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Application of Generative Design on Architecture to Optimize Design Decision in Preliminary Design Stage

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ABSTRACT

This study investigates the application of generative design through Autodesk Forma, a cloud-based AI platform, to optimise architectural decision-making in the preliminary design stage of a ten-story hotel in Cirebon City, Indonesia—a region characterised by a hot and humid climate. The research employed simulations based on five environmental parameters: sun hours, daylight potential, wind distribution, microclimate conditions, and solar energy. Three optimal models were selected based on orientation, spatial configuration, and environmental responsiveness. Subsequent development simulations were conducted on these three models by refining openings, adding vegetation, and enhancing shading strategies. Model-2 emerged as the best-performing design. It demonstrated an energy efficiency potential of approximately 23%, achieved through improved daylighting (VSC ≥ 27% on most facades), reduced reliance on artificial cooling due to stable microclimatic conditions (temperatures moderated by 2–3°C during peak hours), and the integration of solar panels generating an estimated 165,000 kWh/year from 40% roof coverage at 10% efficiency. The results confirm that AI-driven generative design can significantly accelerate the design process while enhancing environmental performance. This approach supports energy-efficient architecture in tropical regions, although it requires access to advanced technology, skilled practitioners, and robust internet connectivity.

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1. INTRODUCTION

Preliminary design is the foundation of successful building planning. This stage not only determines the aesthetic and functional direction of the building but also influences sustainability, cost efficiency, and overall project collaboration. At this stage, the project's initial vision is realised as a design concept that provides a basic framework for further development. Decisions made at the preliminary design stage will affect all aspects of the project, including functionality, aesthetics, sustainability, cost efficiency, and implementation schedule. Therefore, understanding the importance of preliminary design is key to ensuring the project's overall success.

Preliminary design serves as the main guide for all project planning and implementation stages. A study by Ching [1] emphasises that this initial design framework influences how the building will function in the context of its use. According to Smith & Lee [2], buildings designed with sustainability in mind from the early stages can reduce energy consumption by up to 30% compared to buildings that do not adopt this approach. According to a report by the American Institute of Architects [3], up to 70% of project cost decisions are made at the early design stage. Thus, resolving design issues at this stage can avoid delays and budget overruns. A study by Jones shows that cross-disciplinary collaboration at the preliminary design stage can increase project efficiency by up to 25% [4]. This is because all parties have a shared understanding of the project's goals and constraints. According to research by Zhang, risk management conducted at the early stages can reduce potential problems during construction by up to 40% [5].

In the architecture industry, therefore, the preliminary design stage plays a crucial role in determining the project's overall success. At this stage, the design decisions will affect the project's various aspects such as aesthetics, functionality, cost, and sustainability. However, the decision-making process at this stage often faces challenges of high complexity and uncertainty. Therefore, a more intelligent and adaptive approach is needed to optimise the design, such as using artificial intelligence assistance.

Artificial intelligence (AI) has changed how architects design, analyse, and implement their projects. With the ability to analyse complex data, simulate various scenarios, and generate innovative designs, AI offers unprecedented efficiency in this industry in architecture [6]. AI is used in multiple aspects. First, generative design helps create alternative designs based on specific parameters, such as energy efficiency, occupant comfort, and material availability. Second, simulations and analyses use environmental data to predict building performance concerning climate, energy use, and natural lighting. Third, an automation Process to accelerate manual tasks such as layout creation, technical documentation, and construction cost estimation.

Generative design is an AI-based approach that allows users to generate multiple design alternatives based on specific parameters, such as energy efficiency, materials, and costs. In architecture and construction, generative design has proven to enhance project efficiency, creativity, and sustainability. This technology is increasingly becoming an essential part of the industry in developed countries, while its application in developing countries, including Indonesia, is still minimal. Therefore, it is necessary to introduce the application of generative design to optimise design decisions in the preliminary design stage in Indonesia.

Developed countries like the United States, Canada, and various European countries have widely utilised generative design. This technology is used for multiple purposes, including urban planning, such as in the cities of Toronto and Singapore, using generative design to design efficient and environmentally friendly urban layouts [7]. Energy Efficiency, such as the Edge project in Amsterdam, uses generative design to optimise natural light and ventilation [8] and development. Innovatively, in the housing sector, generative design helps create modular residences that are quickly built yet still meet sustainability standards [9]. The success of implementing generative design in developed countries is supported by access to high technology, skilled labour, and significant investments in research and development.

In developing countries, such as Indonesia, the adoption of generative design still faces many obstacles, such as limited access to technology like Autodesk Forma software or Rhino + Grasshopper, which require reliable hardware and internet connections that are not always available in Indonesia [10]. The limitation of human resources, such as the lack of skilled labour in using generative design tools, has become a significant obstacle [11]. Implementation costs, such as the licensing fees for generative design software, are often too expensive for many small to medium-sized architectural firms in developing countries, and there is a lack of awareness of the potential of this technology to enhance design efficiency and innovation. Nevertheless, with the right strategy, Indonesia can leverage generative design to tackle the challenges of urbanisation and create a more sustainable future.

Autodesk Forma excels as a generative design platform specifically designed to meet the needs of architecture and urban planning. With real-time data integration [12], multivariate design options [13], cloud-based collaboration capabilities, and support for in-depth environmental analysis with BIM compatibility [14] , Autodesk Forma provides comprehensive solutions for the preliminary design stage.

While other tools like Rhino + Grasshopper or Houdini offer high flexibility for creative design, they require greater technical expertise and are less suitable for integration with BIM. On the other hand, tools like Test-Fit are more limited in scope, focusing on site planning without in-depth building design capabilities, as well as Revit + Dynamo with more limited generative capabilities.

This study explores the potential of AI-assisted generative design to optimise preliminary design decisions in tropical, hot-humid climates, using Autodesk Forma as a simulation platform. Through a case study of a ten-story hotel in Cirebon, West Java, the research examines how early-stage simulations based on sun hours, daylight potential, wind patterns, microclimate conditions, and solar energy can inform environmentally responsive design strategies.

2. RESEARCH METHOD

This research adopts a simulation-based case study methodology to evaluate the effectiveness of generative design, using Autodesk Forma, in optimising architectural decision-making during the preliminary design stage. The study focuses on a ten-story hotel building in Cirebon, a city with a hot and humid climate, to examine how AI-assisted design can contribute to energy efficiency, environmental responsiveness, and spatial optimisation from the earliest stages of development.

The research process is divided into two phases. In the first phase, the Autodesk Forma platform generates and evaluates building design alternatives for the project site on Jl. Siliwangi is imported into the software using its geospatial mapping tools, which allow the contextual placement of the building within its real-world surroundings. This includes mapping adjacent structures, access roads, and environmental elements, such as solar exposure zones and wind corridors. Regulatory parameters are then input, including a maximum building height of 60 meters, a building coverage ratio (KDB) of 70%, a floor area ratio (KLB) of 8.4, a minimum green area of 15%, and a setback (GSB) of 8 meters. Environmental inputs—such as temperature, humidity, wind patterns, and sun paths—are loaded from local meteorological data and integrated through Forma's climate data layers. Environmental data in Autodesk Forma were sourced from integrated global meteorological and geospatial databases, including Meteonorm, OpenStreetMap, and satellite-derived solar radiation datasets. The platform interpolates these datasets based on the precise project site coordinates to simulate local climatic conditions.

The generative design engine in Autodesk Forma is configured with key architectural targets: a building with ten floors, a minimum width of 18 meters, integrated vegetation, and optimal orientation toward the north or south to reduce heat gain. Based on these inputs, the platform generates 54 design alternatives using multi-variable algorithms, considering spatial efficiency and environmental performance. The generated models are automatically evaluated based on five criteria: sun hour exposure, daylight potential (using Vertical Sky Component analysis), wind flow optimisation, microclimate adaptation, and solar energy generation potential. Three models are selected from these alternatives based on performance scores, contextual fit, and compliance with local regulations.

Each selected model is then virtually positioned on the project site. The final placement ensures that building masses respond to the local environment: Model 2, for example, is oriented with its primary facades facing east and west to control solar exposure, while maximising openings to the north and south for improved ventilation. The site, measuring approximately 8,900 m², is bounded by a TNI AL residence north, Gang Kramat to the south, dense housing to the west, and Jl. Siliwangi to the east. Model 2's design includes an entrance facing Jl: Siliwangi, buffer vegetation along noise-heavy zones, and rooftop solar panels oriented to maximise midday solar gain.

In the second phase, the three models are further refined. Design interventions include adding shading devices, optimising window-to-wall ratios, refining room layouts based on passive cooling principles, and strategic landscape enhancements. Each revised model is re-simulated using the same five parameters to validate thermal comfort, natural lighting, and energy efficiency improvements. One of the models is selected as the best-performing alternative, demonstrating measurable benefits in temperature regulation, reduced artificial lighting dependency, and an estimated annual solar energy production.

Data were collected from local climate records, site observations, and Autodesk Forma's built-in analysis tools to support these simulations. This data includes temperature patterns, humidity levels, solar radiation intensity, wind direction and speed, and site-specific building regulations. Both qualitative and quantitative analyses are conducted, with key indicators such as Vertical Sky Component scores, hours of solar exposure, diurnal temperature and humidity fluctuations, and estimated annual solar energy output (in kWh/year) used to measure design performance.

2.1. Case Study

Since Cirebon City is one of West Java's fastest-growing cities, it was selected as the case study site. The population of this city has been steadily increasing, rising from 337 thousand in 2021 to 342 thousand in 2023. This city, which is situated in a lowland region close to Java's northern coast and has an average height of 5 meters above sea level, has 28.4°C temperatures, 70.9% humidity, and 225.1 mm of rainfall on average (see Figure.1). As a result, like other large Indonesian cities (Jakarta, Semarang, Surabaya, etc.) [15], this city is categorized as having a hot and humid environment throughout the year, which calls for an appropriate design plan from the beginning to maximize energy consumption.

This research was conducted on Jl. Siliwangi, Cirebon City, is only about 500 m from Kejaksan Station, one of the main stations in Cirebon, as shown in the Figure. 2. Located in the city centre, this site offers convenience for tourists to reach various tourist destinations, shopping centres, and public facilities. With an area of 8,900 square meters, this site has a KDB limit of 70%, a maximum KLB of 8.4, a minimum KDH of 15%, a maximum building height of 60 m, and a GSB of 8 m, bordered as follows: to the north by the TNI AL official residence, to the south by Gang Kramat, to the west by residential areas, and the east by Jl.

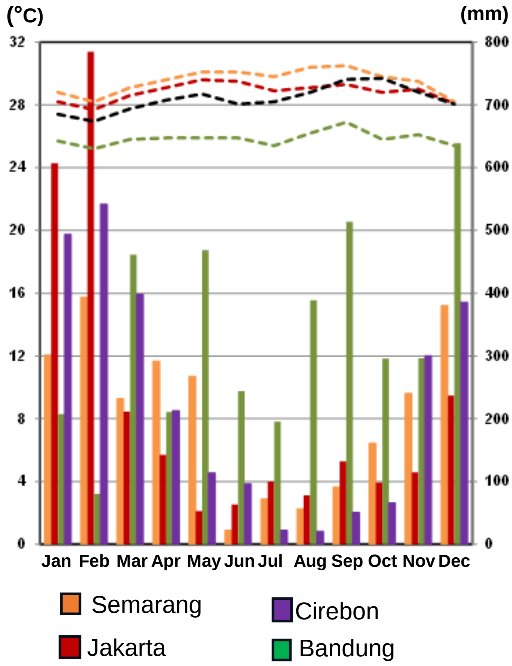

Figure. 2 Climatic condition in surveyed city

Figure. 1 Cirebon city. (a) Map of Cirebon; (b) Building site location

Siliwangi.

2.2. Case Study Building

In addition to being a commercial hub, Cirebon is regarded as a religious city due to the presence of numerous Islamic artefacts, including the Great Mosque of Cirebon, the Cirebon Sultanate, and numerous sizable pesantrens, which make the city a popular tourist destination. The number of visitors has increased steadily since the Cisumdawu toll road opened in 2022, rising from 1.5 million in 2019 to 4.7 million in 2024 [15]. The demand for lodging facilities has increased along with the number of visitors, particularly for 4-star hotels, which are in high demand but still limited. Several hotels are located near the site, as shown in Figure 3. Because hotels are meant to be comfortable places to stay, they rely significantly on active cooling, which uses much energy, in hot and muggy weather patterns. The choice to create a structure that adapts to the environment from the start will significantly impact the building's sustainability, particularly in terms of energy efficiency and the thermal comfort of hotel guests.

Figure. 3 Existing hotels around the site. (a) Luxton; (b) Swiss-Belinn; (c) Metland

2.3. Generative Design Autodesk Forma

Generative design has become one of the greatest architectural innovations, enabling faster and more optimal design decision-making. Among the various available platforms, Autodesk Forma is the best generative design solution for the preliminary design stage.

Autodesk Forma integrates intelligent algorithms designed to generate various design alternatives based on user parameterisation. The standout features of Autodesk Forma include ease of use: Compared to other generative design software like Grasshopper or Rhino, Autodesk Forma has an intuitive interface, making it easier for architects and designers without a technical programming background to utilise this technology [16] effectively. Integrated analysis: Autodesk Forma allows users to directly analyse design results based on environmental factors, such as natural lighting, shading, and energy efficiency, within the same platform. This reduces the need to transfer data between software, which often takes time. Scalability: Forma is designed to support architectural projects of various scales, from single building designs to urban areas [17].

Autodesk Forma significantly accelerates decision-making in the preliminary design stage. With the ability to generate dozens to hundreds of design alternatives in minutes, designers can explore more innovative and data-driven options. A study by Miller and Johnson [18] shows that using Autodesk Forma can reduce design exploration time by up to 40% compared to conventional methods or other software.

This platform also contributes significantly to sustainable design, with automated analysis related to energy efficiency, natural lighting, and environmental impact. Autodesk Forma supports applying green architecture principles from the early stages [19].

Compared to other generative design software (Grasshopper, Revit Generative Design, Space-maker, etc.), Autodesk Forma offers comprehensive advantages in ease of use, time efficiency, analysis integration, and flexibility [20]. This technology becomes the best solution to optimise and accelerate design decisions at the preliminary design stage, ensuring more innovative, efficient, and sustainable outcomes. This study uses Autodesk Forma 2024 with the parameters used being: Daylighting, potential daylighting, wind and micro-climate.

3. RESEARCH METHOD RESULTS AND DISCUSSION

3.1. Site analysis

Site analysis is an evaluation process that identifies various factors affecting a building at a location where the building will be erected, such as the sun's movement and wind, that relate to parameters of Autodesk Forma. These factors are described as follows:

3.1.1. The Sun's Movement

This analysis aims to understand how sunlight exposure and air temperature affect the building site so that the resulting design can optimise thermal comfort and energy efficiency. As shown in Figure. 4, in December, when the summer solstice occurs in the southern hemisphere, the sun is positioned high in the sky with an elevation angle reaching 70.29°. This provides a maximum duration of natural lighting for 12.31 hours, which needs to be utilised to optimise sunlight reception on the southeast and south sides of the building. On the March and September equinoxes, the sun's path is nearly vertical, with an elevation reaching over 75°, creating shorter shadows and an even distribution of sunlight across the building. On the other hand, in June, the sun's path is lower with an elevation angle of 57.74°, resulting in a shorter duration of sunlight, namely 11.44 hours, and longer shadows on the northern side.

Based on this variation, design strategies that focus on shading devices, appropriate materials, and natural ventilation systems are essential to maintain the thermal comfort of the building. This will allow the building to maximise natural lighting and avoid excessive heat during the summer, while maintaining thermal comfort during periods with lower sunlight intensity.

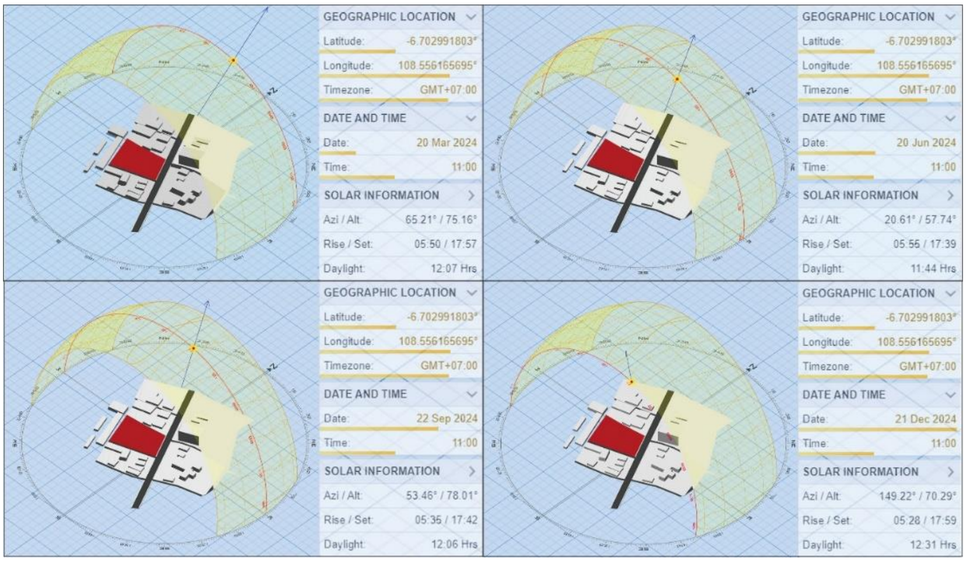

Figure. 4 Sun movement

3.1.2. Wind

Wind-related site analysis is a crucial aspect of the architectural planning and design process, aimed at understanding wind flow characteristics at a specific location. Wind has a significant influence on thermal comfort, energy efficiency, and the stability of buildings. At this stage, various wind-related data, such as direction, speed, and frequency, are analysed to evaluate their impact on the site and the structure to be built. The analysis of wind patterns (Figure 5) at the site location shows a dominance of wind coming from the south with a maximum speed reaching 5.1 meters per second (m/s) and the highest frequency, which is 34%. This indicates that the southern wind is the most significant microclimate element.

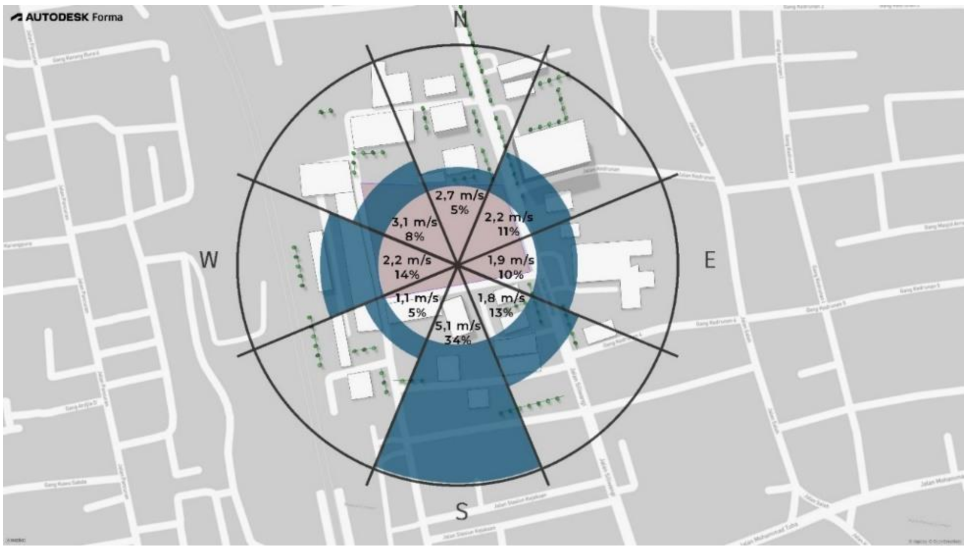

Figure. 5 Wind

3.2. Design model planning

The parameters for generating the building mass are determined by selecting building options using models, city blocks, tower buildings, and mixed buildings. Other parameters are also defined, such as having 10 floors, a building width of 18 meters, a tower block width of 18 meters, and vegetation that must be present around the building model. This process allows artificial intelligence to explore various design alternatives quickly and innovatively. The generative design process using artificial intelligence on the Autodesk Forma platform produced fifty-four (54) building mass models, as shown in the Appendix. This technology enables the' rapid and efficient development of designs by considering various architectural parameters, such as shape, orientation, and environmental context. Each mass model created offers multiple solutions, allowing design optimisation to meet design needs. From the generated models, the three best alternatives were selected by considering the characteristics of the hotel building and the environmental factors coming from site analysis, as shown in Figure 6. The alternative models must have the widest openings facing the north or south side. The model must also have a garden around the mass of the building. In addition, the three options are ensured to comply with applicable regulations and rules, so the resulting design not only meets aesthetic and functional standards but also considers environmental sustainability and thermal comfort, two critical factors in supporting hotel design.

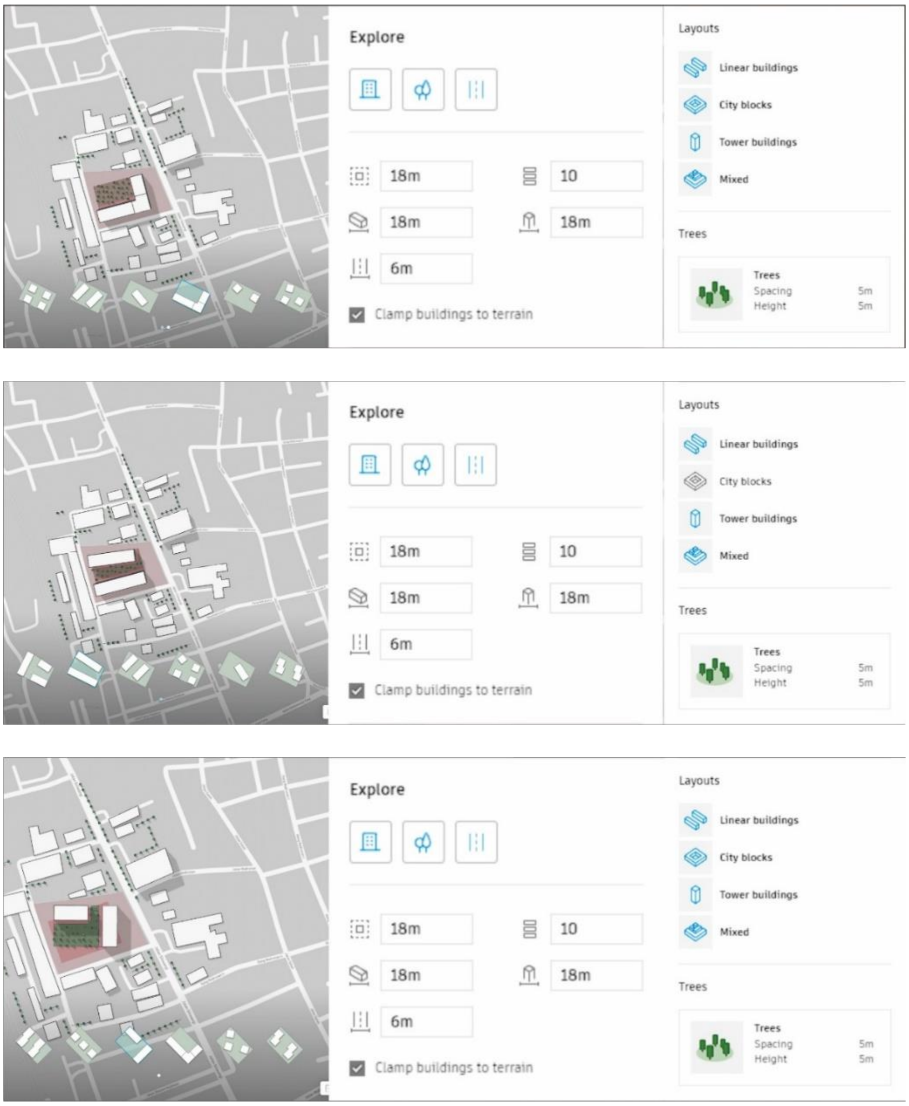

Figure. 6 Building models; (a) Model 1; (b) Model 2; (c) Model 3

3.2.1. Model 1

In the first alternative model in Figure 6a, generative design produces an L-shaped hotel building mass. The mass orientation in this first alternative has the widest openings facing the north and south sides. This step is a strategic effort to optimise natural lighting and ventilation, while also reducing direct sunlight exposure during the day, thereby enhancing thermal comfort within the building.

3.2.2. Model 2

The generative design produces two hotel building masses in the second alternative model (Figure 6b). This design is formed by selecting a predetermined freeform shape of the building. The presence of vegetation around the building is also one of the essential elements, with a garden located between the two building masses, creating a green open space that enhances the environmental quality around the building. This second alternative design provides a balance between space efficiency and the use of vegetation to create a more comfortable environment.

3.2.3. Model 3

The generative design produces two hotel building masses in the third alternative model (Figure 6c). This design is formed by choosing the shape of the building mass that is perpendicular to the north and south sides. The mass orientation in this third alternative model is divided into two building masses. The first building mass has the largest openings facing east, allowing natural light to enter in the morning without causing excessive heat during the day. Meanwhile, the second building mass has north and south openings, which is the optimal orientation to reduce direct sunlight exposure and enhance natural air circulation.

3.3. Research Process of Phase 1: Design of mass model simulations

The three best models selected above were simulated by several parameters such as sun hours, daylight potential, wind, micro-climate and sun energy. The following sub-section explains the analysis of Model 2 as an example.

3.3.1. Sun hours

The sun hour simulation is conducted during the solar equinox, or when the sun passes directly over the Earth's equator. Figure 7 shows that the simulation times are set for March 20-21, June 20-22, September 22-23, and December 21-22. The simulation at that time is due to the distance between the sun and the Earth being the closest, and the duration of day and night being the same worldwide. This analysis focuses on several parts of the building: the ground surface, facades, and roofs.

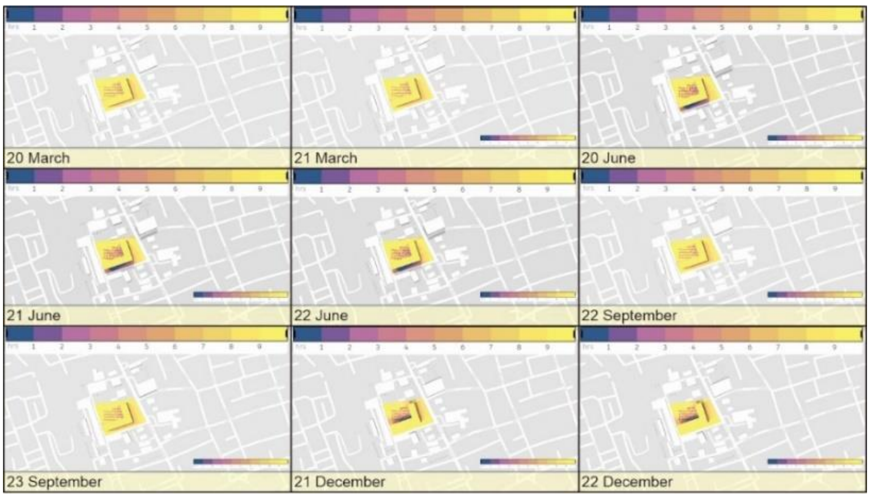

Figure. 7 Sun hours

The results of this simulation show that the highest sunlight exposure occurs in March and September, particularly in the ground and roof areas, with some parts of the building receiving more than 9 hours of sunlight exposure. However, in June and December, sunlight exposure on the facade decreases significantly, although the roof and ground areas still receive quite a high level of exposure.

3.3.2. Daylight potential

The model generated by artificial intelligence is then simulated to determine the potential sunlight on the building. This analysis uses a model of an overcast sky and predicts lighting on the building's surface using the Vertical Sky Component method. By analysing the potential sunlight, it will be possible to determine the performance of the sun on the building, particularly highlighting the areas of the building facade. The analysis results provide an assessment (Vertical Sky Component score) for areas where larger windows or layout changes are needed to address the lack of sunlight optimisation, or areas that are difficult or impossible to achieve adequate sunlight (Table 1).

Table 1 Vertical sky component score

Threshold of the Vertical Sky Component (VSC) – for points on the facade.	Daytime conditions
VSC ≥ 27%	The design of conventional windows is usually satisfying.
15% < VSC < 27%	A larger window/layout change is usually needed.
5% < VSC < 15%	It's difficult to get enough sunlight.
VSC < 5%	Reaching sufficient sunlight is often impossible.

Overall, as shown in Figure 8. This alternative model has a high potential for natural lighting, especially on the roof and most of its facade. This potential can be utilised to reduce dependence on artificial lighting and improve overall energy efficiency. However, in some areas of the facade with lower lighting, optimisation may be necessary, for example, by using more adaptive designs such as larger windows or more reflective materials to improve the distribution of natural light.

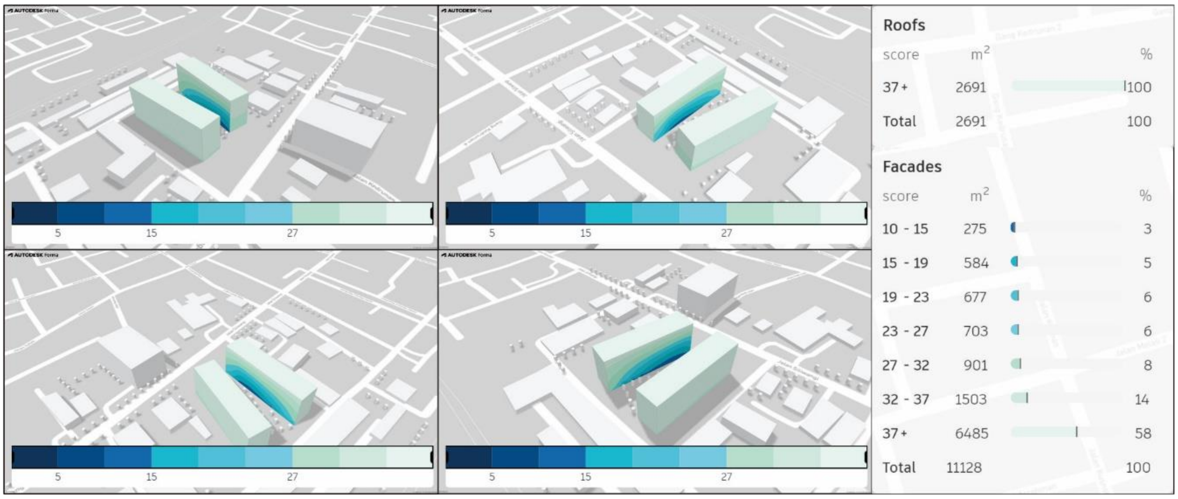

Figure. 8 Daylight potential

3.3.3. Wind

Wind analysis at the site location is crucial to sustainable architectural planning. By understanding the wind movement patterns around the site, architects can optimise natural air circulation to create cool indoor spaces and improve the building's energy efficiency. This analysis includes the identification of the dominant wind direction and wind speed.

Figure 9 shows the dominance of wind from the South direction with speeds of up to 5.1 m/s at roof level, accounting for about 34% of the total wind direction. Other significant wind directions include

winds from the Southwest with an average speed of 1.1 m/s at ground level and winds from the Southeast, contributing 13% of the total wind directions.With a speed of 1.9 m/s. The wind from the Northwest also contributes 8% with an average speed of 3.1 m/s. The wind rose diagram shows that the South and Southeast.
Directions have the most influence, while the winds from the West and Northwest have a minor impact.

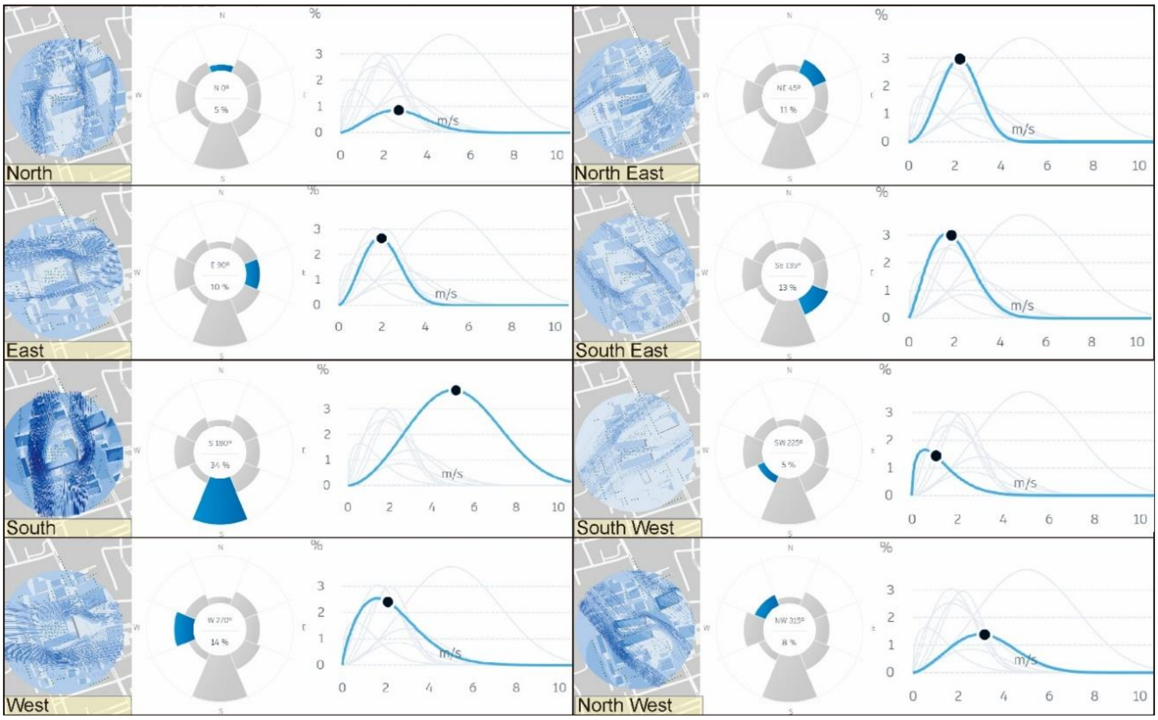

Figure. 9 Wind Analysis

3.3.4. Micro-climate

Microclimate simulation at the site location is a critical step in architectural planning to understand the local climate conditions in detail. This simulation combines the results of solar, daylight, and wind analysis with local weather conditions to calculate the perceived temperature at the site location. This insight will help understand how local climate conditions can react to the shade and wind situations created by the design. Microclimate analysis aims to help make more precise and sustainable decisions when designing outdoor spaces at the site location.

The results of the microclimate simulation on alternative model 2 that have been conducted, as shown in Figure 10, show a significant temperature variation (Figure 10a) and humidity (Figure 10b) throughout the day, with a consistent pattern at each observation time. The data shows that the temperature in the morning ranges from 26°C to 27°C and gradually rises during the day and evening to peak around 30°C to 32°C, before dropping progressively at night to 27°C to 28°C. A decrease in relative humidity accompanies this increase in temperature; in the morning, relative humidity ranges from 84% to 90%, but gradually decreases to its lowest point at night.

These microclimate changes show a strong relationship between increased temperatures and decreased relative humidity during the day, caused by increased evaporation and solar radiation intensity. Conversely, at night, the drop in temperature causes an increase in moisture due to the atmospheric cooling process, resulting in the condensation of water vapour in the air. Based on this information, building design requires planning for ventilation systems, building materials, and passive design elements to adapt to microclimate changes.

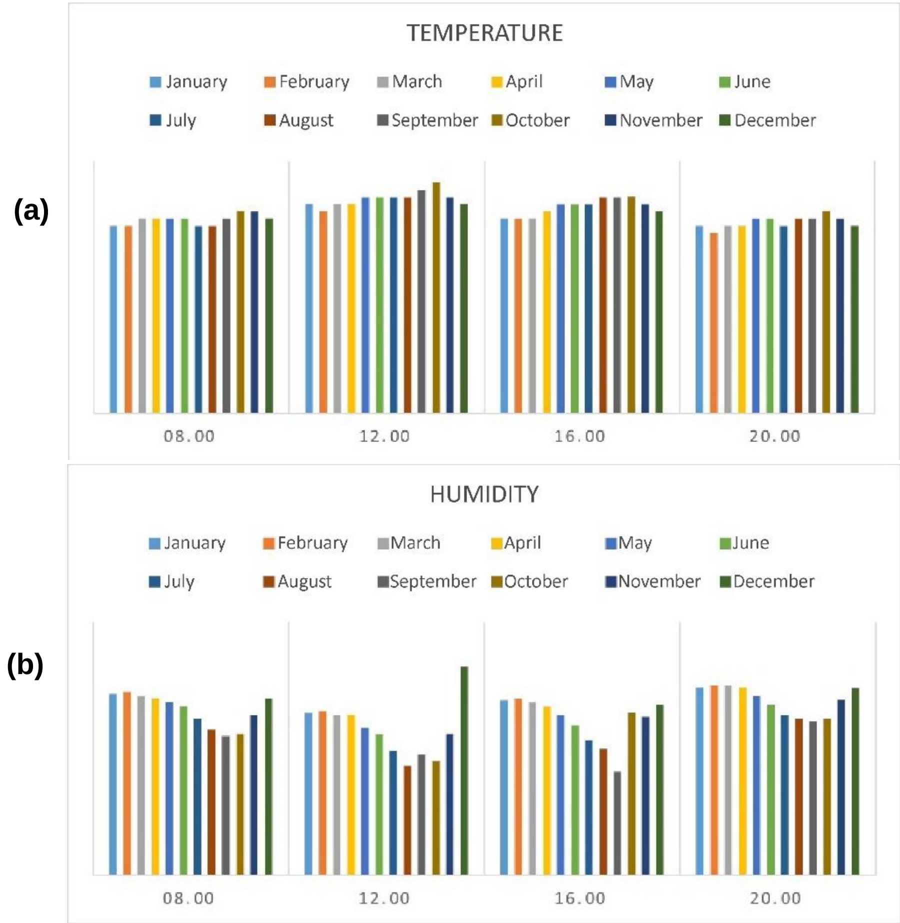

Figure. 10 Micro-climate on site; (a) Temperature; (b) Humidity

3.3.5. Solar energy

The detailed solar energy simulation results allow for evaluating the potential to generate electricity using solar energy at the building's location. Solar energy simulations can also help identify which facades or roofs are most exposed to solar radiation and allow for estimating the annual electricity production potential from solar panels—Figure 11. The simulation results for the second alternative indicate that from 2,690 m² of roof floor area, the estimated placement of solar panels can be done on 40% or approximately 1,076 m² with a solar panel efficiency of 10%. The installed solar panels are estimated to generate an annual electricity amounting to 165,000 kWh. This simulation shows that the building has significant potential to harness solar energy, although the panels' efficiency is relatively low.

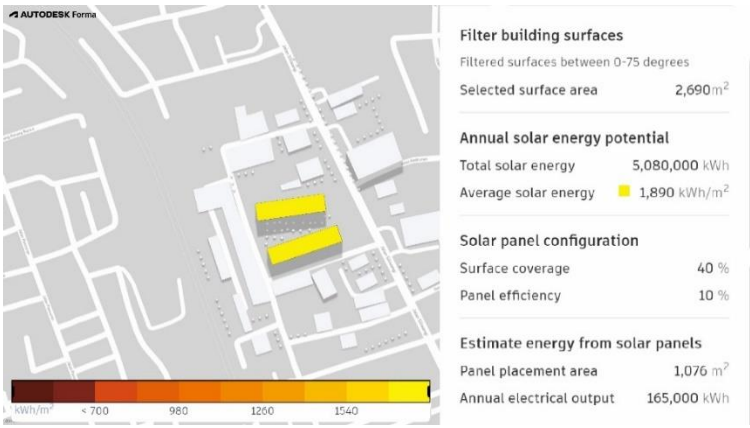

Figure. 11 Solar energy

3.4. Research Process of Phase 2: Design of development model simulation

To enhance and optimise the results of the analysis that has been conducted, a design intervention can be implemented. At this stage, several alternative design models are developed, taking into account architectural parameters related to the environment. Each model is formulated to optimise the interaction between the building and its surrounding environment, to achieve energy efficiency and occupant comfort through a design approach responsive to the local climate, such as temperature, humidity, wind direction, and sunlight intensity. Then, the exact simulation was conducted in sub-sections 3.3.1-3.3.5.

The interpretation of data from Autodesk Forma simulations revealed significant insights into the environmental performance of the design alternatives. Three massing models were shortlisted based on their orientation, compliance with building regulations, integration of green spaces, and potential to enhance thermal comfort. These alternatives were then developed in more detail, incorporating additional openings, optimised window-to-wall ratios, passive shading elements, and landscape adjustments.

The sun hours analysis showed that Model-2 distributed solar exposure more evenly throughout the year, reducing the risk of overheating while maximising natural lighting. This supports reduced reliance on artificial lighting, particularly during peak daytime hours. Daylight simulations using the Vertical Sky Component (VSC) method indicated that over 70% of Model-2's facade achieved VSC scores ≥ 27%, signifying adequate daylight penetration and minimal need for layout adjustments.

Wind simulations demonstrated that Model-2 provided better natural ventilation potential, with its form and orientation accommodating dominant southern winds (5.1 m/s, 34% frequency), enhancing indoor air circulation. Microclimate modelling indicated that this design maintained temperature fluctuations within a narrow range of 2–3°C throughout the day, especially during peak thermal hours, and maintained relative humidity levels conducive to comfort. These findings confirm that Model 2 offers improved passive cooling and indoor environmental quality.

Solar energy analysis showed that approximately 40% of the total roof area (1,076 m^2) was suitable for photovoltaic installation. An efficiency rate of 10% could yield an estimated 165,000 kWh annually, significantly contributing to the building's energy supply and reducing dependency on grid electricity.

While the findings of this study highlight the benefits of AI-assisted generative design, it is essential to note that adopting such technologies may not be accessible to all practitioners. Smaller architectural firms or projects with limited budgets may face barriers due to the high costs of software licenses, necessary hardware upgrades, and the need for skilled human resources. Consequently, the applicability of the results may skew toward firms with significant technological and financial resources. Future research should explore strategies to democratise access to generative design tools, such as developing open-source platforms, more affordable licensing models, or collaborating with educational institutions to enhance skill-building across a broader range of practitioners.

3.5. Data Reliability Considerations

Although AI-assisted generative design platforms such as Autodesk Forma integrate real-time environmental data and advanced simulation algorithms, the design outcomes' reliability heavily depends on the quality, accuracy, and completeness of the input data. If the environmental, site, or regulatory data fed into the system is outdated, incomplete, or inaccurate, it can result in suboptimal or misleading design solutions. This limitation underscores the critical role of careful data verification before simulation and suggests that AI should complement — rather than replace — professional judgment. Future studies should emphasise robust data collection practices and consider validating AI outputs through cross-referencing with manual analysis or alternative simulation tools.

4. CONCLUSION

This study explored the application of artificial intelligence-assisted generative design, using Autodesk Forma 2024, to optimise architectural decision-making in the early planning stage of a ten-story hotel in the hot-humid climate of Cirebon, Indonesia. By simulating five critical environmental parameters—sun hours, daylight potential, wind distribution, microclimate conditions, and solar energy potential—the research generated 54 alternative building mass models. Following a two-phase evaluation and development process, three models were shortlisted, and Model 2 was identified as the best-performing alternative. It achieved notable improvements, including an estimated 23% energy efficiency gain, enhanced daylight access (Vertical Sky Component ≥ 27% across more than 70% of the facade), and solar energy generation potential of approximately 165,000 kWh/year.

The findings demonstrate that AI-driven generative design can significantly accelerate the preliminary design process while promoting environmental responsiveness and energy efficiency. However, the study also acknowledges key limitations related to technology accessibility, high costs for smaller firms, and the dependency on accurate and comprehensive input data to ensure reliable outcomes.

Future research should validate AI-generated results across various building typologies and climatic contexts, integrate occupant comfort modelling, and explore multi-objective optimisation approaches that balance environmental, functional, and experiential design goals. Expanding access to generative design tools through open-source platforms and targeted educational initiatives may also help democratise the benefits of AI-assisted design across the architectural profession.

By advancing generative design practices within diverse local contexts, architects and planners can contribute meaningfully to developing more resilient, sustainable, and innovative built environments.

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