainable high towrs is an important way to secure sustainability in cities.

The trend in urban design has shifted towards verticality, which serves as the first solution to address the mentioned issues, particularly in response to the massive influx of population caused by various factors, including migration to metropolitan areas [3]. High-rise construction, apart from its responsive viewpoint on housing solutions, can also serve as a city landmark and a symbol for representing the city from an urban perspective. It can contribute to the identity of a small area of the city, which itself has specific design principles and different construction technologies. However, adhering to these principles can still result in problems throughout its lifespan, with the most significant issue being the distancing of humans from nature and the separation established between the two. On the other hand, the need for energy resources has become an integral part of modern life, which, due to the limited availability of fossil fuels and the resulting pollution, drives humans towards the use of renewable and clean energy sources [4].

The design of sustainable residential towers has become one of the fundamental challenges for architects and urban planners. In this regard, utilizing renewable energy, especially solar energy, along with green design approaches can help improve the quality of life for residents and reduce negative environmental impacts [5]. Solar energy, as a clean and inexhaustible resource, has the potential to meet part of the energy needs of buildings. Alongside this, green design, with an emphasis on the optimal use of natural resources, water management, and the creation of green spaces, can assist in achieving sustainability goals. This paper examines the coexistence strategies between solar energy and green design in residential towers and, by reviewing successful domestic and foreign projects, aims to provide effective patterns for the development of sustainable residential towers that not only enhance energy efficiency but also improve the quality of life for residents. Ultimately, this research can serve as a guide for architects, engineers, and policymakers in designing sustainable and smart residential complexes.

2. Research Methodology

This study is designed as a case study. In this method, several sustainable residential towers that utilize solar energy technologies and green design are selected and analyzed. Various methods such as direct observation and project documentation reviews are used for data collection. The results obtained from these analyses will contribute to identifying the features, strengths, and weaknesses of existing designs and will provide a foundation for offering suggestions for improving sustainable construction methods.

3. Theoretical Foundations

- **Principles of Green Design in Buildings**

Green design refers to a set of principles and methods aimed at reducing negative environmental impacts and improving the quality of life for building occupants. This design focuses on the optimal use of natural resources, ensuring that spaces are designed to maximize the use of natural light and ventilation. This not only reduces the need for artificial lighting and mechanical ventilation systems [6] but also helps save energy. The selection of sustainable materials is another key principle of green design. Utilizing recycled and renewable materials with minimal environmental impact, along

with choosing durable materials, can help reduce environmental effects. Furthermore, water management is particularly important; designing rainwater collection systems and reusing greywater, along with using water-saving fixtures, can contribute to water resource preservation. The use of renewable energy sources, such as solar panels and wind systems, is also vital in green design, as these systems can supply the energy needs of buildings and reduce energy demand [7]. Additionally, designing to minimize waste production and properly managing it helps reduce greenhouse gas emissions and negative environmental impacts.

Creating green spaces, such as gardens and yards, not only improves air quality but also enhances biodiversity. In this regard, the use of native plants requiring less maintenance is recommended. Moreover, the design should ensure comfort, health, and well-being for residents, while fostering social spaces and human interactions [8]. Considering the opinions and needs of the local community can lead to the creation of spaces that facilitate social interactions. Furthermore, designing effective waste management systems for waste segregation and encouraging recycling and reuse of materials is also considered a principle of green design. Finally, attention to economic sustainability, taking into account the long-term maintenance and operational costs of the building, not only reduces construction expenses but also helps increase property value and attract sustainable investments. By adhering to these principles, architects and designers can create buildings that are efficient, sustainable, and enhance the quality of life for residents [9-10].

- **Coexistence of Solar Energy and Green Design**

Coexistence in building design refers to creating spaces that meet human needs while being in harmony with the environment and other living beings [11]. This approach seeks to establish a balance between human activities and nature, and it can manifest in various ways in building and urban space design. In this context, the sustainable use of natural resources is particularly important. Buildings should be designed to harness natural light, natural ventilation, and rainwater to reduce the need for energy and other resources [12]. Moreover, protecting habitats during the design and construction of buildings must be taken into consideration.

Integrating green spaces into building design, such as green roofs, green walls, and planted courtyards, can improve air quality, reduce temperatures, and create a healthier environment for residents. These spaces can also serve as places for social interaction. Selecting sustainable materials is another important aspect of coexistence design; materials with minimal environmental impact, including recycled and renewable materials, should be chosen for their longevity and lower maintenance needs. Water management is also a crucial element of coexistence in design. Designing effective water management systems, such as rainwater harvesting and greywater reuse, can help conserve water resources and reduce negative environmental impacts [13-14].

Additionally, engaging with the community and involving residents in the design process can lead to the creation of spaces that facilitate social interactions and foster a sense of belonging and responsibility among residents. Buildings should also be resilient to climate change, which includes using modern technologies to reduce energy consumption and increase building efficiency. Finally, promoting a culture of coexistence through educating residents about the importance of environmental protection and sustainable resource usage is highly significant. This can include educational programs, workshops, and social activities. By adhering to these principles in building design, it is possible to create spaces that not only meet human needs but also harmonize with nature and contribute to environmental sustainability.

Table 1: Characteristics of Sustainable Residential Towers

Eco-Friendly Materials	The increasing production of waste, coupled with the very slow growth of recycling systems, poses significant environmental threats and challenges to the ecological system of the country. Construction waste is one of the major types of waste in Iran, ranking second after municipal waste. In Tehran, the production of construction waste is five times that of municipal waste, with 40,000 tons of construction debris generated daily; meanwhile, the ratio of construction waste to total waste in the United States is around 30% [15].

	This situation arises from the high volume of demolitions and renovations occurring in the city. The disposal and improper accumulation of these wastes have caused many problems in urban areas. These issues push us toward the production and use of products that are less harmful to the environment. Eco-friendly materials are those that are produced from less hazardous substances, utilize fewer natural resources, possess green environmental characteristics, and have greater recycling potential compared to other materials.
Water and Wastewater Management Systems	Water resource management involves planning, developing, distributing, and efficiently managing water resources. It is a subset of integrated water cycle management. With the increasing uncertainties of global climate change and the long-term effects of management actions, decision-making will become more challenging. Continuous climate changes may lead to situations we have not encountered before [16]. As a result, alternative management strategies should be pursued to prevent barriers and problems in the allocation of water resources.
Design of Green Spaces and Its Impact on Quality of Life	Green spaces in buildings can have positive effects on the mental and physical health of residents. Studies have shown that being in green environments can reduce stress and promote mental calmness. Especially in urban areas where individuals face congestion and air pollution, access to green space in residential towers can have positive impacts on public health [17].

- **Solar Energy and Its Application in Residential Towers**

Solar energy, as a renewable and sustainable resource, is increasingly being utilized in residential buildings, offering numerous benefits. One of its primary applications is electricity generation through solar panel systems, which convert sunlight into electricity, enabling the provision of clean energy and reducing electricity costs. Additionally, solar water heating systems can supply hot water needed for household uses such as showers, laundry, and space heating [18]. Alongside these applications, the use of solar energy in air conditioning systems is also expanding; some of these systems can operate using solar energy, thus reducing energy consumption. The combination of solar energy with smart technologies can help optimize energy consumption [19]. For instance, energy management systems can schedule the use of solar energy to minimize costs and ensure efficient consumption.

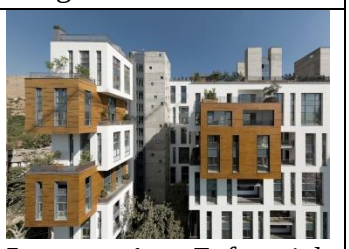
Moreover, utilizing solar energy in residential towers contributes to reducing greenhouse gas emissions and negative environmental impacts. Towers equipped with solar energy systems typically have higher value and are considered more attractive to buyers [20-21]. Overall, the use of solar energy in residential towers not only helps reduce costs but also contributes to environmental preservation and enhances the quality of life for residents. With advancements in technology and decreasing costs, the applications of solar energy in buildings are expected to increase in the future.

Table 2: Solar Energy and Its Application in Towers

Various Solar Energy Collection Technologies (Solar Panels, Thermal Systems)
How to Integrate Solar Energy Systems with Building Design
Benefits and Challenges of Using Solar Energy in Residential Towers

- **Case Study Review**

Table 3: Examination of several successful projects of sustainable residential towers with a coexistence approach to solar energy.

Project Name	Approach	Project Features	Images
Zafaranieh Garden Residential Complex	Utilizing Combined Renewable Solar Energy	Avoiding tree removal within the footprint area (30% of land area over 60%) was considered the primary factor in the mass loading design of the Zafaranieh Garden Residential Complex. Consequently, the total built area was organized into two separate building blocks, which are connected in some parts underground. The concept of the Plant Box was highlighted as a symbol of the interaction between urban humans and nature in organizing the volume.	 **Image 1:** Zafaranieh Residential Complex, Tehran
Hermes Garden Tower	Green Architecture	The design of the Hermes Garden Tower structure was carried out based on American design standards, as well as the national building and housing regulations of Iran, using bolted connections. The design of the tower was fully aligned with the architectural plan, incorporating innovations and initiatives in various structural sections, including subsurface exploration using ground-penetrating radar (GPR), the use of high cantilevers, 12-meter spans, and high floor heights. All these features led to the selection of the Hermes Garden Tower as the country's top metal structure in 2015.	 **Image 2:** Hermes Tower, Tehran
Bosco Verticale—Vertical Forest, Milan	Sustainable Architecture	Designed by Italian architect Stefano Boeri, Bosco Verticale represents a significant step towards sustainable architecture. This vertical forest tower was built over 5 years and is among the most famous vertical gardens globally. Bosco Verticale, meaning "Vertical Forest," consists of two green towers with 113 apartment units, each enjoying expansive views of the city.	 **Image 3:** Bosco Verticale, Milan, Italy

One Central Park, Sydney, Australia	Green Architecture	This vertical garden is covered with vegetation that includes 250 species of Australian plants and flowers. The facade of this beautiful tower is enhanced by the shade of these plants, enveloping its luxurious penthouse. It is reported that the building's energy consumption is 25% less compared to conventional buildings of similar size.	 **Image 4:** One Central Park, Sydney, Australia.
Domus Vista, Skyscraper in Frederiksberg, Denmark	Solar Energy	This project has significantly reduced energy and water consumption by using solar panels and rainwater harvesting systems. Residents of this tower have benefited from abundant recreational facilities and green spaces, which have enhanced social interactions.	 **Image 5:** Domus Vista, Denmark

What has been less emphasized in the planning and design of these towers is adherence to the principles and standards related to environmental quality and the needs of individuals. This has led to the creation of cold, lifeless masses that lack the necessary conditions to foster a sustainable connection with residents, resulting in alienation, a decreased sense of belonging, and reduced social interactions in their living environment .

The main goal of socially sustainable development is to ensure that future generations have equal or greater access to social resources compared to the current generation. Additionally, addressing needs, improving quality of life, and utilizing all capacities to enhance practical design solutions for achieving social sustainability and, consequently, inclusive social development, are vital. This includes creating identity-driven structures to foster a sense of belonging, building a harmonious environment, providing flexible spaces, and improving and protecting the environmental infrastructure. All of these aims are considered other objectives of social sustainable development. Therefore, in the designs of such buildings, regulations must be established to ensure that these standards and constructions can provide sufficient access to open space, natural light, and air for residents, while enhancing public and shared spaces in residential environments. This is regarded as a crucial priority for presenting a new model of tower construction based on social sustainable development.

- **The Future of Sustainable Residential Towers**

The construction industry has one of the most negative and destructive effects on the environment due to its great development, which has led the countries of the world to seek to solve this issue and the problems that arise from it. One of the solutions to solve this The crisis is the use of new technologies in the construction industry. Technologies that in all stages of construction supervise the work of the designer, structural engineer, accountant, project manager, etc. and cause the best progress of the project in all stages of construction. Technologies, etc. and cause the best progress of the project in all stages of construction. One of these new technologies in order to achieve these goals of sustainable design is advanced building information modeling technology. This construction technology is able to Multidimensional modeling of all building information, accurately perform the initial design of the building and properly consider the process of changes in documents during the construction project.

Emerging technologies have become an integral part of the concept and identity of contemporary architecture in Iran and around the world. Architectural algorithms, as a practical tool, have influenced modern designs and led to the creation of products that blend the forms of traditional and modern cities.

4. Conclusion

This article examined sustainable residential towers through the lens of the coexistence of solar energy and green design. By analyzing several case studies of garden residential towers, we were able to achieve significant results regarding the integration of renewable energy technologies and sustainable environmental design. The results showed that using solar energy as the primary energy source in these towers not only helps reduce energy costs but also minimizes negative environmental impacts. In particular, in the case studies reviewed, it was observed that green design and the presence of green spaces, both interior and exterior, have contributed to improving residents' quality of life and increasing their satisfaction.

Furthermore, the appropriate coexistence between natural and artificial elements in these towers has led to the creation of sustainable ecosystems and increased biodiversity in urban areas. Given the obtained results, it can be said that the design of garden towers as an innovative solution offers the possibility of creating healthier and more sustainable living spaces. Therefore, sustainable residential towers that incorporate solar energy and green design are not only an effective solution for reducing negative environmental impacts, but also contribute to the establishment of healthier and more sustainable communities.

In light of global challenges such as climate change, urban population growth, and the need for sustainable energy resources, these kinds of designs can play a key role in shaping the future of cities. Ultimately, this research demonstrated that to achieve sustainable development goals in urban areas, it is necessary for designers and urban planners to seriously consider the integration of green technologies and sustainable designs. It is suggested that future research also examine the social and economic impacts of such designs in order to gain a more comprehensive understanding of their benefits and challenges. Future studies should delve deeper into various aspects of these projects to help develop more effective strategies for achieving sustainable development goals. Given the ongoing trend of urbanization and the need for sustainable living spaces, it is time for designers, architects, and urban planners to collaborate to build a greener and more sustainable future for generations to come.

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