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Impact of HVAC Systems Integration on Aesthetic of Public Buildings in Brunei Darussalam

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ABSTRACT

In the context of architectural and urban design, the aesthetic of a building is a relative and dynamic concept that involves different aspects including building façade style, form, color, texture, and overall artistic expression. However, this evolution can be influenced by various factors such as cultural shifts, technological advancements, materials available, and changing tastes and trends in architecture. Traditionally, building facades in Brunei have prioritized uniformity, symmetry, and cultural ornamentation. Contemporary challenges such as climate change necessitate a re-evaluation of these aesthetic principles. The integration of HVAC systems into public buildings presents unique challenges and opportunities for other architectural aesthetic ways. Modern architectural practices now emphasize ecological and interactive facades that enhance building aesthetics while addressing environmental conditions. This study examines how integrating HVAC systems affects both the aesthetics and functionality of public buildings in Brunei, and explores solutions, including exterior decorative HVAC system models, that balance visual appeal with practical functionality. The findings aim to support the aesthetic goals of modern architecture and align with broader efforts to create sustainable and resilient urban environments in Brunei Darussalam.

1. Introduction

In architectural and urban design, a building's aesthetic is a relative and dynamic concept that comprises various elements such as façade style, form, color, texture, and overall artistic expression. This concept is influenced by factors like cultural shifts, technological advancements, available materials, and changes in architectural tastes and trends. This paper focuses specifically on one aspect of façade style, examining the impact of HVAC systems integration on the aesthetics of public buildings in Brunei Darussalam. Traditionally, building facades often prioritize uniformity, symmetry, and cultural ornamentation [1], and have been regarded as a critical element in architectural design, serving as a symbol of aesthetic expression and cultural identity [2]. However, as we navigate in a world increasingly impacted by climatic change and environmental concerns, specifically in Brunei,

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the aesthetic of old public buildings has been affected by mechanical appliances (HVAC systems) that are installed onto facades randomly.

In addition, the installation of these mechanical appliances on these old public buildings' facades has significantly affected both the aesthetics and functionality of these buildings where it become crucial for most of the buildings to balance the visual appeal with the practical necessities of mechanical systems such as HVAC systems. However, while Architects nowadays shift their focus towards ecological interactive and innovative ideas, facades not only enhance the aesthetics of a building but also respond and adapt to the changing environmental conditions [3].

Due to global warming and environmental changes, Brunei Darussalam is becoming hotter day by day, leading to the continuous use of HVAC systems, especially in public buildings to maintain a conducive interior environment. This has become a big challenge to the façades of old public buildings which are iconic landmarks in the city but their façades are sculptured with HVAC systems [4]. This research paper is here to elaborate on this issue and propose different approaches that will help to maintain the aesthetics of the buildings and the urban realm at large.

Maintaining the aesthetic of public buildings and the urban design environment of the city requires innovative design techniques that incorporate mechanical elements as integral parts of the architecture. This includes considering the external elements to cover the in-use HVAC system [4]. With the help of these innovative architectural elements and ideas, spoiled and ugly facades affected by these systems will be improved to support the aesthetic goals of modern architecture at the same time, reveal potential ways to align with broader efforts to create sustainable and resilient urban environments in Brunei Darussalam.

1.1 Brief of Study

1.1.1 Historical perspective on facades

Historically, facades have been designed with an emphasis on aesthetics, symbolizing the architectural style and cultural significance of an era [2]. Examples include the intricate carvings of Gothic cathedrals or the sleek lines of Modernist buildings. These facades were often static, focusing primarily on visual appeal. [1]. Therefore, the principles of facade beauty have evolved significantly since the Gothic era, reflecting broader changes in architectural theory, technology, and cultural values [2]. From the verticality and ornamentation of Gothic cathedrals to the sleek minimalism of modernist buildings and the innovative, sustainable facades of contemporary architecture, the facade remains a crucial element in defining a building's aesthetic and functional identity [2].

1.1.2 Industrial revolution

1.1.2.1 Materials

However, the Industrial Revolution introduced new building materials such as iron, steel, and glass, which revolutionized architectural design [5]. These materials allowed for the construction of larger, more robust structures with expansive interior spaces that were previously unattainable with traditional masonry techniques. The Crystal Palace, designed by Joseph Paxton for the Great Exhibition of 1851 exemplifies this shift. The era saw the rise of functionalism, where the design of a building was driven primarily by its intended function rather than aesthetic considerations alone [5]. This philosophy was championed by architects like Louis Sullivan, who coined the phrase "form follows function." Industrial buildings such as factories, warehouses, and train stations were designed for efficiency and utility, emphasizing straightforward forms and minimal ornamentation. This shift

towards functionalism also influenced residential architecture, leading to the design of more practical living spaces that prioritized functionality over decorative elements [6].

1.1.2.2 Urbanization

In addition, the rapid urbanization during the Industrial Revolution necessitated new approaches to housing and urban planning. The need to accommodate large numbers of factory workers led to the development of tenements and row houses, which prioritized function and density over aesthetics. These housing units were often austere and utilitarian, reflecting the industrial ethos of efficiency and mass production [3].

1.1.2.3 Climatic change

On the other hand, climate change has also significantly impacted architectural design, pushing architects to reconsider the aesthetics and functionality of buildings. The need to adapt to new environmental conditions has driven innovations in building materials, design strategies, and the integration of mechanical/HVAC systems to ensure comfort and sustainability.

1.2 Problem Statement
1.2.1 Problem

The integration of mechanical appliances into architectural designs, such as HVAC systems, solar panels, and shading devices, profoundly impacts both the aesthetic and functional aspects of buildings. As contemporary architecture progresses, achieving a balance between visual appeal and the practical needs of these mechanical systems becomes increasingly vital. Most architectural spaces have become dormant, and the sound from these appliances is not pleasant to space attendants. Figure 1 illustrates how building facades are being spoiled by the installation of HVAC systems. Therefore, there is a need for architects to rethink how these appliances/systems be incorporated into the design or provide exterior decorative HVAC system models for facades that enhance the overall aesthetics of buildings and also adapt to changing environmental conditions.

Fig. 1. Image that shows how building facades are being spoiled by HVAC systems installation

Despite the importance of integrating mechanical systems in maintaining indoor comfort and ventilation control, their installation often poses aesthetic challenges. The traditional methods of concealing these systems within the structure are relatively expensive and hard to maintain. This pressured residents to replace this method with a cheaper alternative that involves placing HVAC units on the façade, which significantly challenges the building's aesthetic and overall urban appeal.

Overcoming this challenge requires innovative design techniques and ideas that celebrate them as core parts of the architecture, ensuring that their functionality does not compromise visual appeal.

1.2.2 Proposed solutions

1.2.2.1 Exterior decorative HVAC system models

Considering the functionality of the space, Exterior decorative HVAC system models serve multiple functions, primarily focusing on enhancing the building's aesthetic while maintaining or improving its functional capabilities [7]. These systems can be designed to blend with or complement the building's architectural style, transforming what might otherwise be an eyesore into a visually appealing element [2], as shown in Figure 2. Decorative HVAC models also incorporate features to dampen sound, reducing noise and improving the acoustic environment both inside and outside the building.

From a functional standpoint, exterior decorative HVAC systems are strategically placed to optimize performance and efficiency, ensuring better air circulation and temperature control. Their exterior placement facilitates easier maintenance and repairs, minimizing disruptions to interior spaces. These systems are built to withstand various weather conditions, protecting the HVAC components and ensuring longevity. Additionally, they often include eco-friendly technologies and materials that minimize environmental impact and enhance the building's sustainability.

Fig. 2. Shows the exterior HVAC system model solution to accessible façade and how they enhance multifunction and overall building's aesthetic

These models also maximize interior space by relocating HVAC components outside, enhancing the building's overall functionality and usability. They showcase innovative technologies and designs, reflecting a commitment to modern, cutting-edge solutions, and can even serve as a branding tool, adding a unique identity to the structure. Designed to comply with local building codes and standards, decorative HVAC systems ensure regulatory compliance while improving ventilation efficiency and indoor air quality, creating healthier environments for occupants [8]. By fulfilling these functions, exterior decorative HVAC system models contribute to creating buildings that are both beautiful and highly functional.

Fig. 3. Shows the exterior HVAC system model solution to inaccessible façade and how they enhance visual appeal

The chaotic installation of outdoor units of air conditioners continued to become a real problem because no rules were established to guide residents onto the installation of outdoor AC systems hance glazing their balconies and facades in their way. To bring back the aesthetic of the building, architects have to dedicate special spaces for HVAC Systems within the architectural plans to prevent chaotic installations. These spaces can be concealed in balconies or placed within specially designed exterior modules that contribute to the building's overall aesthetic [9], as demonstrated in Figure 3 and Figure 4.

Fig. 4. Exemplifies how to re-design both walls and exterior modules to contribute to the building's overall aesthetic

1.2.2.2 Collaboration and regulations

Establishing clear guidelines and regulations for the installation of mechanical systems in buildings will prevent chaotic installations and ensure aesthetic coherence. This can be done through collaboration between architects, mechanical engineers, and designers from the early stages of a project to ensure that mechanical systems are considered integral parts of the design process. By

considering these solutions, architects can create buildings that are not only functional and comfortable but also visually appealing and harmonious with their surroundings.

1.3 Aims and Objectives

1.3.1 To evaluate the integration of mechanical appliances in building design

The primary objective of the study is to evaluate how mechanical appliances such as HVAC systems, solar panels, and smart building technologies are integrated into building design. This involves examining the methods used by architects to incorporate these systems into the aesthetics of a building without compromising its visual appeal. The study aims to identify best practices and innovative techniques that successfully merge functionality with aesthetics, thereby enhancing the overall design [10].

1.3.2 To assess the impact of mechanical appliances on building functionality and sustainability

Another key objective is to assess the impact of mechanical appliances on the functionality and sustainability of architectural spaces. This includes analyzing how these systems contribute to indoor climate control, energy efficiency, and overall building performance. The study seeks to understand the balance between maintaining aesthetic integrity and meeting the practical needs of building occupants, especially in the context of increasing energy demands, functionality of the spaces, and environmental considerations [11].

1.3.3 To explore the possible solutions to in-use HVAC systems and innovation

The study also aims to explore how the integration of mechanical appliances influences broader architectural trends and drives innovation. By examining case studies and contemporary architectural projects, the study highlights how emerging technologies and design philosophies are shaping the future of building aesthetics and functionality. This includes investigating the role of sustainable design practices, smart building technologies, and adaptive systems in creating aesthetically pleasing and highly functional spaces [12].

Considering the functionality of the space, the integration of Exterior decorative HVAC system models serves multiple functions, primarily focusing on enhancing the building's aesthetic while maintaining or improving its functional capabilities [7]. These models can be designed to blend with or complement the building's architectural style, transforming what might otherwise be an eyesore into a visually appealing element.

Therefore, the study on the aesthetic of buildings and the effect of mechanical appliances aims to provide a comprehensive understanding of how modern technologies can enhance both the beauty and functionality of architectural spaces. By focusing on the integration, impact, and influence of mechanical systems, the study seeks to contribute valuable insights to the field of architecture, promoting designs that are not only visually appealing but also efficient and sustainable.

1.4 Case Studies

Several contemporary buildings exemplify the successful integration of mechanical appliances into their design.

1.4.1 The Bosco Verticale in Milan

The Bosco Verticale in Milan, designed by Stefano Boeri Architetti, incorporates extensive greenery as a natural HVAC system.

The building's facade features a vertical forest that not only enhances its aesthetic appeal but also improves air quality and energy efficiency [20], as shown in Figure 5.

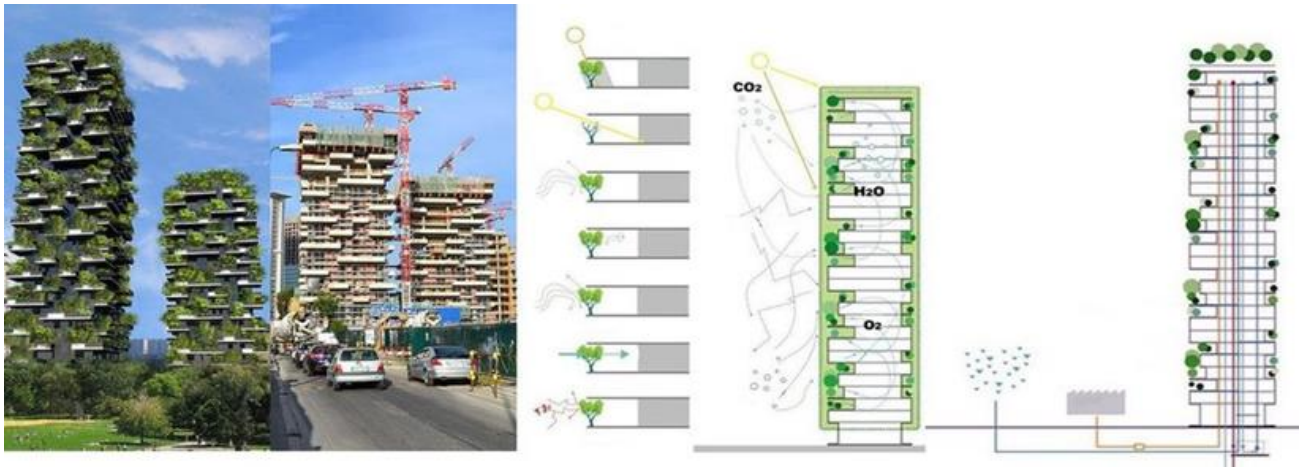


Fig. 5. Green facade that not only enhances its aesthetic appeal but also improves air quality and energy efficiency

1.4.2 The Bullitt Center in Seattle

The Bullitt Center in Seattle, designed by Miller Hull, exemplifies how solar panels and other sustainable technologies can be integrated into the design to create a building that is both functional and visually appealing [13], as shown in Figure 6.

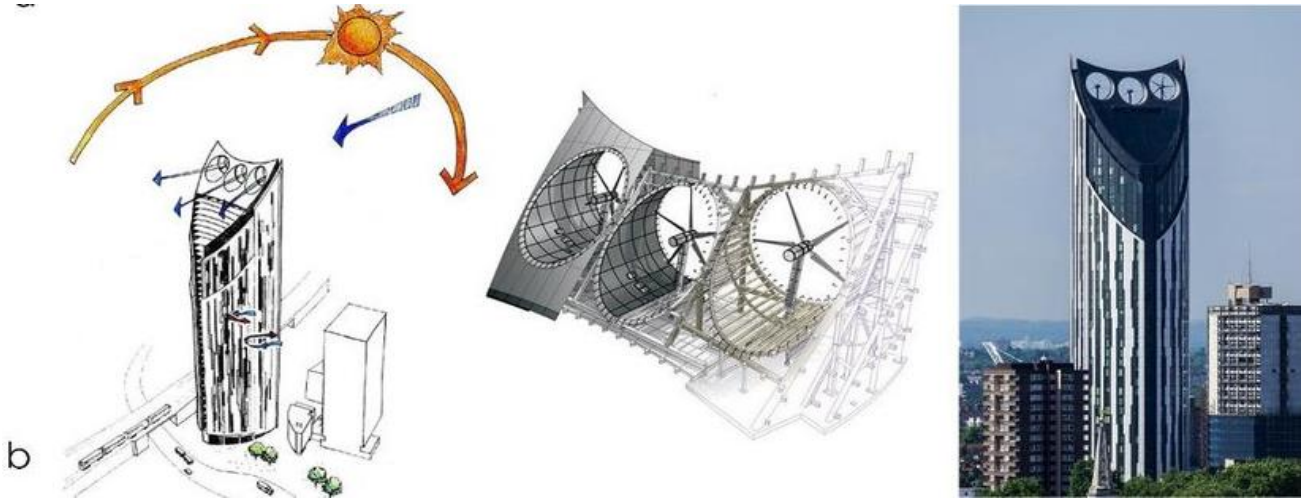


Fig. 6. Exemplifies how mechanical technologies can be integrated into the design initially to create both functional and visually appealing building

1.5 Exterior Decorative HVAC System Models

Concerning the functionality of the space, Exterior decorative HVAC system models serve multiple functions, primarily focusing on enhancing the building's aesthetic while maintaining or improving its

functional capabilities [7]. These systems can be designed to blend with or complement the building's architectural style, transforming what might otherwise be an eyesore into a visually appealing element [2], as shown in Figure 7. By integrating seamlessly into the building's exterior, they contribute to a cohesive and harmonious design. Decorative HVAC models also incorporate features to dampen sound, reducing noise and improving the acoustic environment both inside and outside the building.

Fig. 7. Shows the different examples of exterior models with different patterns

2. Methodology

The study adopts a mixed-methods approach focusing on qualitative methods to achieve its research objectives [14]. It aims to reach the integration state between modern building services and the visual characteristics of the low-rise house facade in Brunei especially in Gadong one of the business centers in the capital of the country. To achieve this, the study must acquire accurate preliminaries through a logical arrangement, to be applied through these steps in Figure 8 below:

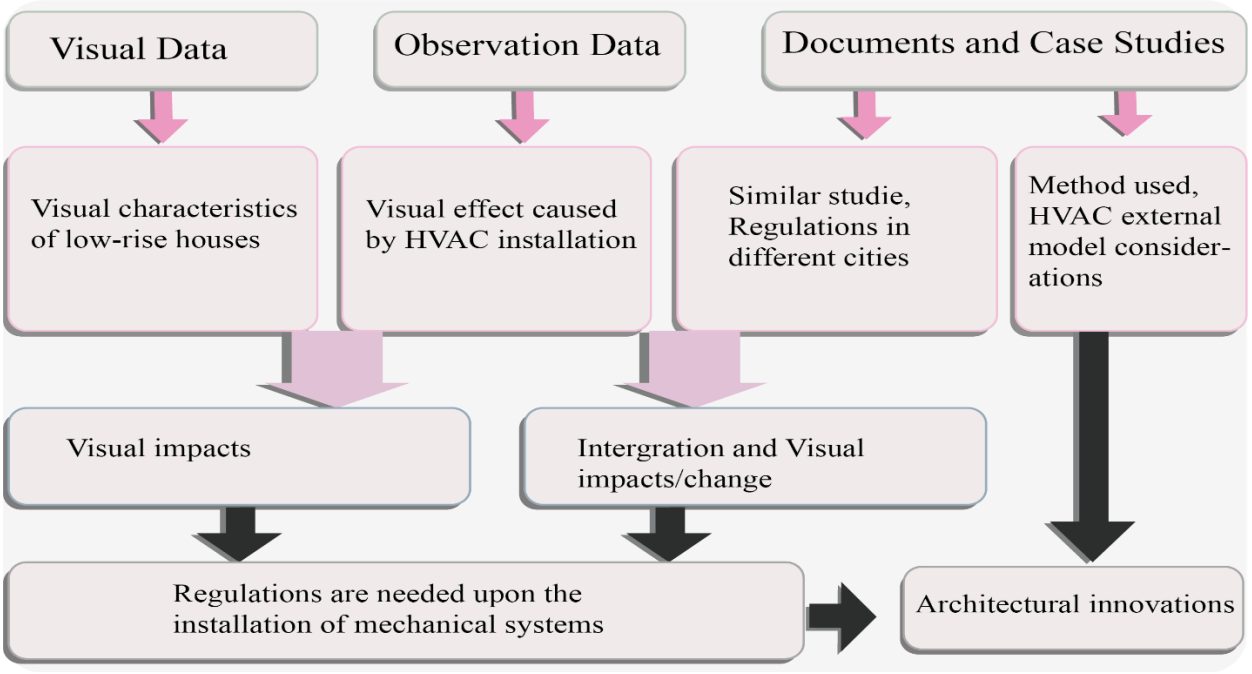


Fig. 8. Diagram showing the structure of methodology of this study

2.1 Observation Data

Due to environmental impact and Climatic change the temperature in Brunei extremely increased which made the indoor environment so difficult and uncomfortable. This increased the reliance on HVAC systems to maintain the comfortability of the indoor environment [4]. However, this reliance has in turn influenced building aesthetics due to the installation of HVAC systems onto their façade. However, with the integration of these systems into the architecture planning phase minimized their visual impact [11]. For example, hidden ductwork, underfloor heating, and cooling systems, and smart ventilation solutions are employed to maintain clean, unobtrusive interiors [10].

2.2 Visual Data

The older buildings between 20 to 30 years old, especially low-rise public houses are struggling to adapt to climate change. But with the integration of mechanical systems has helped to withstand extreme weather changes and fluctuating temperatures within the building's enhancing visual characteristics. This increases the urban heat island effect and lowers the aesthetic but helps the functional performance of buildings [15].

Figure 9 below illustrates how these older buildings, which are often considered as iconic or landmarks to the urban centers, have faced challenges to their visual appeal due to the installation of HVAC systems on their facade. With this study, these buildings' façade is deeply studied and analyzed, in an appropriate way that elaborates their visual characteristics according to the aesthetic design principles. This will be utilized later as a platform to measure the visual impact made by building services installed [4]. Through dynamic expressions, this method will help the researchers and academia understand the visual impacts of mechanical installations on the building aesthetics in Gadong Trading Center and other centers in the city.

Fig. 9. Shows how HVAC systems were irregularly installed on the building facade spoiling its visual appeal

In addition, observations in the Gadong Trading Center to investigate modern building services installations on the shophouse facade will be necessary to personalize their visual impact by comparing the visual characteristics of both the shophouse facade and modern building services installations [4].

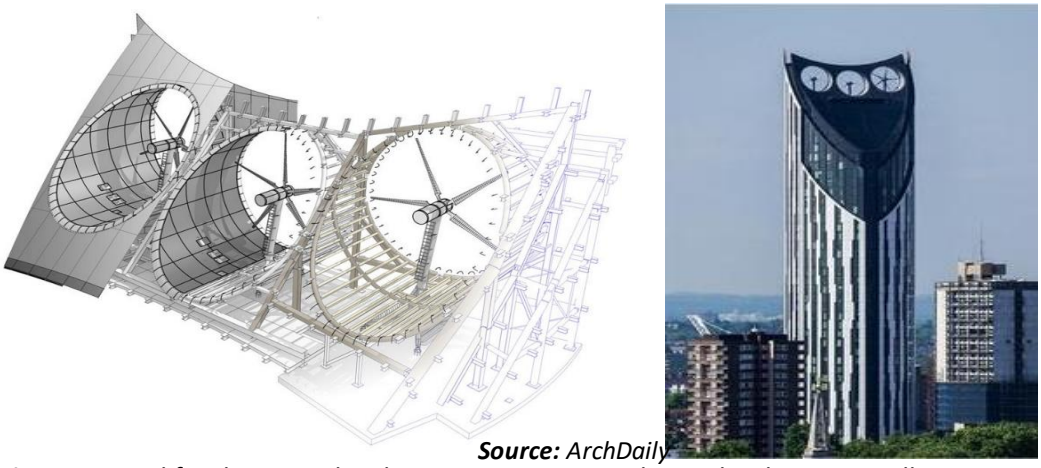
2.3 Documentation and Case Studies
2.3.1 Documentation

From the documents, that explore the integration of mechanical systems like Clement-Croome in his article “Intelligent Buildings: Design, Management, and Operation” explains that mechanical

appliances can either enhance or detract from the visual appeal of a building. However, the challenge lies in integrating these systems into the design. For instance, modern public buildings often hide mechanical systems within the structure, while older designs sometimes celebrate these elements as part of the aesthetic. The integration of mechanical systems into facades in a smart way, for example, can create a high-tech, industrial look that appeals to contemporary tastes [16] which is the different case to most low-rise public buildings which turned them into chaotic looks which led to losing the urban realm of the city.

2.3.2 Case studies

One approach to maintaining the aesthetic integrity of old buildings in our center is through innovative design techniques that incorporate mechanical elements as integral parts of the architecture. For example, the Hearst Tower in New York City, designed by Foster + Partners as shown in Figure 10 below, uses a diagrid structure that integrates mechanical systems within its aesthetic framework, creating a visually striking and functional design [17].



Source: *ArchDaily*

Fig. 2. Exemplifies how wind turbines were integrated into the design initially to create both functional and visually appealing building

The necessity to design energy-efficient and resilient buildings has transformed architectural aesthetics. This shift is driven by the growing awareness of environmental sustainability and the need to reduce energy consumption. Architects now prioritize the integration of energy-efficient systems, such as solar panels, green roofs, and advanced insulation, which influence the visual aspects of buildings. Resilient design principles, which focus on durability and adaptability to changing climates, also shape the aesthetics by encouraging the use of sustainable materials and innovative construction techniques [12]. The incorporation of renewable energy sources such as has become a common practice where these technologies are primarily functional, and contribute to the building's aesthetic through sustainability. For example, the Bullitt Center in Seattle, designed by Miller Hull, exemplifies how solar panels and wind turbines as sustainable technologies that can be integrated into the design to create a building that is both functional and visually appealing [13].

Secondly, in contrast, ecological facades prioritize the ability to respond and adapt to environmental changes. As shown in Figure 11 below, these facades incorporate features such as green walls, and living roofs to mitigate heat gain and maximize energy efficiency [18]. By integrating sustainable design principles into the facade, we can create a harmonious relationship between the building and its surrounding ecosystem. These advancements in facade design not only improve the aesthetic appeal of buildings but also contribute to reducing energy consumption and mitigating

climate change [18]. Moreover, the control of energy consumption and thermal comfort in building facades plays a crucial role in achieving these goals. Through the integration of ecosystem biomimicry and renewable energy technologies, we can reimagine building facades to be both visually appealing and environmentally sustainable [19]. For example, The Bosco Verticale in Milan, designed by Stefano Boeri Architetti, incorporates extensive greenery as a natural HVAC system. The building's facade features a vertical forest that not only enhances its aesthetic appeal but also improves air quality and energy efficiency [20].

Fig. 11. Shows how greenery was integrated into the design initially to promote visually appealing buildings enhancing sustainability

Studies like (Alderson, 2009) and (Park, 1999) focused on the importance of visual analysis, in the issue of building systems integration. Therefore, in this research, the approach of a visual analysis is adopted as a personal method of measuring the impact of new building services on the shophouse façade [4].

2.3.3 Exterior decorative HVAC system models

Considering the functionality and visual appeal of the building, Exterior decorative HVAC system models serve multiple functions, primarily focusing on enhancing the building's aesthetic while maintaining or improving its functional capabilities [7]. These systems can be designed to blend with or complement the building's architectural style, transforming what might otherwise be an eyesore into a visually appealing element" [2]. By integrating seamlessly into the building's exterior, they contribute to a cohesive and harmonious.

In addition to a functional standpoint, as shown in Figure 12, exterior decorative HVAC systems are strategically placed to optimize performance and efficiency, ensuring better air circulation and temperature control. Their exterior placement facilitates easier maintenance and repairs, minimizing disruptions to interior spaces. These systems are built to withstand various weather conditions, protecting the HVAC components and ensuring longevity. Additionally, they often include eco-friendly technologies and materials that minimize environmental impact and enhance the building's sustainability.

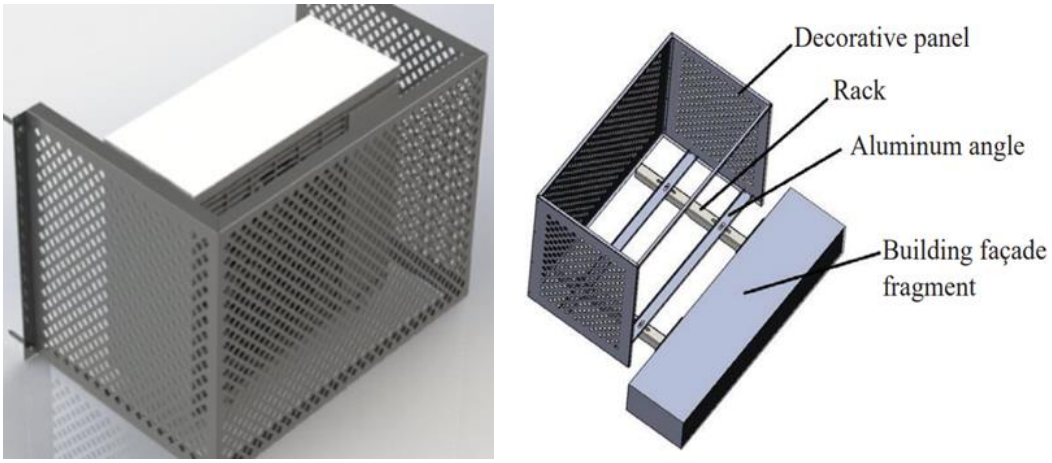


Fig. 12. Shows the design of the external HVAC system model and how to be fixed to the wall/façade

Connecting findings of all previous steps, along with the literature about the conservation guidelines of installing new systems to old buildings, to build a model of refined recommendations towards optimum integration.

3. Results

The mixed-methods approach employed in this study yields a comprehensive understanding of the integration of mechanical appliances with the visual characteristics of low-rise house facades in Brunei, particularly in Gadong. The combination of observation data, visual data, and case studies provides a nuanced view of how modern building services impact both the aesthetics and functionality of architectural spaces.

3.1 Results from Documents and Case Studies

The integration of features to withstand extreme weather events and fluctuating temperatures has significantly influenced modern architectural aesthetics. The use of reflective materials and cool roofs has been shown to mitigate the urban heat island effect, enhancing both the aesthetic and functional performance of buildings. For instance, studies have shown that cool roofs can reduce roof temperatures by up to 50°C, significantly lowering cooling energy use [15]. Green building designs, such as green roofs, living walls, and rain gardens, not only improve the thermal performance of buildings but also enhance visual appeal by incorporating natural elements into urban environments.

Ecological facades, which prioritize adaptability to environmental changes, incorporate features such as green walls, and living roofs, to mitigate heat gain and maximize energy efficiency [18]. These advancements in facade design improve both the aesthetic appeal of buildings and their environmental sustainability, demonstrating a harmonious relationship between architectural form and function [19].

For example, as shown in Figure 13 below, the Bosco Verticale in Milan, designed by Stefano Boeri, exemplifies how integrating greenery into building facades can address climate challenges while creating visually striking architecture [21]. These adaptations contribute to reducing energy consumption and improving resilience against climate-induced stressors.

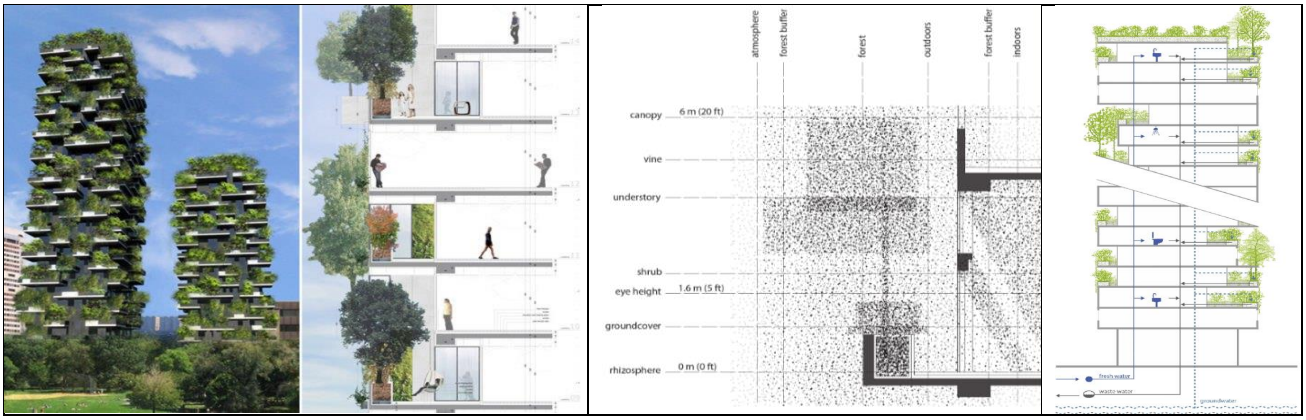


Fig. 13. The vertical forest in Milan shows that also flora can change the visual appeal of the building

Also, mechanical appliances play a crucial role in maintaining indoor environmental quality, but their integration into building design poses aesthetic challenges. Traditional methods often concealed these systems within the structure, but modern designs sometimes celebrate them as part of the building's aesthetic.

3.2 Results from Exterior Models for Mechanical Appliances

Exterior decorative HVAC system models significantly enhance the aesthetics of building facades while addressing environmental changes. These systems are designed to blend seamlessly with the architectural style of buildings, transforming potential eyesores into visually appealing elements that complement the overall design [2]. By incorporating decorative elements, as shown in Figure 14 below, the HVAC system's external models can maintain and enhance the aesthetic integrity of both old and historic buildings. This helps to ensure that the building's appearance is not compromised by unnecessary mechanical installations, contributing to a cohesive and harmonious visual appeal.

Fig. 14. Image result of before and after hiding the air conditioner in the facade

In light of environmental changes, decorative HVAC system model designs can integrate eco-friendly technologies and materials, thereby improving the building's sustainability. For example, the use of solar-powered HVAC systems, in a smart way not only improves energy efficiency but also aligns with the aesthetic values of eco-conscious architecture [11]. These technologies contribute to reducing energy consumption and greenhouse gas emissions, addressing climate change while maintaining the building's visual integrity.

Fig. 15. Image result for how the air conditioner made the facade ugly

Fig. 16. Shows the overall façade after the installation of external models

Fig. 17. Shows how the special space designed initially from the design phase enhances the overall building's aesthetics preventing AC chaotic façade

In respecting the function of the space, decorative HVAC system models can incorporate co-functional features in terms of height and human ergonomics to facilitate multifunctionality, enhancing the space's functionality. For example, as shown in Figure 15, when the system model is installed on balconies, it can serve as a laundry table in a smart way that not only improves space efficiency but also aligns with the aesthetic values of architecture. Additionally, Figure 16 illustrates the overall façade after the installation of external models, and Figure 17 shows how the special space, designed from the initial phase, enhances the building's aesthetics while preventing an AC-chaotic façade.

Fig. 18. Shows the example of HVAC systems installed on balconies that are subjected to solutions in Figure 22 and 23

Fig. 19. Explains how the external model considers both privacy and allows the efficiency of airflow for AC system

Fig. 20. Shows how with different ideas, the model can hide an air conditioner while integrated with a garden to increase aesthetics

Overall, exterior decorative HVAC system models play a crucial role in balancing the need for effective climate control with the desire for aesthetically pleasing building facades. As illustrated in Figures 18, Figure 19, and Figure 20, these systems integrate functional and decorative elements, enhancing the visual appeal of buildings while addressing the challenges posed by environmental changes. This approach not only supports the aesthetic goals of modern architecture but also aligns with broader efforts to create sustainable and resilient urban environments.

Fig. 21. Shows how with different materials external HVAC system models enhance the multifunction and aesthetic of the whole building

Fig. 22. Explains how the external model considers both patterns and allows the efficiency of airflow for AC system

Therefore, the introduction of external HVAC system models, as shown in Figure 21, along with advancements in HVAC technology and the use of new materials, as illustrated in Figure 22, will help architects to design facades that are both functional and visually striking. These changes highlight the evolving relationship between architectural design and environmental stewardship, demonstrating how multifunctional elements can enhance the overall aesthetic of buildings.

4. Conclusion

Highlights from different documents show that climate change has greatly influenced the aesthetics and functionality of buildings. This has spurred major innovations in building design, with a focus on sustainability and resilience through the adoption of sustainable design practices and the integration of advanced HVAC systems while preserving aesthetic appeal. These changes underscore the evolving relationship between architectural design and environmental stewardship in the face of a changing climate.

Also, case studies on Exterior decorative HVAC system models highlight how they strongly enhance the aesthetics of building facades while improving the urban environment. When blended seamlessly with architectural building styles, these models transform potential eyesores into visually appealing elements that complement the overall design. This integration helps maintain the aesthetic integrity of both modern and historic buildings, ensuring that mechanical installations do not compromise the building's visual appeal.

Incorporating eco-friendly technologies and materials, decorative HVAC systems models enhance building sustainability. For example, by use of local materials and Solar-powered HVAC systems, improves energy efficiency while aligning with the aesthetic values of eco-conscious architecture while preserving the building's visual integrity.

In terms of functionality, decorative HVAC system models can incorporate co-functional features, such as integrating with balconies to serve as laundry tables. This not only improves space efficiency but also aligns with architectural aesthetics, ensuring that the HVAC system does not detract from the functionality of the space.

Overall, exterior decorative HVAC system models play a crucial role in balancing effective climate control with the desire for aesthetically pleasing building facades. By integrating functional and decorative elements, these systems enhance the visual appeal of buildings while addressing environmental challenges. This approach supports the aesthetic goals of modern architecture and aligns with broader efforts to create sustainable and resilient urban environments.

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References

[1] Frampton, Kenneth. Studies in tectonic culture: the poetics of construction in nineteenth and twentieth century architecture. Mit Press, 2001.
[2] Cucuzzella, Carmela, Negarsadat Rahimi, and Aristofanis Soulikias. "The Evolution of the Architectural Façade since 1950: A Contemporary Categorization." *Architecture* 3, no. 1 (2022): 1-32. https://doi.org/10.3390/architecture3010001
[3] Hall, Peter. ""The City of Theory": from Cities of Tomorrow: An Intellectual History of Urban Planning and Design in the Twentieth Century, 4th edn (2014)." In *The City Reader*, pp. 440-453. Routledge, 2020.
[4] SABAH, OMAR ADIL. "IMPACT OF BUILDING SERVICES INTEGRATION ON HERITAGE SHOPHOUSE FACADE IN GEORGE TOWN, PENANG." (2017).
[5] Jones, Edgar. "Industrial architecture in Britain: 1750-1939." *(No Title)* (1985).
[6] Roth, Leland M. *Understanding architecture: Its elements, history, and meaning*. Routledge, 2018.
[7] Mckoy, DeQuante Rashon, Raymond Charles Tesiero, Yaa Takyiwaa Acquaah, and Balakrishna Gokaraju. "Review of HVAC systems history and future applications." *Energies* 16, no. 17 (2023): 6109. https://doi.org/10.3390/en16176109
[8] Hydes, Kevin, and Jennifer Fosket. "Sustainable Heating Ventilation and Air Conditioning." In *Sustainable Built Environments*, pp. 465-479. New York, NY: Springer US, 2020. https://doi.org/10.1007/978-1-0716-0684-1_900
[9] Archcouncil of Moscow, "Committee for Architecture and Urban Planning of Moscow 2013–2024," Archcouncil of Moscow, Moscow, 2013.
[10] Clements-Croome, Derek, ed. *Intelligent buildings: design, management and operation*. Thomas Telford, 2004.
[11] Wang, Shengwei, Chengchu Yan, and Fu Xiao. "Quantitative energy performance assessment methods for existing buildings." *Energy and buildings* 55 (2012): 873-888. https://doi.org/10.1016/j.enbuild.2012.08.037
[12] Hestnes. A. G, ""Building Integrated Photovoltaics: A Concise Description of the Current State of the Art and Possible Research Directions.," Energy and Buildings, pp. 36(5), 487-495., 2017.
[13] Miller Hull Partnership, ""The Bullitt Center: A Case Study in Energy Efficiency." Retrieved from The Bullitt Foundation," 2013.
[14] Creswell, "Research design: Qualitative, quantitative, and mixed methods approaches (3rd ed.)," 2009.
[15] A. &. Levinson, "Cooling energy savings potentials of reflective roofs for residential and commercial buildings in the United States, 2008.

[16] G. Giebeler, "Refurbishment Manual: Maintenance, Conversions, Extensions. Birkhäuser," 2010. https://doi.org/10.11129/detail.9783034614337
[17] ArchDaily, "Hearst Tower / Foster + Partners.," Retrieved from ArchDaily, 2006.
[18] Hannoudi, Loay Akram, Michael Lauring, and Jørgen Erik Christensen. "Evaluating economic and environmental aspects of using solar panels on multi-angled facades of office buildings." In *AIP Conference Proceedings*, vol. 1884, no. 1. AIP Publishing, 2017. https://doi.org/10.1063/1.5002510
[19] Pedersen Zari, Maibritt, and Katharina Hecht. "Biomimicry for regenerative built environments: Mapping design strategies for producing ecosystem services." *Biomimetics* 5, no. 2 (2020): 18. https://doi.org/10.3390/biomimetics5020018
[20] Dezeen, "Bosco Verticale by Stefano Boeri completes in Milan.," Retrieved from Dezeen, 2014.
[21] Boeri, ""Bosco Verticale: A Model of Vertical Greenery." Retrieved from ArchDaily," 2015.