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Article

Energy-Saving of the Garuda Palace Building: Shaping the New Capital City of Nusantara

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Abstract: This research examines the Garuda Palace building of the Presidential Office in the New Capital City of Indonesia, Nusantara. Taking into account the new city regulations, the aim of this study is how to find out the Garuda Palace design could respond to the new Capital City of Indonesia's concepts: smart, sustainable, and resilient city in line with latest city regulations by being associated with a sustainable design consisting of three fundamental dimensions: environmental, economic, and socio-cultural. The research employs a qualitative method, combining descriptive-interpretative with face-to-face interviews with the sculptor artist and team, alongside direct observation to gather comprehensive data documentary analysis such; as sketch ideas, design concepts, drawing designs, simulated modelling, and copies of videos. The Garuda Palace building is composed of a metal brass louver patterned by abstracting the realist expression of the mythical bird gesture into a geometrical shape and upscaled into superlative dimensions. To meet the smart city concept of the New Capital City, Nusantara, the building must show an energy-saving design procedure. As result, the Garuda Palace design meets energy-saving design by applying a building design model simulations supported by IES-VE software; (a) simulation models of the passive design by adding the louvers, and (b) simulation models to ensures the metal brass louvre does not have a significant impact on the thermal conditions of the external environment. Furthermore, the Garuda Palace architecture design has a dual role, as a symbol of the Indonesian national identity and, as the double skin façade of the presidential building office. Due to the case study approach chosen, the results of the study may lack generalizability. Therefore, researchers are encouraged to test propositions in further research. The discourse of architects, art sculptors, engineers, and students interested in energy-saving during the composition of building façade designs. The social implications of this research are to encourage appreciation of architectural works oriented toward sustainable architectural design. This paper reveals a part of the process of a new future city of Indonesia represented by the Garuda Palace of the Presidential Office (2024) to show the largest organic shape that meet the energy-saving requirement.

Keywords: energy-saving; Garuda Palace; IKN Nusantara; metal brass louver; new future city

1. Introduction

In 2019, Indonesia became the ninth country to move its capital, from Jakarta to Nusantara City. Previously, America moved from New York to DC in 1871 (Mary-Elizabeth, 2023). Ten decades later, Australia moved its capital from Melbourne to Canberra after a process from 1908 to 2005 (Stewart, 2008). Two decades later, the Turkish State moved from Istanbul to Ankara (1923) (Kacar, 2010). In the middle of the 19th century, Pakistan moved the country's capital from Karachi to Islamabad (1947) (Shah & Nizami, 2021). And it was followed by the Brazilian, from Rio de Janeiro to Brasilia (1960) (Kelly, 2020). The Nigerian state also moved the country's capital from Lagos to Abuja (1991) (Obia, 2024), followed by Kazakhstan (1999) which moved the country's capital from Almaty to Astana. (Arslan, 2014). Then, Malaysia moved from Kuala Lumpur to Putrajaya (1999) (Jamil & Madya, 2022). The rationalization for moving the capital is that Indonesia needs a New Indonesian platform to respond to the challenges of the Golden Year of Indonesia (2045), coinciding with the momentum of Indonesia's 100 years. In 2045, Indonesia will become economically advanced, and Indonesia will enter the top 5 in the world. Several best practices for moving the capital have been considered is to reduce the burden on the already congested city of Jakarta, which is the need for equitable development in the central and eastern regions. (Rachmawati et al., 2021). The decision to move in 2019, followed by a competition for master plan ideas for the new capital, and resulted in the *Nagara Rimba*-Jungle Country concept. (The Ministry of State Secretariat of the Republic of Indonesia, 2019) and (Urbanplus.co.id, 2020).

In year 2021, a limited competition design was held to preparing the Presidential Palace architecture design included the Presidential State Palace is a place for ceremonies, and the second is the Garuda Palace for presidential office building. (Kompas.com, 2021). Nusantara (*Ibu Kota Nusantara* - IKN) is the name of the new Capital City of Indonesia designed as: a smart, sustainable, and resilient city (Berawi, 2022). Consequently, all building design concepts are must in line with the regulations associated with a sustainable design consisting of three fundamental dimensions: environmental, economic, and socio-cultural (Mba, Igwe, Oforji & Ozigbo, 2024), including how to implement the energy-saving design (Pastore & Andersen, 2022).

Energy-saving is a key part of sustainable energy and could prepared since the architectural design stage by employee a building envelope to respond with thermal performance. (Natephra,Yabuki and Fukuda, 2018). Building envelope design is a fundamental part of architectural design and is placed in the exterior face of a building, including windows, doors, and decorative features. Façade, as a key element separating the indoor space from the outdoor, is a requirement for heating and cooling to maintain comfort space, indoor air quality, and building safety. Because of its significance in building performance, then facades have a role for both aesthetic and functional reasons. Façade could consider to sustainable energy by concerned with how to design. In many cases, smart building envelopes could utilize advanced materials and intelligent control technologies to adjust to environmental changes (Kodli et.al, 2023), and applying a double-skin façade with adjustable louvers could reduce the energy. (Tao et.al, 2021). To achieve optimal of energy-saving in building, by considering the conceptual model which integrated design with the building façades. (Oliveira & Melhado, 2011). Traditionally by ensure the thermal comfort for its occupants, by created integration between the outer surface of the building envelope, or by implementing a 'louver system' design. In tropical countries, louvers are shading devices to reduce solar gain (heat and light). By implemented sustainable building envelope design the energy cost saving and occupant satisfaction were achievement. (Wu, Ng and Skitmore, 2016). In the conceptual design stages, it could present its architecture design conduct to energy-saving design by applying a minimum Overall Thermal Transfer Value (OTTV). By implementing OTTV the amount of heat that enters a building can reduce the energy needed for air conditioning. An evolutionary-based computational approach of biomimetic design of building facades for cooling in hot and humid climates. (Hays, Badarnah, and Jain, 2024).

Furthermore, the IES-VE software is a computational tool for thermal environment of accuracy. (Oleiwi et al., 2019). The Garuda Palace as the president's office was initiated by sculptor artist Nyoman Nuarta. President Joko Widodo does not want people to remember that the palace not only the presidential workplace, but is also the palace should remind people of the national symbol of pride, progress, and greatness. (Wiryomartono, 2020). The Garuda Palace designed has superlative dimensions and occupies the highest location. The original basic design has the ratio of the length and width from the top view is 1:1.06. By orientation on the North to South. The figure of the Garuda Palace shows a 'protective' gesture which 77.7 meters height, and span 180 to 230 meters. Visually, the impression as an expression of realist art is captured virtually, so it is feared that it is not meet by the concept of sustainable architecture. The dimension of the Garuda Palace became the dominant sight in the government area of Indonesia's New Capital, Nusantara. For the construction phase, the Garuda Palace initial design was enriched to be Detail Engineering Design (DED) by P.T. Arkonin Consultants in collaboration with PT PP Contractor to meet to the Nusantara Capital City concept to be smart, sustainable, and resilient city. (Berawi, 2022). The research is intended to the Garuda Palace design respond to goal 11 of SDGs 2030 related to sustainable cities and communities. Therefore, the research question addresses how the Garuda Palace, within an artistic expression of realist sculptures, responds to the energy-saving design.

2. Theory and Method

This study is a qualitative research method with case studies (Rule & John, 2015) combining interpretivism and descriptive research design. (Andersen, 2024). To reveal the energy-saving of the Garuda Palace design. The analysis was carried out by investigating by visited on site, and in-depth interview. (Rutlegde & Hogg, 2020) with the sculptor artist and his engineering team to reveal the Garuda Palace design and the energy- saving design materialized. Data were complemented by documentary analysis, design concepts, drawing designs, and copies of videos. (Nuarta, 2024).

2.1. Organic Façade Theories

The presidential office facilitates policy implementation by communicating information about the country's direction and policies. (Pepin-Neff, McManus & Ormerod, 2023). In many countries, it was performed in the classical architectural style. However, the Garuda Palace is an unusual concept for the Presidential office, because it was designed by employing an artistical shape of the mythical bird figure. Therefore, the facade of the Garuda Palace is formed by abstracting the organic form of realist expression of the Garuda bird. The designer is Nyoman Nuarta, an artist sculptor of monuments of superlative size. His two monuments in the realist statue are 60 meters high at the *Jalesveva Jayamahe* Monument at Surabaya (1996) and 121 meters high at the *Garuda Wisnu Kencana statue* at Denpasar Bali. (Ardhiati, 2017).

The Garuda Palace's façade shows a 'protective' gesture of Garuda bird as a symbolically 'to care' a new Indonesia. By metaphorically design approach, the sculptor artist of the Garuda Palace solves the rationality (Casakin, 2006) and imagination (Ayiran, 2012) of the realistic expression by abstracting organic form into geometrical form by employee the rhythm of pattern brass metal louvers into superlative scale. In order meet to the green architecture requirement then the Garuda Palace conduct to the green building assessment. Furthermore, the Garuda Palace is also need to express extravagance (*luxuriate*) of palace buildings, banquets, furnishings, luxury, architecture, and aristocracy. (Condelo, 2016). Then, a luxurious of Garuda Palace were create by implemented the architectural façade made from metal brass which supported by a structural frame of perforated weather steel. (Garuda Magazine, 2024). Futurist expressions are designed by modifying 'the organic shape' of Garuda bird silhouette into the geometrical shape.

In this case study, the Garuda Palace's façade embedded with complex systems designed for several performance criteria associated with sustainable architecture, aesthetic, and cultural context. (Roginska-Niesluchowska, 2017). The construction has advanced due to new technologies and materials adapting to satisfy the changing demands of occupants. (Capeluto & Ochoa, 2017). The significant improvement is influenced by the similarity with the "bird face" making it pleasing visually. By elaborating on geometric and mathematics science, the Garuda façade is characterized by different building styles, proportions such as the golden ratio, and classical orders. (Sandak, Sandak & Brzezicki, 2019). It has the largest span of steel industrial application is 180 meters to 230 meters from the West to East wing, and total height is 77.7 meters. The Garuda's façade divided into 16 segmentations, was composed of the rhythmic pattern of Garuda's louvers of the mythical bird's gesture. The Garuda mythical bird, it a heroic symbol of the Indonesian ancient that show through art, science and technology concept by convey adashing impression, and futuristic impression to create communication between internal and external environments. The dashing impression were formed by the rows of superlative louvers of metal brass, and it's represented the natural dramatic effect that occurs on the Skydeck. Skydeck is a twin room as the VVIP lounges. Located right under the construction on both wings of the Garuda on the top floor of the building of the Garuda Palace of Nusantara's Presidential Office at the Complex of Presidential Palace (2024) as shown in Figure 1. (top) and Figure 1. (below) (Nuarta, 2024). It is mean is a part of the new city of Nusantara.

Figure 1. (top) The Garuda Palace composed by abstracting Garuda mythical bird of organic figure into geometric Figure 1 (below) The site plan of the New City of Nusantara where is the Presidential Palace area. (Source: Nyoman Nuarta, 2021).

2.2. Overall Thermal Transfer Value (OTTV)

Green Architecture has become a requirement in today's architectural practice including in the New Capital City of Nusantara. It conducts with requires a minimum Overall Thermal Transfer Value (OTTV) below the limit of 35 watts/m². (UN-Habitat, 2010) and (Hariram, Mekha, Vipinraj & Sudhakar, 2023). The Indonesian National Standard (SNI) (2000) is the regulation concerning energy conservation of building envelopes refers to the amount of heat (watts) /m^2. This regulation concerning energy conservation of building envelopes refers to the amount of heat (watts) /m^2. Reducing OTTV is a one method to energy-saving by increasing the number of openings and windows, including the sun radiance effect. Several factors influence the OTTV value as opening orientation, opening ratio, shading dimensions, sheathing material, and insulation material.

To response to energy-saving of architecture design it needs to calculating the impact of solar radiation in the daytime on the internal environment of building by calculating the limiting OTTV. (Chan & Chow, 2013). The best of tropical architecture it needs a modelling on envelope design or façade building. (Sayed & Fikry, 2019). In order meet to limiting the OTTV by using Integrated Environmental Solutions-Virtual Environment (IES-VE) software. The IES-VE software is an integrated circuit for accurate whole-building performance simulation it can analyzed and improve a room's existing lighting and heat levels. (Qays et al., 2019), especially in the tropical climate country. (Kusumawati, Erni & Purnomo, 2021).

Meanwhile, to finding an architectural design in order meet to design environments, were support by Smartgeometry (SG). This software could explore the creative computational methods for the 3D design related to the ecology of environments who are defining the future of design. Smartgeometry (SG) has several simulations of the passive design strategies, that can expand architectural design possibilities in computational design. (Peters & Peters, 2013).

The result is the path analysis of sun radiance of the face of the building by various parameters. OTTV is the amount of heat (watts) received by a building per m^2 affects the value of the cooling load and artificial lighting in the building. It is calculated by adding the amount of heat got by the building through walls or solid areas, conduction through windows, and solar radiation from windows. The largest value is through window radiation (70-85%), followed by conduction through windows (10-20%), and the smallest is conduction through walls (0.2–0.5%). It can be seen that opening or windows are a factor that has a big influence on the size of a building's OTTV. It is appropriate that louver is added to the face of the building. Meanwhile, MicroFlo-CFD simulations is a tool to appraisal the naturally ventilated and mixed-mode buildings. MicroFlo-CFD runs as an adjunct to APsim, exchanging data at run-time to achieve a fully integrated simulation of air and thermal exchanges. (IES-Intergrated Environmental Solution Limited, 2025).

2.3. Solar Heat Gain Coefficient (SHGC) and U-Value

Solar Heat Gain Coefficient (SHGC) is a numerical value that represents the fraction of solar radiation admitted through a window. Both directly transmitted and absorbed and subsequently released inward. It is a measure of how well a window design can block heat from the sun. SHGC will allow a high level of heat transference into the space, especially in tropical building envelope material. (Chiradeja & Ngaopitakkul, 2019). The several factor should be taken when selecting windows to ensure performance and energy efficiency; (a) climate: determine whether you need windows that reduce heat gain in hot climates or maximize it in cold climates, (b) Building Orientation: consider the direction your windows face.

South-facing windows in the Northern Hemisphere receive more solar radiation, so SHGC values should be carefully chosen for these, (c) window size and placement: larger windows can admit more solar heat, influencing the choice of SHGC, (f) shading: external shading devices or architectural features can impact the effectiveness of SHGC, and (g) U-factor or U-Value and Visible Transmittance (VT): Balance SHGC with other performance metrics like insulation properties and natural light transmission. (Finlayson, 2024). U-Value is used to measure a material's thermal transmittance or how much heat passes through it. In tropical climates, it is better to increase the quality of SHGC compared to U-Value. However, in principle the lower these two components, the better. In this study case, the OTTV calculation uses a double glass with SHGC 0.3 and U-Value 1.8. (Satria & MSSM Associates, 2021).

2.4. Model Wind Loads by Computational Fluid Dynamics (CFD)

Computational fluid dynamics (CFD) simulation is used to predict fluid flow and heat transfer especially the site location of the Garuda Palace built in a hilly topography (88 meters height), which it has a dry climate with hot summers and breeze winds. The average temperature at the site location, at the North of Penajam Paser of Kalimantan is approximately 25 °C (night) to 30 °C (day). The highest temperature only occurs for around 1.9 days in September – October, which means it is not too hot or cold. Rainfall itself is around 100 mm. Meanwhile, what is considered wet is 150 and dry is 30. The site itself has no problems with rainfall. By simulated design, sunlight does not directly enter the building but becomes indirect sunlight. This can reduce incoming heat/solar radiation. (Satria & MSSM Associates, 2021).

The Garuda Palace also require HVAC systems stands for heating, ventilation, and air conditioning to regulates the temperature, humidity, and air quality of indoor spaces. To simulate the functionality of a HVAC system in different situations, summer and rainy, using specialized software ANSYS-Fluent by employ a 2D building model. That can show the indoor air temperature and air velocity in different conditions. The results are presented as graphs/plots and spectra of interest parameters. By uses Computational Fluid Dynamics (CFD) tools to model wind loads on structures, the data collected day by day in a year simulation in 2021. The wind simulation enriched by FORCE Technology and RWIND Simulation software model to determine the dynamic response of structures, uses a 3D finite-volume mesh to simulate wind flows around building.

Model simulations of the naturally ventilated and mixed-mode buildings were need to ensure the building by using MicroFlo-CFD simulations. MicroFlow-CFD is a tool to appraisal the naturally ventilated and mixed-mode buildings, it runs as an adjunct to APsim, exchanging data at run-time to achieve a fully integrated simulation of air and thermal exchanges. Nowadays, a simulation method used is a building design model simulation with IES-VE software. It supporting by ApacheSim, MicroFlo, and Suncast tools. (IES-Intergrated Environmental Solution Limited, 2025). ApacheSim is a dynamic thermal simulation program based on a mathematical model of heat transfer. Simulation in ApacheSim will produce a resultant value of the thermal environmental conditions of the habitable space, which will change dynamically due to changes in disturbances from time to time. MicroFlo simulation is applied to obtain the distribution of environmental parameter values for living space at a certain height, CFD simulation is needed. Meanwhile, Suncast is used to obtain irradiation flux values on the surface of the building envelope. The work steps carried out are as follows: (a) built model, (b) simulation scenario.

For the MicroFlow simulation to be held, several geometric simplifications were carried out efficiently. The geometric modeling carried out includes topographic modeling, building shading modeling, and room modeling. Material settings were carried out using the U-Value approach of the combination of materials that make up the casing. Meanwhile, simulation scenario was prepared to support the analytical analysis of the calculation approach used to provide a description of the influence of the Garuda brass sheathing on thermal conditions and heating loads in the building. The simulation scenario is as follows: (a) simulation of thermal conditions inside the Garuda envelope. In this stage it is hoped that a description of the thermal conditions in the casing will be obtained, including: (i) distribution of air temperature in the casing relative to the outside air temperature, (ii) distribution of irradiation on the surface of the casing in 1 year, (iii) direction of airflow in the casing, (iv) Thermal flow in metals. Furthermore, (b) simulation of heating loads in buildings, including OTTV and Recommendations for OTTV. In-line with energy-saving to visualize a grand impression in night by using the digital projection technology of LED lighting. LED Lighting System uses a self-adaptive weighted data fusion algorithm (Sung & Lin, 2013), and operates for various applications in three different modes, namely manual, auto, and hybrid. The Wireless Sensor and Actuator Network (WSAN) method is a solution for collecting data for LED lights, which are designed personally for building occupants. (Kumar et.al, 2017).

3. Findings

3.1. Simulation Models of the Facade Facing in Eight Directions

The original basic design of the Presidential Palace has a ratio of the length and width from the top view is 1:1.06. the Simulation models held by Nyoman Nuarta and his consultant Satria Revano and MSSM Associates (2021) as shown in Figure 2. By orientation on the North to South, and exposure to sunlight by forming independent shadows. In the morning, eastern sunlight can enter obliquely (perpendicularly) to the face of the building. In the afternoon, the western sunlight falls directly behind the building, causing shadows on the face of the building, and it can reduce exposure to sunlight in open areas. The simulation models using the facade facing the eight wind directions every morning at 06.00, at 12.00, and 18.00 show the direction of the sun's light falls each month in one year from January to December. It concluded that the most direct radiation comes from the West, the clearest shadows occur in the afternoon, while in the morning and afternoon, most diffuse radiation by 3 (three): (a) buildings without louvers, (b) with 50% louvers, and (c) with 100% louvers. (Nuarta, 2021). The high value is through window radiation (70-85%) followed by conduction through windows (10-20%), and the smallest is conduction through walls (0.2-0.5%). The OTTV calculation by dividing the 3D building design into 8 (eighth) parts according to the direction facing the cardinal directions. Each part will have its OTTV calculated and added to get the total OTTV value as shown in Figure 3 and Figure 4. (top) and Figure 4. (bottom).

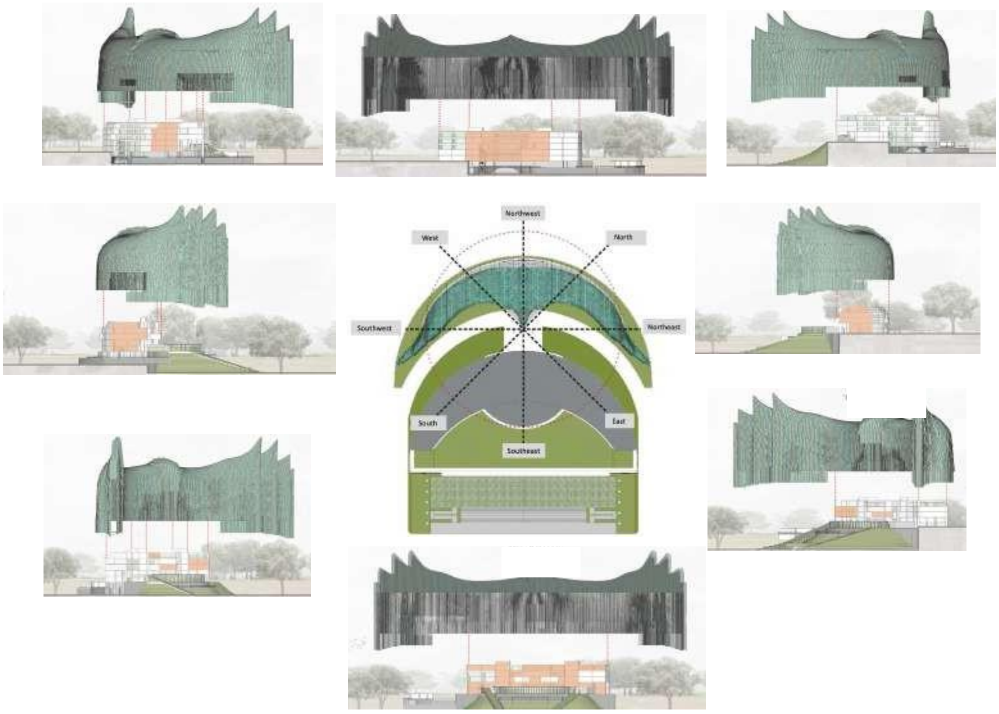

Figure 2. Simulation models of the facade facing and wind 8 (eight) directions (source: Nyoman Nuarta, 2021).

3.2. Additional Louvers Recommendation

Evaluation of heat transfer characteristics of building façade elements. (Al-Sanea, 2000). Calculate the OTTV per section, simulate it without using louvers, and then combine them to get the OTTV value of the building without louvers as below. The OTTV result without the louvers was 20.41%, which meets the regulations. However, the window-to-wall ratio is quite low at 22.56%. (Nuarta, 2021). Future recommendations are to add louvers to minimize OTTV thermal transfer and temperature reductions by louvers as shading systems. (Shah et al., 2022). The simulation by adding louvers then OTTV obtained at 14.76 with the same Window Wall Ratio (WWR). It concluded that adding louvers lowers heat entering the building. Besides employing louvers, and placing plantations inside, the Garuda Palace has shown bioclimate design strategies on the buildings' performance to the SDGs goals. (Elaouzy & El Fadar, 2022). The expression of the building is an abstraction of Garuda's gesture into a rhythmic composition of a static lattice pattern of brass material called the Garuda louver blade, which forms the building envelope and was visualized as a 'caring' gesture.

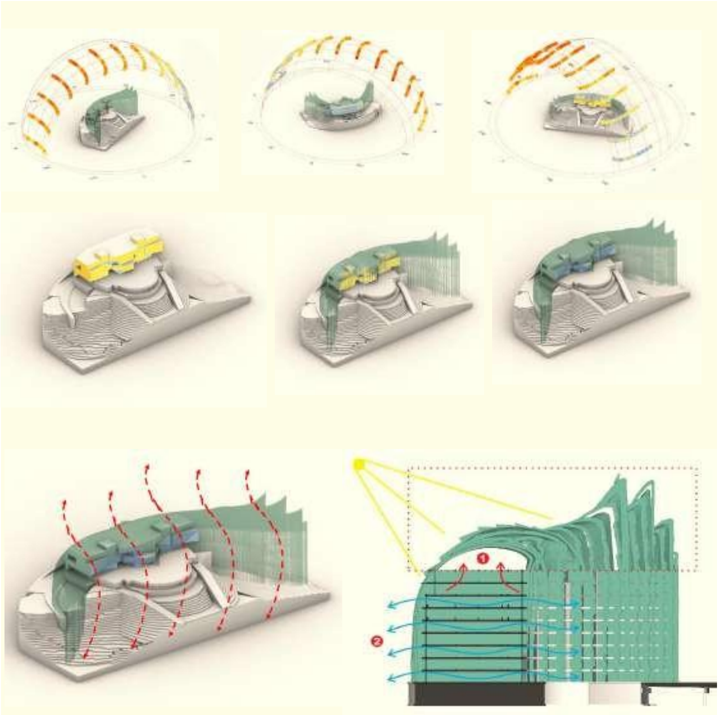

Figure 3. The graphical process to minimize OTTV of the Garuda Palace (source: Nyoman Nuarta, 2021).

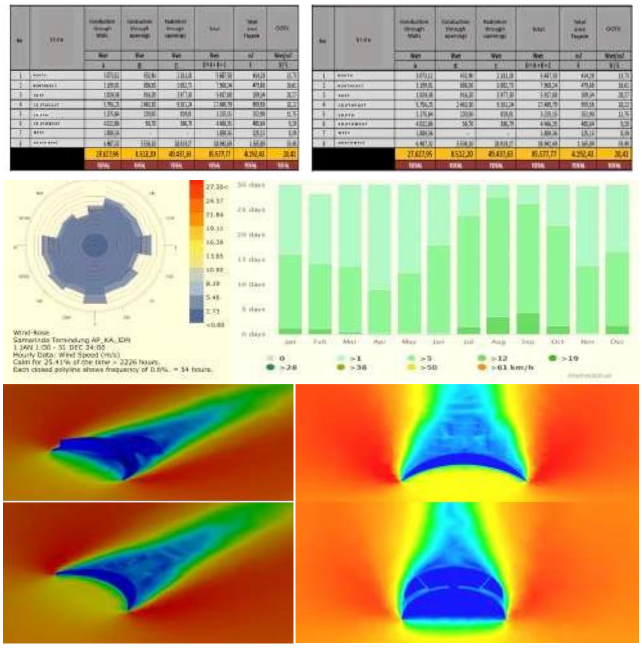

Figure 4. (top) Simulates adding louvers to obtain OTTV 14.76 W/m^2. Figure 4 (bottom). The Wind movement by using CFD shows the wind strength is no more than 5 knots. (source: Nyoman Nuarta, 2021).

3.4. The Effect of Brass Materials on Thermal Conditions in Buildings

According to the Garuda Palace's initial design, the materials for the louvers it was from brass materials, named *the Garuda blade*. (Nuarta, 2021). To ensure that the Garuda blades made from brass are expected to cause a greater burden on electrical energy consumption to fulfill thermal comfort. In addition, the Nusantara of IKN's geographical condition is near the equator in Kalimantan island which has a fairly high annual average temperature and lots of sun exposure. Therefore, the four simulation models applied IES-VE from the Center of Excellence for Sustainable Buildings and Infrastructure of Gadjah Mada University. (Gadjah Mada University, 2023). By implementing 4 (four) simulations. Simulation 1 was carried out by comparing the geometric models resulting from Sketch-Up software (SKP) and IES-VE software. To operate IES-VE, it is necessary to simplify the geometric model to make it more efficient, including the drawings of building shapes and land counters as shown in Figure 5.

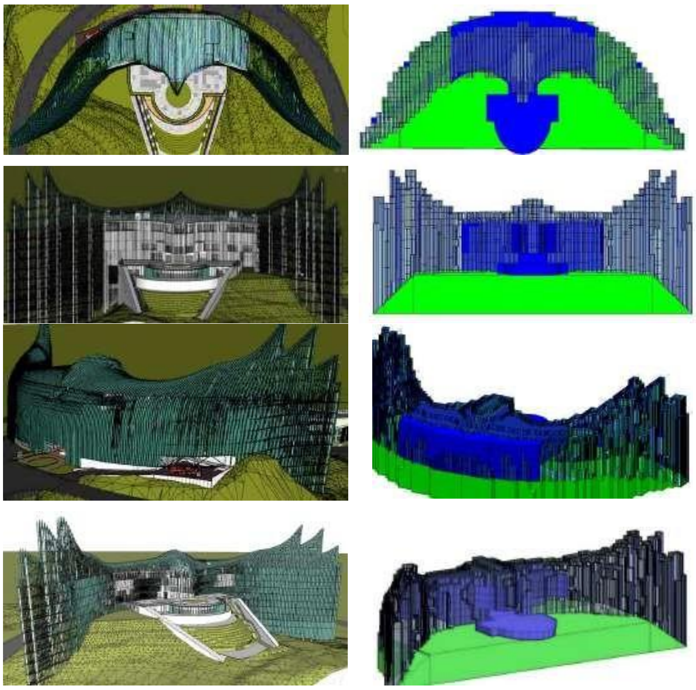

Figure 5. The simulation 1 shows geometry model by Sketch-Up (SKP) and model by using IES-VE software (Source: Gadjah Mada University, 2023).

The simulation 2 was carried out to obtain a calculation of the U-value of the building envelope materials. The Garuda louvres were placed not attached to the main building with distance being 1 meter, it could be as; (a) Position of fabricated casing, (b) as detached casing and (c) as casing close to the main building as shown in Figure 6. The resulting U-Value calculation is according to Tables 1 and 2.

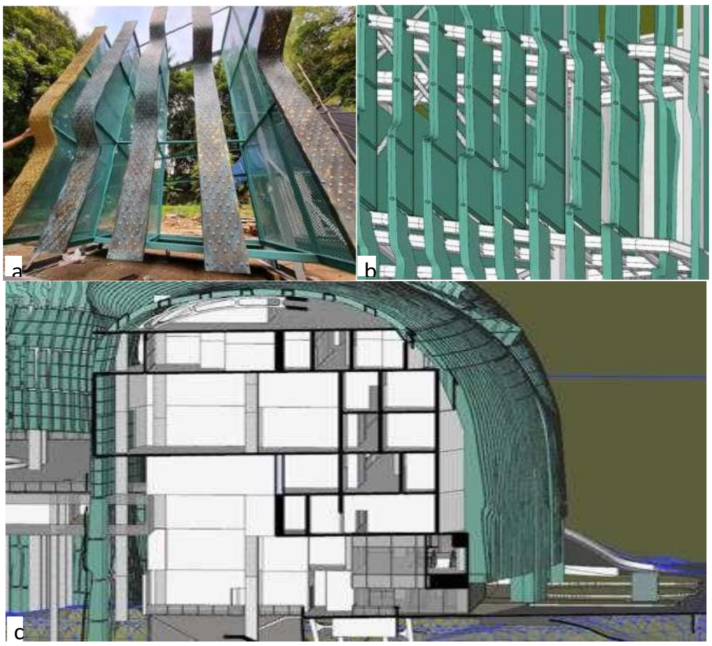

Figure 6. The simulation 2 show: (**a**) a fabricated casing, (**b**) detached casing and (**c**) casing close to the main building (**c**) (Source: Gadjah Mada University, 2023).

Table 1. Building envelope materials.

Building Envelope Materials			
Materials	Thickness	Thermal Condition	Resistance Thermal
	(m)	(w/mk)	(m^2k/w)
External Surface	-	-	0.04
Brass	0.251	109	0.00230
Perforated Steel	0.8	1.824	0.43860
Iron	0.8	79.5	0.01006
Internal Surface	-	-	0.13

The U-Value calculation for the Garuda casing not attached to the main building is shown as follows.

Table 2. Thermal Resistant Calculation.

Thermal Resistant Calculation		
Part	Thermal Resistant	U-Value
	(m2k/W)	(W/m^2k)
R1 (Re+Rk+Rb+R1)	0.18237	5.48
R2 (Re+Rk+R1)	0.17230	5.80
R3 (Re+Rk+R1)	0.61090	1.64
Total	0.18797	5.32

Thermal conditions inside the Garuda façade as building's envelope apart from showing the thermal conditions, it can also show whether the casing can be considered local shading for the main building. Simulations to obtain air temperature distribution were carried out using microflow simulation (CFD) using a simple model with reduced size as shown in Figure 7a. It is hoped that this model will be more sensitive to the adverse effects of temperature changes on the weather.

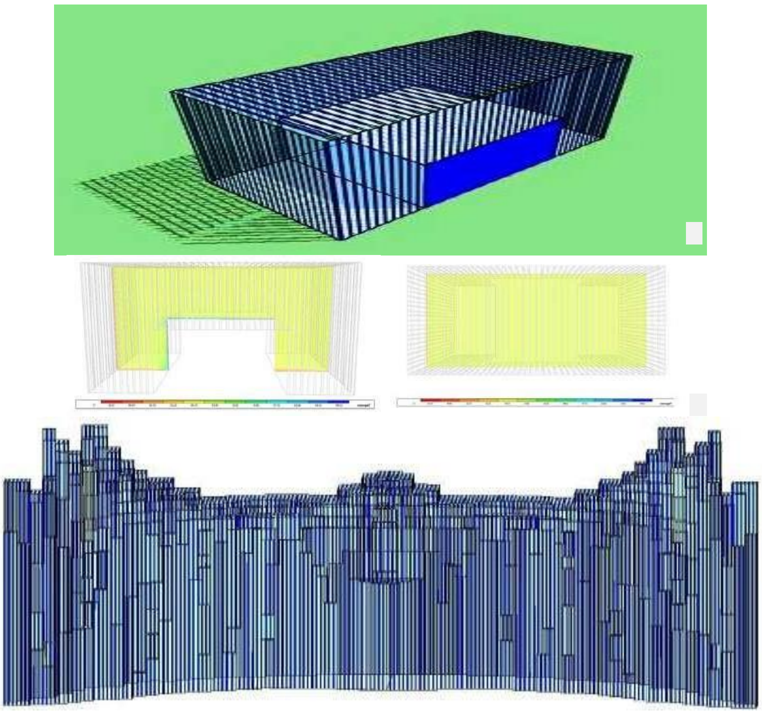

Figure 7. Simulations of air temperature distribution by using microflow simulation (CFD) (Source: Gadjah Mada University, 2023).

The simulation was carried out with solar radiation of 972 W/m^2, outside air temperature (Dry-Bulb) of 31 °C, and wind speed of 6.1 m/s in the direction of 200°. The simulation results are shown in Figure 7b. It can be seen that the temperature distribution in the volatility is quite even, at around 31.4 °C with temperatures near the hotter fluctuations around 33.2 °C–34 °C. There is no significant increase in internal air temperature due to the warming temperature outside, this shows:

a. The convection energy from external heat

It transmitted by the radiation holes and the energy transmitted by the brass radiation is not large. The same results are shown by dynamic simulations in ApacheSim on wave geometry with shapes and sizes close to the shape of the design drawing Figure 7c.

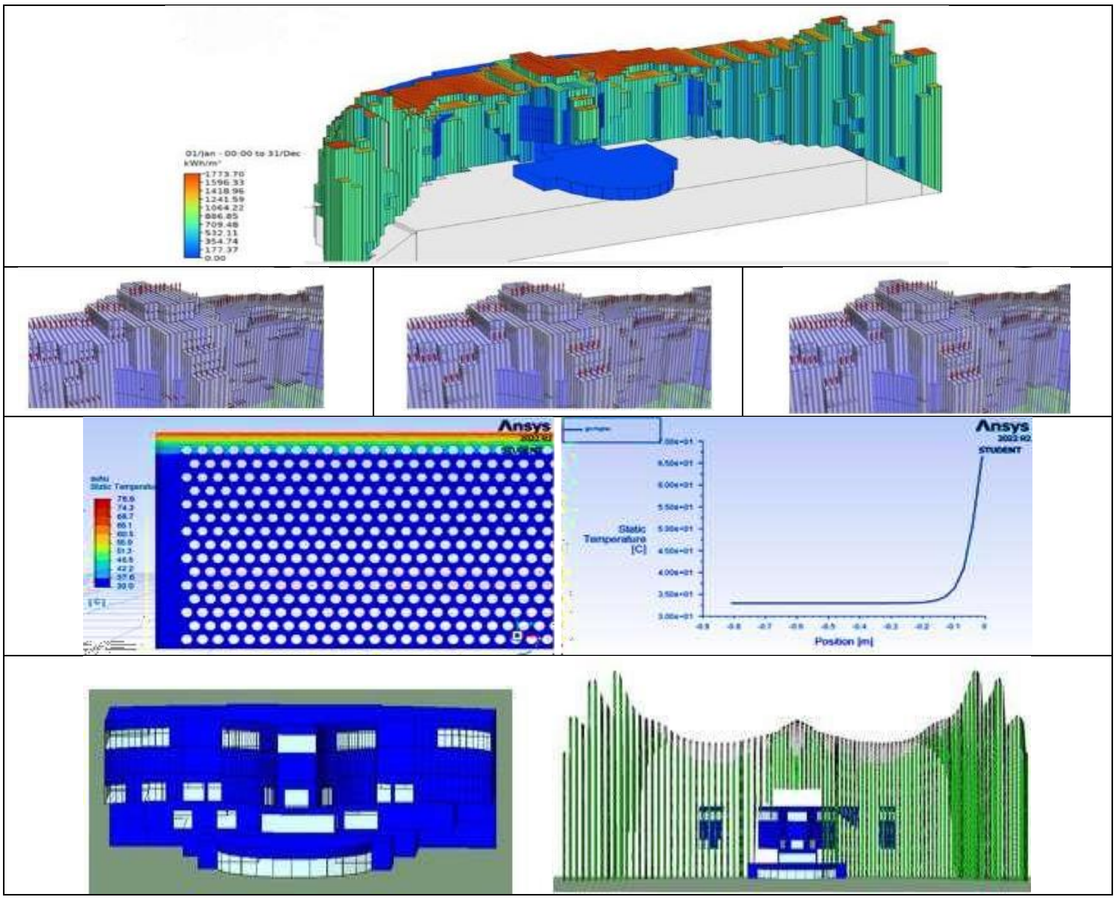

Figure 8. Distribution of radiation energy on the surface of the Garuda's façade and direction of airflow at certain hours (Source: Gadjah Mada University, 2023).

b. Distribution of irradiation on the earth's surface in 1 year

Figure 8. shows the distribution of irradiation on digestion in 1 year. Weather data uses weather data from the Balikpapan Airport station (the City near to Nusantara). It can be seen that exposure to radiation energy in 1 year is greatest on the upper anxiety surface as shown in Figure 8a.

c. Direction of air flow in the façade

The dominant airflow direction throughout the day as shown in Figures 8b, c, and d where air enters from the sides and exits towards the top of the casing. This is by the results shown in Figure 8e. The surface of the top façade which is hotter than the side will cause the air to flow upwards. Meanwhile, Figure 8e and Figure 8f are shown the geometry model without building envelope is 49, 18 W/m^2 and with building envelope is 46, 13 W/m^2. According to the model simulation, then the recommended materials of walls by concrete precast finish ACP (U-value 2.03 W/m^2 K) and windows by laminated glass (U-value 5.7 W/m^2 K and SC 0.8). Figure 8g and Figure 8h are shown a OTTV comparison with and without sheath.

d. Simulation of thermal flow in metal

To get the effect of the Garuda envelope on the part of the main building wall closest to it, by refer to the simulation results report on thermal flow in metal. The report shows that significant heat propagation effects only penetrate the perforated metal to a maximum of approximately 20 cm from the inner surface of the brass casing as shown Figure 8. Moreover, the temperature of the perforated metal is only slightly above the ambient temperature as shown in Figure 9. and Figure 10.

e. Profile of the Garuda Louver Blade from brass materials

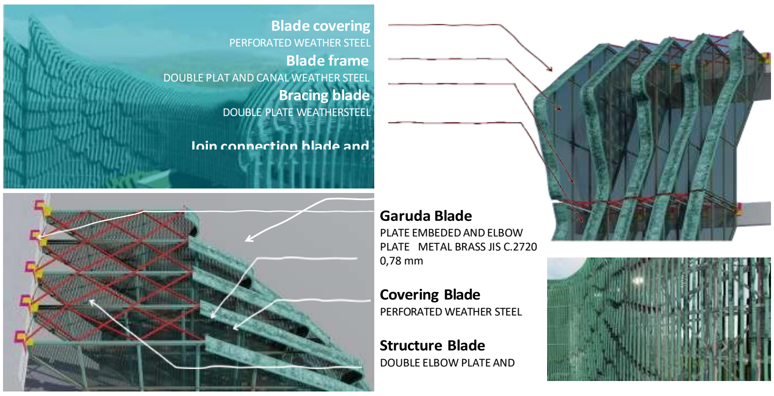

Figure 9. Visualization of the Garuda louvre profile and it composed to be the secondary façade of the Presidential Office building (source: Nyoman Nuarta, 2024).

Figure 10. Visualization of the Garuda Palace gesture at the Presidential Office Plaza (source: Author (s), 2024).

4. Discussion

The Garuda's louvres role as the building envelope

Based on three parameters of path analysis of sun radiance in New Capital of Nusantara it has recommendation building by using the louvre. (Nuarta, 2021). The recommendation meets to the initial of The Garuda louvre design which was develop based the 3D virtual. It held by abstracting of the Garuda bird gestures into 16 of segmentations then composed the be a rhythmic pattern of Garuda's louvres were create based on the mythical bird of Garuda's gesture. The 'caring' gesture of the Garuda were implemented by facing vertically to covering the Presidential Office building, means it roles as the secondary façade or building envelope. To assembling the rhythmic louvres, the steel construction that forms the head and wing-body has been prepared by span 180 meters to 230 meters, and 76 meters high.

Initially, the Garuda Palace was designed to be a building without air conditioning. It using by the principle of cross ventilation. The gaps formed by the construction of the blades in the form of cavities will find an opportunity for hot air to flow through the 'inner space' which can then flow into other cavities. To ensure accuracy so that the wind flow into the construction cavities occurs correctly, modelling analysis was carried out based on monthly sun radiance effect data. This sun radiance effect behavior benefits because an egg crate has occurred, a meeting between the perpendicular eagle blades and the horizontal elements of the floor plate extension and steel structure construction. According to the first simulating of OTTV value, the additional of the Garuda louver blades reduce OOTV to 14.76% with the same Wall Window Ratio (WWR) (Nuarta, 2021). The initiated building within a non-air-conditioned space at the Garuda Palace it could not be realized. Even though OOTV obtained with the addition of louver meets the National Standard Indonesia (SNI) requirements, unfortunately the standard operational procedures (SOP) for the Presidential Palace Building were require a primary security from unexpected things such as vandalism, terrorism, or snipers. For this consideration, only the Skydeck areas roles as the VVIP guest room which is has permitted without air conditioning.

The Natural Breeze of the Skydeck

The 3D figure of the Garuda Palace will be installed 77.7 meters high on the pedestal of the President's Office, with the theme of *the beauty of the construction of the Garuda's wings*. Natural plantations were preparing in surround of the Skydeck areas in order to create the bioclimate architecture. (Widera, 2015). By implemented the bioclimate architecture concept, the Garuda Palace as performance tends to pursuing happiness, which reflected the sustainable of architecture design. (Lyubomirsky, Sheldon & Schkade, 2005). The real of scale enlargement method is applied in Skydeck areas. (Nyoman Nuarta IG, 2025). In this area were found the superlative of Garuda Palace into three parts; (a) Right wing structure, (b) head and shoulder structure, and (c) left wing structure. The wing structure concept consists of support beam as top wing support truss vertical, support cantilever beam, roof—waffle system dan main structure wing flat truss by superlative of dimension between 180 meters to 230 meters span beam as shown in Figure 11 (top). Meanwhile, the below parts are the sky deck structure, diagonal grid-bracing system, and wind brace. The Skydeck as part of the Garuda Palace is a new model of sustainability, including greater incentives to energy-saving. (Riffat, Powell, & Aydin, 2016) as shown in Figure 11 (below).

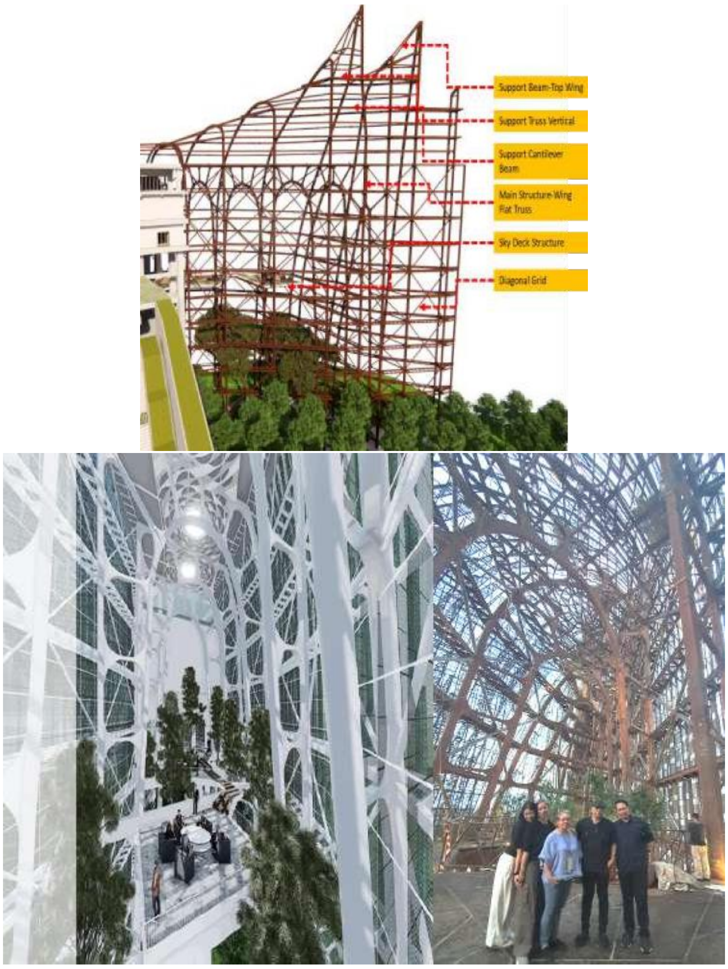

Figure 11. (top) Skydeck construction, 3D image. Figure 11 (below) The Skydeck project realization in 2024 (source: Nyoman Nuarta, 2024).

The LED in night

A daylight and aesthetic Skydeck were create by natural daylight, and the intertwining that occurs from the construction structure that forms the wings of the Garuda. To visualize a grand impression in night, the digital projection technology of LED lighting attracts and engages first- time Nusantara visitors to the Garuda Palace building façades. LED Lighting System uses a self- adaptive weighted data fusion algorithm. (Sung & Lin, 2013), and operates for various applications in three different modes, namely manual, auto, and hybrid. The Wireless Sensor and Actuator Network (WSAN) method is a solution for collecting data for LED lights, which are designed personally for building occupants. (Rahman et.al, 2019). To materialize the glorious façade building, then all façade providing a great space suffused with light from a massive skylight above the Garuda's façade. Meanwhile, the Dynamic LED enriched the Presidential Palace extra-perience in the surroundings of Garuda Palace and the city scale with interactive LED. The different ambiances attract visitors psychologically to watching the Presidential Palace in Nusantara, especially the Garuda Palace's silhouette. As shown in Figure 12.

Figure 12. The Garuda Palace at Night by LED. (source: Author(s), 2024).

Shaping the New Capital City of Nusantara

Nusantara Capital City Authority (Indonesian: *Otorita Ibu Kota Nusantara*, abbreviated as OIKN) is a ministry-level agency formed by the Indonesian government, working directly under the President of Indonesia. The OIKN shaping a smart city by divided into 6 (six) aspects; smart government, smart transformation and mobility, smart living, natural resources and energy, industries and human resources, and built environment and infrastructure. (Nusantara Capital City (IKN), 2025). Therefore, the smart city concept of Nusantara enriched to Riffat et al. theory of the future cities and environmental sustainability in Southeast Asia. (Riffat, Powell & Aydin, 2016). Furthermore, (Berawi, 2022) stated that, the New Capital City of Nusantara was created to be a smart city as the Indonesia's active contribution in three global campaigns; climate change, biodiversity, sustainable development goals.

In the context of the climate change, Nusantara Net Zero Strategy 2045 as the Roadmap to a city with net zero emissions in 2045 was launched in December 2023 at COP-28 in Dubai. The Nusantara is the first city in Indonesia to have a net zero emission roadmap. This is earlier than Indonesia's target of becoming net zero emissions by 2060. In biodiversity, the Nusantara's nature positive plan as the Master Plan for biodiversity has been soft-launched on the momentum of the International Day of Forests on March 21, 2024. This document is aligned with the Kunming-Montreal Global Biodiversity Framework. And, related to Sustainable Development Goals, the voluntary local review (VLR) for the Sustainable Development Goals (SDGs) of the Capital City was launched in February 2024 at UN-ESCAP Bangkok. It was the first new capital city in the world to submit its VLR to the United Nation (UN). (Investor.id., 2024).

The Garuda Palace building simulates adding louvers is meet to the smart city of IKN Nusantara was meant the Garuda Palace building had contribution into shaping a future city had meet to smart city trends and innovations to shape a future of city (Okello & Akoko, 2023), by implemented PEAK Urban's approach. According to PEAK Urban's approach there are four central pillars to guide research across radically different contexts by prediction, emergence, adoption and knowledge. (Peak Urban, 2025). Prediction is related to what can we now forecast about cities. Emergence is related to what types of urban structures and systems are emerging? Then, Adoption is how do cities adopt new ideas and technologies? And, Knowledge is related how can we create and share knowledge globally and locally? By employee PEAK Urban's can asserts an interdisciplinary inquiry into city futures it is essential to reconcile the sciences of prediction and projection with culturally sensitive readings of the institutional architectures and urban contexts which will mediate specific technological disruptions. (Keith, O'Clery, Parnell & Revi, 2020).

In process of shaping a future city it was suspected the three speculations which influences to the new city, there are (a) the Industrial Revolution's impact had composed of hardly any cities to one which is completely dominated by cities, (b) cities will unpredictable to get larger but size limits will emerge, and (c) cities classified by their size by their internal dynamics. (Batty, 2022).

Meanwhile, Xing Su (2023) stated forming a new city in the Global South, included Indonesia tend to applied three mechanisms of neoliberal planning, by employee deregulation, authoritarian state intervention, and public-private partnerships. (Su, 2023). Even though, Nusantara City already started to shape, the three of them have match with the *Nusantara Capital City Authority held to shaping the new city.* While holding full authority, the Indonesian government seeks partnership opportunities both domestically and abroad. Event, the government provides incentives to investors, such as Building Use Right (Indonesian: HGB) for up to 160 years. This investment opportunity is a product of the deregulation of Government Regulation (PP) Number 29 of 2024 concerning Amendments to Government Regulation Number 12 of 2023 concerning the granting of business licensing, ease of doing business, and investment facilities for business actors in the IKN. (Kompas.com, 2024). Furthermore, the Nusantara Capital City Authority had promised that the infrastructure in Nusantara continued. (Konstruksi Media, 2025).

Enthusiasm to visit IKN Nusantara. Curiosity and desire to get closer to the Presidential Palace Area. On the other hand, during the Garuda Palace under construction shows the trend of the public.

Fortunately, the Garuda Palace's designer has preferred to build at the highest location in the area. At a height of 70 meters on a hill, visitors can see the Garuda Palace building from several of the best vantage points, including (a) from the Zero Point of the IKN at the Monument Protection Wing plaza, (b) from the Zero Point flagpole plaza, (c) from the front plaza of the Presidential Palace Area which is now a commercial cafe. Shortly, along with the development of the New City of the IKN Nusantara, the need for guided tourism can be the initial glue between the Indonesian people, regions, and potential investors to get to know this city better. However, the tourism framework needs to be synergized with the initial concept of this smart city, including in line with SDG standards. (Fitriadi, Privagus, & Darma, 2023).

5. Conclusion

The energy-saving design of the Garuda Palace within a series of simulations assisted by software were shows the careful attitude of the initiating artist and team of experts so that the building is in harmony with the smart city concept of the New Capital City, Nusantara. Two simulation models are (a) simulation models of the facade facing of the eight wind directions by recommended additional louvers, by support SmartGeometry software and (b) simulation models to ensures the metal brass louvre Garuda's as the building envelope does not have a significant impact on the thermal conditions of the external environment by support IES-VE software. The Garuda Palace of the Presidential Office in the New Capital City of Indonesia, Nusantara designed shows the significantly consideration with energy-saving proven by simulate model of OTTV at 14.76 W/m^2 with the same Window Wall Ratio (WWR).

On the other hand, the other simulation was held to ensure that the Garuda blades made from brass are expected to cause a greater burden on electrical energy consumption to fulfill thermal comfort. According to the Garuda Palace's initial design of the President’s choice in 2019, the louvers were brass materials. The four simulation models applied IES-VE were held. Compared to the nearest countries, the Garuda Palace of the Presidential Office's performance seemed to look more casual-luxury, and unique. The extravaganza was composed of perforated brass louvers that form by abstracting the Garuda bird gesture 180 meters to 230 meters of the curved wing. It stands at 77.7 meters in height on 88 meters of highland. In response to the green architecture issue, the Palace's concept was implemented as a bioclimate architecture, especially at the atrium of Skydeck as the VVIP lobby area.

Additionally, the Garuda louver blades function as the natural daylight and air flows into the atrium Skydeck. By employing the idea of a ‘caring gesture’ of the mythical bird Garuda it was materialized a structural Skydeck’s luxurious impressions were enhanced by the splendor effects of LED technology. The mutual mirroring effect occurs when pieces of glass reflect each other making luxurious sense. The luxury of brass materials of the ‘mythical Garuda bird’ structural façade supported by steel construction enriched by LED at night. On the one hand, the mythical artifact is designed on a superlative scale to encourage joy and pride. It becomes a public education about the exploits of the Indonesian nation's mighty ancestor symbol in the sky. Then, the luxury of the structural Skydeck represented a 'complex poetics' of architectural engineering to serve the visitor's expectations and carry out the Indonesian’s Pride Palace’. This means the Garuda Palace performance tends to pursue Indonesian happiness, it reflected the architecture of sustainable change.

The creative process of architecture design and engineering was indicated as the 'complex poetics' of architecture, including collaboration between Sculptor Artists, Architects, Civil Engineers, and industrial applications. This served as proof that the Sculptor-artist implemented the four aspects of the future palace building theories by composing entertainment-health- wellness-learning-personalized products to ensure the Garuda Presidential Office's lifetime**.** The results showed that the Garuda Palace met with the concept of the Presidential Office have successfully represented Indonesian pride by accommodating art, science, and technology.

The study provides empirical insights into the strength of energy-saving of the architectural design concept of the Presidential Office. By exploring the Indonesia ancestral heritage hybrid with the future presidential office concept, which has a chance to be a lifetime of Indonesia national branding. It suggests that the successful Architect in office design/acts as an “integrating force” on two levels: integrating the elements of national/ cultural identity and mediating between national branding and contemporary visitor habits. This study also provided a new model of sustainability of Presidential Offices especially in the tropical climate.

Conflict of Interest
The authors declare that there is no conflict of interest.

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