Solar Simulation to Realize the Concept of Smart Building at Ibnu Sina Regional General Hospital of Gresik

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Abstract: In realizing the smart city concept, it requires the existence of smart buildings within the scope of the city, which can be initiated by the local government. Hospitals as health service institutions by the government, provide complete individual health services, starting from the provision of inpatient, outpatient, and emergency services. The object of the case study is the Ponek Building and the Emergency Unit of Ibnu Sina Hospital – Gresik, East Java. The development, both in quality and quantity, was carried out in stages at the Ponek Building and Emergency Unit at Ibnu Sina Hospital (2015 and 2020), both due to increased workload, and as an effort to serve Covid-19 patients. As climate change worsens, hazardous weather events become more frequent or severe. So that the concept of smart building is needed to be applied in formulating strategies for buildings that are environmentally friendly and synergize with smart cities, without compromising user convenience. The right strategy can be formulated by identifying responsive characters, implementing optimizations, conducting simulations, and designing automation applications. Solar simulation in buildings is important to minimize energy use in the operation of the Ponek Building and the Emergency Unit of Ibnu Sina Hospital.

1 INTRODUCTION

Along with the development of technology and the start of the industrial era 4.0, the health sector no longer views technology only as facilities and infrastructure. However, technology has now evolved into a strategic asset in hospital services. In various parts of the world, the use of technology such as Big Data, Internet of Things, and Artificial Intelligence in the world of health has become commonplace. Smart hospital designs are made in such a way as to improve patient experience and reduce costs to get maximum profit or results. Basic concept of Smart Hospital (Figure 1) is a concept that emerged as a result of the rapid digitization of the entire Health care industry with the use of information technology as a key enabler, especially the Internet of Things (IoT), data analytics, personalized service availability, and Artificial Intelligence (AI), as well as Cloud Computing.

Figure 1: Smart Hospital Basic Concept.

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Aimed at overcoming obstacles that allow networks in different regions to still be connected and used by several types of users simultaneously and integrated, involving patient service integration, stakeholder integration, and technology integration. In addition, the emergence of Cloud Computing and sensor awareness of infrastructure-architecture methods, service-oriented architecture, software delivery and development, are contributing factors to the smart environment (Al-Fuqaha et al., 2015; Noor, 2017).

Ibnu Sina Regional General Hospital is located on Jl. Dr. Wahidin Sudirohusodo No. 243B, Kembangan Village, Kebomas District, Gresik Regency, East Java. Geographically, Gresik Regency is located between 112° to 113° East Longitude and 7° to 8° South Latitude, is a lowland with an altitude of 2 to 12 meters above sea level. The PONEK Building and the Emergency Room at the Ibnu Sina Hospital were totally rehabilitated in 2015 due to an increased workload on the PONEK and Emergency Room service units. In 2020, this building is focused on serving Covid-19 patients. The Emergency Room is equipped with facilities, such as Radiology (CT scan, General X Ray), Laboratory, Pharmacy/Pharmacy, Blood Bank, Ambulance Service (Emergency Ambulance, Transport Ambulance, Body Ambulance), Central Surgery. The Emergency Room is also equipped with equipment, including: Bed Site Monitor, ECG, Difibrillator, Infusion Pump, Syringe Pump, WSD, Suction Pump, Emergency Kit, Ventilator, Infrant Warmer and Incubator.

Paper of Balocco (2011) as previous research revealed that transient simulation using the FEM-based CFD technique can be used to analyze the efficiency, adequacy, and improvement of existing HVAC systems equipped with VAVs. In this case, no one else can provide input for handling air quality, patient comfort, and energy consumption in building operations. Other research (Kadaei et al., 2023) in encouraging the realization of smart buildings that also support sustainable development, it is necessary to educate from a material perspective. This is important due to challenges during the development process in the form of "Errors in labor and errors during execution."

1.1 Logical Architecture of iotHEALTHCARE

To get a smart healthcare system with the previous five components, it is recommended that iotHEALTHCARE compile architectural logic as shown in the picture below (Figure 2). Where each iotHEALTHCARE component is discussed as a feature. The main characteristics of each feature must be maintained to carry out its duties.

Figure 2: Logical Architecture of iotHEALTHCARE.

The following are the characteristics of the five features (Figure 2), namely: (1) Stability, real-time sensor monitoring continuously requests stability for data collection; (2) Continuity, interoperability support for network intelligence requires continuity to communicate with users, the internet, and between each other; (3) Confidentiality, strong storage for computing resources into cloud computing for confidentiality of storing dynamic data; (4) Reliability, big-data analysis asks for reliability to turn dynamic data into valuable information; (5) Efficiency, smart hospital asks for efficiency for proper diagnosis and treatment. Building an IoT application for iotHEALTHCARE requires integrating five different features. If one of the characteristics is missing, it can damage the perfection of the features and turn into a worthless system (Atzori et al., 2010).

To increase efficiency in health care and biomedical, is one of the main goals in today's modern life. Therefore, it is very important to provide high-quality healthcare to patients and be able to reduce healthcare-related costs, as well as address staffing issues and shortages.

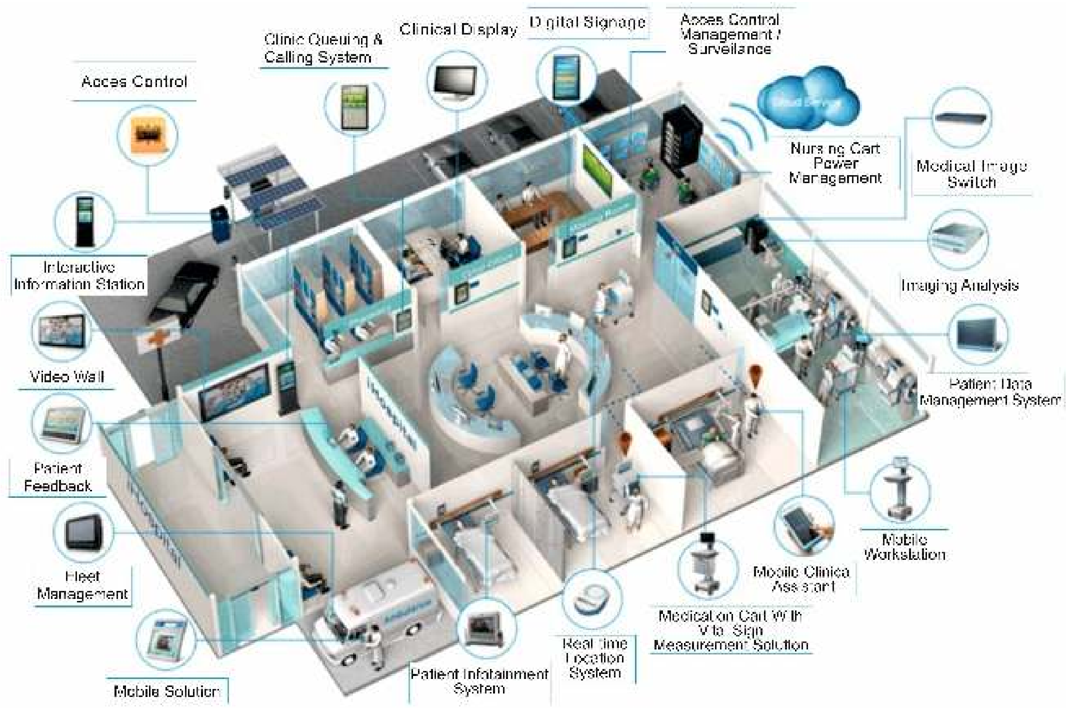

Figure 3: Smart Hospital Concept.

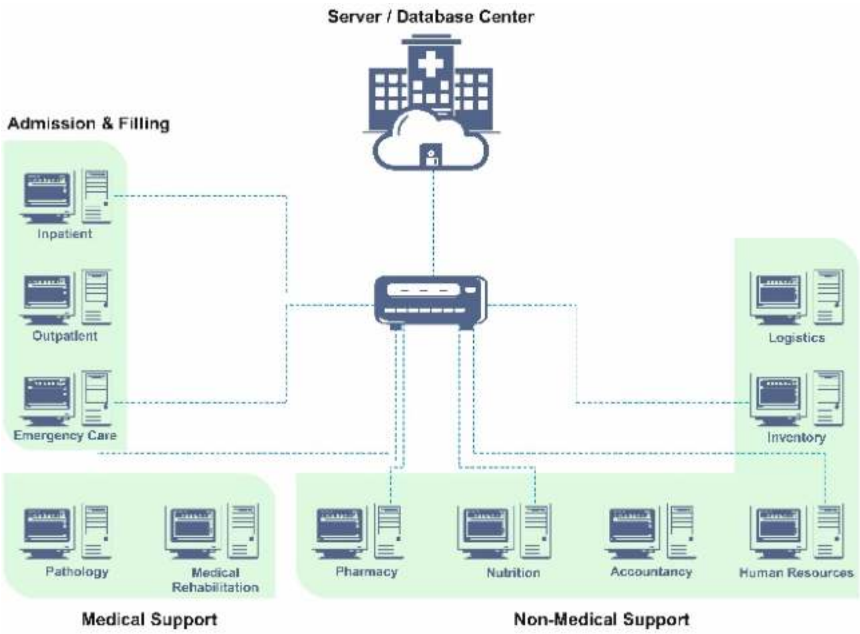

Figure 4: Data Integration at Smart Hospital.

Hospitals as organizations engaged in health services require information technology support in various operational aspects, especially in improving services to patients.

The government has made smart hospital one of the national programs since 2017. This is stated in the Republic of Indonesia's Minister of Health Regulation, No. 46, 2017, which consists of 7 components that determine the success of implementing Smart Health, starting from governance and leadership, strategy and investment, services and applications, standards and interoperability, regulatory infrastructure, policy and policy compliance, and human resources.

Technology has opened a new dimension in the Hospital service process and the administrative and operational management required. With the support of Hospital Information Technology, the Smart Hospital concept can be created (Figure 3). Smart Hospital is a smart concept adopted through hospice services that focuses on optimizing patient care at the hospital by using an internet-based information technology system that supports the connectivity of medical and non-medical equipment, so that it can provide quality services and satisfy patients.

One of the goals of implementing the smart hospital concept is to create an integrated system. Integration intended in health services in hospitals includes integration of patient services (referral services between different health facilities), stakeholder integration (hospitals as part of a health service entity that needs to be supported by other stakeholders, such as the Ministry of Health, Social Security Administration Agency -Health, and other institutions), and technology integration (Using technology in integrating hospital management information systems, integrated referral systems, telemedicine, and so on) (Noor, 2017).

Smart Hospital is not only limited to the use of technology in the services provided. But it also integrates all service units in one unified work system (Figure 4). This integration can encourage each unit to provide quality and efficient services. The use of technology, such as the Hospital Management Information System (HMIS) allows service data to be managed digitally. This digitization can speed up the distribution of information and tasks, so that medical and non-medical work in hospitals can be completed more quickly.

2 METHODS

Building performance simulation (BPS) is crucial in the design and operation of energy-efficient buildings and/or communities (Hong et al., 2018). The smart hospital itself is a product of smart building which has 3 key principles, namely: economy, energy, and technology (Nugroho et al., 2020). Smart building also supports the realization of green & eco building in the framework of energy efficiency, which means that environmental factors cannot be ruled out in its design or operation (Badan Pengembangan Infrastruktur Wilayah (BPIW), 2016; Hidayat, 2011; Lizar, 2021).

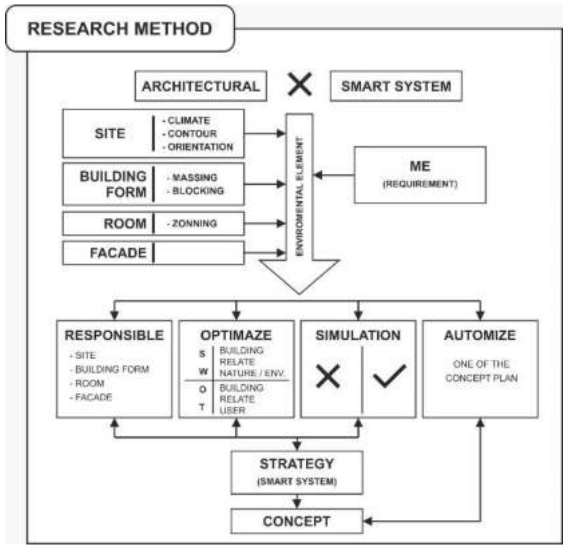

Figure 5: Methods.

Architectural aspects and Smart system aspects in buildings are integrated, to respond to environmental elements, to find the concept of smart building as follows (Figure 5): (1) Responsible, consisting of Site, Building Shape, Space, and Facade; (2) Optimaze, namely by SWOT analysis (SW = Building Relating Nature/ Environment and OT = Building Relating User); (3) Simulation; (4) Automize, so that it can create a "STRATEGY" which contains various smart systems, so that it can finally create a "CONCEPT".

3 CASE STUDY OBJECT

In order to discuss the object of study, it must discuss environmental aspects, users, and building of the Ibn Sina Hospital building.

3.1 Solar

Ibnu Sina Hospital is located on Jl. Dr. Wahidin Sudiro Husodo No. 243B, Kembangan, Klangonan, Kec. Kebomas, Gresik Regency (Figure 6).

Figure 6: Satellite image of the Ibn Sina hospital.

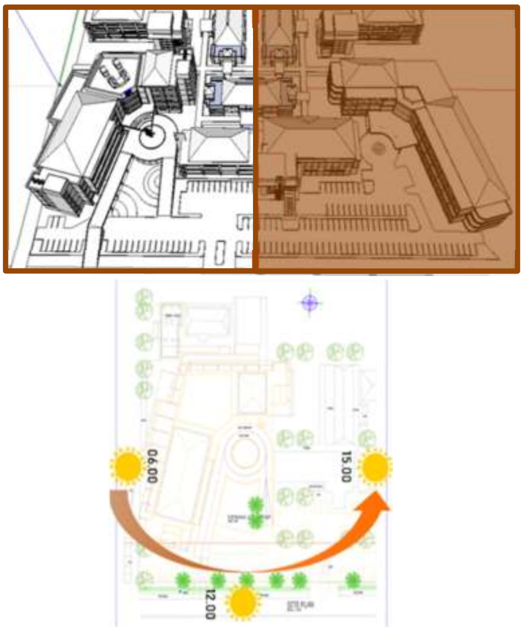

Figure 7: Solar Positioning.

With the condition of the northern site is the mall icon, the East is the Airlangga University Nursing D3 Vocational School, the South is with government offices, and the West is the entrance to the Gresik Regent's office (Figure 7).

3.2 Temperature

Summer with average daily highs above 33°C with a temperature range of 26°C - 34°C (Figure 8). Winter average daily highs are below 32°C. With an average temperature range throughout the year ranging from 25°C - 31°C.

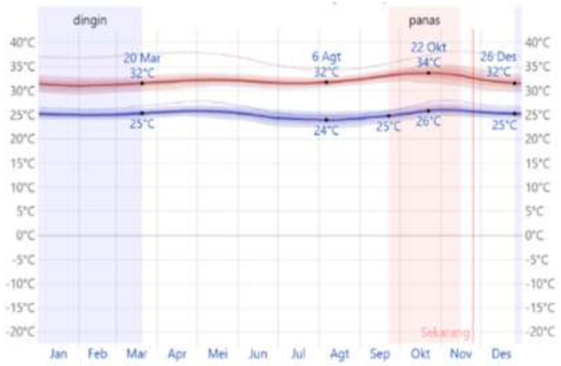

Figure 8: Temperature data.

3.3 Wind

The average hourly wind velocity in Gresik experience significant seasonal variations throughout the year (Figure 9). The windiest season of the year lasted 4.5 months, from 26 May to 12 October, with average wind velocity of over 11.6 kilometers per hour. The windiest month of the year in Gresik is August, with average hourly winds of 14.4 Km/H. The windier period of the year lasts 7.5 months, from October 12 to May 26. The least windy month of the year in Gresik is November, with average hourly winds of 9.0 Km/H.

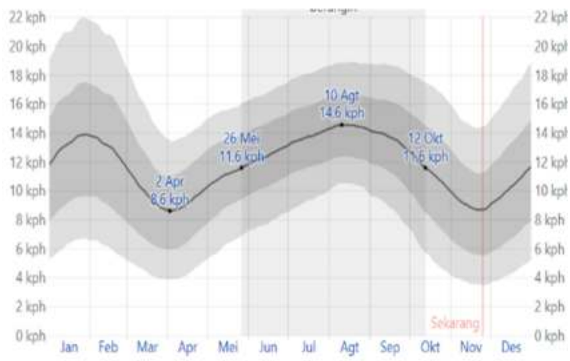

Figure 9: Wind velocity data.

3.4 Humidity

Basis comfort level humidity on the dew point, as this determines whether sweat will evaporate from the skin, cooling the body. Lower dew points feel drier and higher dew points feel more humid. Unlike temperatures, which usually vary widely between night and day, dew points tend to change more slowly, so while temperatures can drop during the night, humid days are usually followed by humid nights. The level of humidity felt in Gresik (Figure

10), as measured by the percentage of time in which the comfort level of humidity is humid and hot, stifling, or miserable, does not vary significantly throughout the year, remaining within the range of 4% from 96%.

Figure 10: Humidity and its sense data.

3.5 Land Contours (Topography)

If viewed from the location of the site and the E-E sectional images, it can be seen because it is in lowland, the site has a flat contour. The location is below 200 masl, this makes the contours and land surface in the lowlands a location with flat and flat land contours. Therefore, there is no cut and fill site work methods, that seen on flat elevation of building floor (Figure 11).

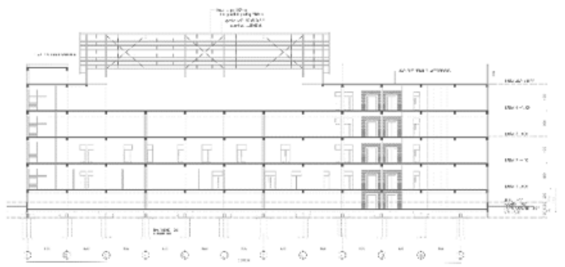

Figure 11: PONEK and Emergency Unit Building Section Plan.

4 RESPONSIVE & OPTIMALIZATION ON BUILT ENVIRONMENT CONCEPT

In order to formulate the smart hospital's building concept, one must understand how buildings respond to the environment, both existing and alternative ideas. The alternative ideas are formulated to optimize building perimeter performance in response to environmental factors. Strategic matters are also formulated to be able to realize the concept of smart hospital building (Table 1).

Table 1: SWOT Matrix of smart Ibn Sina Hospital building strategies.

		S	W
		1. The orientation of the building tends to extend to the North and West (the basic shape of the 'L' plan), so that it has a fairly large view from the site/building. 2. Have active openings as a function of natural air entry/exit in several spaces that are directly adjacent to the outer space 3. The order of the building masses is oriented (widened) to the main road so that it has a high value in visual reach to the site 4. Strategic site location 5. Some buildings with north-south oriented openings get indirect natural light.	1. During the day has a high ambient temperature which affects the low thermal comfort of the building. 2. The majority of building openings that are oriented west-east receive direct natural light and experience glare which risks contributing to high heat loads. 3. The facade of the building has not considered the incoming natural air filtration system 4. Some of the rooms are directly adjacent to the outer space—the direction of the provincial road
O	1. Many open land areas without pavement. 2. Facade walls in the form of large areas that provide opportunities for façade play 3. Using an artificial ventilation system & technology that has high flexibility in room temperature settings 4. The temperature tends to be comfortable during the rainy season 5. The wind velocity is quite high, considering that the environment is not a densely built area.	The application of a healing environment has the potential to be applied in the healing process and as a vista of the interior spaces of buildings that have openings to the north and south sides of the outer spaces (S1, S2, S5, O1, O4) Applying attractive building facade designs, especially in large areas and/or oriented to protocol roads (S3, S4, O2)	Using a building facade/enclosure composition (opaque & transparent) and combining active and dead openings, which is able to reduce heat entering the building and allows passive cooling, in order to reduce the burden of artificial ventilation devices. (W2, O3, O5)

		S	W
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T	1. The thickness of the building causes natural light to not reach all spaces 2. Compartment of space exacerbates the inability of natural light to reach all spaces in the building 3. High ambient temperature during the dry season adds to the burden of the artificial ventilation system 4. Shading against rainwater (direct & indirect) is important, especially during the rainy season 5. The wind carries a number of pollutants considering that Gresik is an industrial area 6. Noise pollution from the direction of the protocol road is quite high because it is a provincial road	The composition of the building envelope must be attractive and able to minimize visibility from existing openings, as well as allow natural light to refract into the spaces in the building, especially in areas facing the main road. (S1. S2, T1, T2, T4)	The noise is high in the room that receives noise from the provincial road, it can be overcome by indoor and outdoor acoustics which are able to dampen outside sounds and function as a natural air filter, especially the rooms in the north. (W3, W4, P6) Softscape elements can be applied in order to engineer the microclimate as well as a noise barrier. (W1, P3, P6)

The strategies resulted from the SWOT analysis (Table 1) are then applied in the re-design process. However, it is necessary to simulate the existing condition of the building, in order to justify the level of urgency of these strategies.

5 SOLAR SIMULATION

The simulation is carried out using web-based software, to justify the accuracy of implementing the strategies to realize the on-built environment optimization concept. The simulation process time was carried out at 08.00, 12.00, and 16.00 GMT+7. During the coldest month, the area of the resulting shadow tends to be wider than during the hottest month. Because during the hottest month, the position of the sun begins to be on the south side.A.

At the time of the Summer Solstice on December 22, the position of the sun is in the southern hemisphere. From the results, it is known that the resulting shadow area tends to be smaller and the heat temperature is higher.

The actual building performance needs to be compared with similar buildings equipped with control solutions (Beguery et al., 2011). Building simulations are presented as data interpretations including thermal behavior, energy patterns, and space placement patterns and behavior in order to design input ideas that can be implemented such as control by occupants and user demands (Fan et al., 2021).

The control solution itself has 2 stages, passive control (by optimizing the basic building design parameters) and active control (with the involvement of ME and AI). Table 2 will show the differences before and after the treatment of the basic building design parameters, in terms of sun exposure.

In the morning, the east wall is filled with red, which means it receives the most heat, but the hot temperature can still be tolerated. During the day, the roof receives the most heat. So, the use of non-concrete roofs is considered less effective, and also because of the high hot temperatures.

In the afternoon, the west wall is filled with red, which means it receives the most heat, and the high temperature causes disruption of thermal comfort. It can be reduced by providing vegetation in the form of tall and shady trees (Table 2).

Table 2: Build environment shadowing.

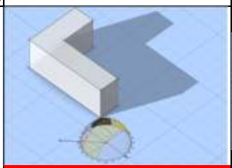
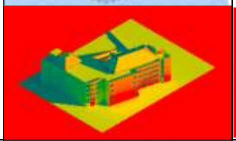
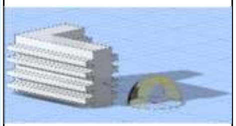
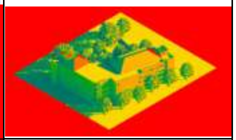
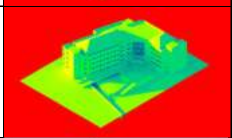
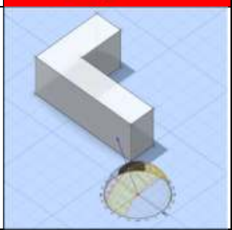
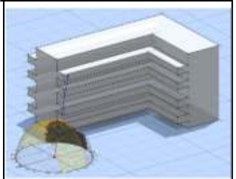
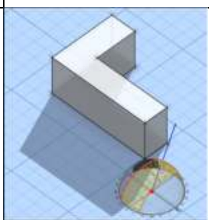
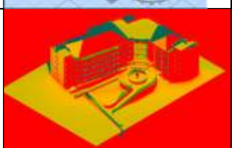
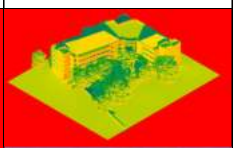
Time, Building façade orientation	Existing	Optimalization on Built Environment Concept
Summer Solstice 08.00 AM GMT+7, East	 	 
Summer Solstice 08.00 AM GMT+7, West		
Summer Solstice 12.00 AM GMT+7, East		
Summer Solstice 12.00 AM GMT+7, West		
Summer Solstice 04.00 PM GMT+7, East		
Summer Solstice 04.00 PM GMT+7, West		 

Figure 12: Existing Emergency Unit façade consist of walls, glasses window, and another opening.

Figure 13: Application of the facade in the VIP Pavilion area.

The shape of the facade of the Ponek Building and the Emergency Room (IGD) of Ibnu Sina Hospital is based on the shape of the VIP pavilion building. The application of form of a shield roof is used to respond to tropical climates, especially during strong winds, especially during the rainy season. Effective for lowering rainwater when it falls.

6 BUILDING MECHANICAL AND ELECTRICAL SUPPORT

To create a smart building concept in a building, at first must be understand the Mechanical and Electrical (ME) supports in the building.

Table 3: ME Support.

• System electrical	System Sentral medical gas	System firearm	Scope of facilities for plumbing and drainage system
• Cubicle & Instalment for medium voltage, 20 KVA • Step-down transformer 20 KVA/0.38 KVA • Low voltage main distribution panel,	• Oxygen • Nitrous Oxide • Vacuum/ Suction • Compressed Air, 4 bar & 7 bar, C4 & C7 • Medical Gas Equipment: a. Gas Station for O2, NO2, compressor	• System Hydrant for outdoor dan indoor • Fire alarm and detector system • Manual call dan system evacuation • Portable fire fighting system	• Supplee clean water include with system pump, filter, water treatment, installs piping, dan sanitary fixtures (toilet and medical type)

• System electrical	**System Sentral medical gas**	**System firearm**	**Scope of facilities for plumbing and drainage system**
completed with cable • Outdoor dan Indoor Lightning & power socket outlet installation • Standby generator set: 2x200 KVA • Uninterrupted power supply: 2x20 KVA	dan central vacuum unit b. Instals pipping c. Outlets for medical gas system d. Medical gas support system, pendant, etc		• Flushing water supply, kitchen, laundry, laboratory, operation theatre, ICU/ICCU, etc • Water supply PDAM • Drainage system for flushing and rainwater, sewerage system for ware included installation and equipment

7 SMART HOSPITAL BUILDING CONCEPT

Based on the results of the SWOT analysis and ME supports, several input ideas for automation can be drawn, namely: (a) Automation lightning: Circadian light. The lighting control system adjusts the time of day and night; (b) Ventilation Automation: Using AC VRV to prevent excessive cooling, by using the Thermostat Control; (c) Fire alarm and detector systems; (d) Smart toilet: by using an automatic toilet and; (e) Smart Curtain: to prevent solar radiation from entering the building envelope; (f) Audio and visual screen beside the patient's bed that is adjusted with live streaming capabilities so that the patient's health condition (real-time) and automation lighting; and (g) Central Vacuum Cleaner: for high level of cleanliness.

Figure 14: The concept of the Ibn Sina Hospital Master Plan.

From this strategy and input ideas, the concept of developing a hospital building with smart hospital building values is "Affordable Smart Hospice Built Environment for Variant Range of Users".

The concept formed is applied starting from the building to the landscape of the Ibnu Sina Hospital (Figure 14). The application of the concept to buildings extends to the spaces within the building, including inpatient rooms, pharmacies, and registration rooms - waiting rooms.

Figure 15: Inpatient Room Interior Concept - circulation area.

Figure 16: Inpatient Room Interior Concept - patient bed area.

Figure 17: Pharmacy's Area Interior Concept.

Figure 18: Registration Room and Waiting Room Interior Concept.

8 CONCLUSIONS

The Smart Hospital design is made in such a way as to improve the patient experience and reduce expenses to get maximum profit or results. Smart Hospital is a concept that emerged as a result of the rapid digitization of the entire Health care industry with the use of key enabling technologies, especially the Internet of Things, data analytics, personalized service availability, and Artificial Intelligence, as well as Cloud Computing.

Intended to overcome obstacles that allow networks from different regions to be connected and used by several users simultaneously. In addition, the emergence of Cloud Computing and sensor awareness of infrastructure-architecture methods, service-oriented architecture, software delivery and development, and is a farkot contributing to the smart environment. Building an IoT application for iotHEALTHCARE requires integrating five different features. If one of the characteristics is missing, it can destroy the perfection of the features and turn into a worthless system.

Therefore, it is very important to provide high-quality healthcare to patients and be able to reduce healthcare-related costs and overcome problems and understaffing. Hospitals as organizations engaged in health services require information technology support in various operational aspects, especially in improving services to patients.

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