The Simulations of Energy based on the Building Masterplan of RSUD Pandan Arang Boyolali

Isra' Nuur Darmawan
Department of Electrical Engineering, Faculty of Engineering
Universitas Wijayakusuma Purwokerto
Purwokerto, Indonesia
isra.nuur.darmawan@unwiku.ac.id

Basuki
Department of Architecture, Faculty of Engineering
Universitas Wijayakusuma Purwokerto
Purwokerto, Indonesia

Priyono Yulianto
Department of Electrical Engineering, Faculty of Engineering
Universitas Wijayakusuma Purwokerto
Purwokerto, Indonesia

Susatyo Adhi Pramono
Department of Civil Engineering, Faculty of Engineering
Universitas Wijayakusuma Purwokerto
Purwokerto, Indonesia

Novi Andhi SP
Department of Civil Engineering, Faculty of Engineering
Universitas Wijayakusuma Purwokerto
Purwokerto, Indonesia

Iwan Rustendi
Department of Civil Engineering, Faculty of Engineering
Universitas Wijayakusuma Purwokerto
Purwokerto, Indonesia

***Abstract*—Safe and comfortable are important factors which can affect to the patient's healing process. However, the patient room designed up to standard requires to creating healthy, safety, and comfortable for inpatient room. This study aims to simulate energy consumption based on Masterplan of the local government hospital of Pandan Arang Boyolali (Rumah Sakit Umum Daerah, RSUD Pandan Arang Boyolali) that prediction the energy saving scenario from a simulation using DesignBuilder software. Definitely, the data's required including the geometry data, weather data, and the cooling load data. Henceforth, the building geometry data is from the blueprint result is then modeled into a 3-dimensional model using the DesignBuilder software and the EnergyPlus analyzed. Whereas the weather data is used based on the Surakarta region data, absolutely this is due to the unavailability of the weather data for the Boyolali region. Furthermore, the cooling load data is covered by the occupant sector, and the lighting system sector. The simulation results show that the electrical energy consumption of the whole building is 5,921.77 kWh for about 1 year and the use of the air system energy is about 568,369.75 kWh or equal to 92% of the total energy use, and about 51,936.53 kWh or about equal to 8% of the lighting system. Meanwhile, the energy saving scenario replace the Variable Air Volume (VAV) air system into Constant Air Volume (CAV). The role of the CAV system to energy savings is evidenced by comparison with the VAV system. Thereby, through of this comparison result has obtained about 0.475% of savings value by the CAV system with the nominal price of Rp. 5.477.637.25, -. However, the value of Energy Consumption intensity (IKE) is 126.56 kWh/m2/year, which is still below to standard of the issued by GBCI. Therefore, it can be categorized as a green building**

Keywords— DesignBuilder, Energyplus, Efficiency energy, System constant air volume, System variable air volume

I. Introduction

A. Background

Energy demand is increasing every day as energy consumption gets bigger. Energy consumption management is an important issue because there are many benefits to environmental, economic and social energy management. Hospitals are the main sectors that consume large amounts of energy and the need to apply energy management strategies to their systems. Approximately 7% of electricity consumption in all commercial buildings is consumed by health care buildings. Recent research that discusses energy consumption and evaluates some of the technology in hospitals gets results There are several challenges in energy management in hospitals that make the management process more difficult and complicated. (Alhurayess and Darwish, 2012)

B. Formulation of Problem

Environmental comfort in the hospital is one of the decisive factors in the healing process of the patient. The faulty form of comfort that can be defined is thermal comfort. Thermal comfort is influenced by several things, including temperature and humidity.

C. Scope of Problem

This study is limited by the following:

1. The object under study is masterplan RSUD Pandan Arang Boyolali
2. The patient's convenience intended in this study is limited thermal comfort only
3. Analysis and discussion of energy simulation result at RSUD Pandan Arang Boyolali only based on assumptions given and based on the operational circumstances RSUD Pandan Arang Boyolali at the time of the study.

D. Purpose

1. Obtain energy consumption value at RSUD Pandan Arang Boyolali design by using EnergyPlus simulation with Constant Air Volume (CAV) and Variable Air Volume (VAV) scenario.
2. Identify energy saving opportunities under CAV and VAV scenarios
3. Knowing the energy savings resulting from the implementation of CAV and VAV scenarios.

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E. Benefit

1. Getting a picture of energy simulation on the design of RSUD Pandan Arang Boyolali is good and appropriate, so it can be one of the reference of similar activities throughout Indonesia.
2. Testing the possibility of a Variable Air Volume (VAV) conditioning system as an air conditioning system capable of creating energy efficiency in RSand Pandan Arang Boyolali hospital design.

F. Hipotesis

Implementation of VAV system is expected to save the cost of electric energy consumption than the CAV system.

II. LITERATURE REVIEW

A. Hospital

Based on Law no. 44 of 2009 on hospitals, which is meant by hospitals is a health service institution that provides full range of personal health services providing inpatient, outpatient and emergency care services (Depkes, 2009).

1) Hospital Duties and Functions

General Hospital has a mission to provide quality health services and affordable by the community in order to improve public health status. The duty of public hospitals is to carry out the efforts of health services in a versatile and effective manner by prioritizing healing and recovery that is implemented in a harmonious and integrated with the improvement and prevention and implementation of referral efforts.

B. EnergyPlus

In the two latest workshops on next-generation energy tools sponsored by DOE and DOD, there is a strong consensus that more elusive and resilient tools with additional capabilities are needed. Repeated simulations throughout the workshop are the design, environment, economy, and comfort and safety of the occupants. Designers need tools that provide answers to very specific questions during design. At least it wants a tool that provides the highest level of accuracy and precision of the simulation, but not so in the user's way. One of the highest priorities is a simulation (simultaneous load and system) integrated for accurate prediction of temperature and comfort.

In response to this, we decided that integrated simulation should be the basic concept of EnergyPlus. The load is calculated by the heat balance machine at user-defined time step (default of 15 minutes) passed to the simulation module of the building system at the same time. Building system simulation module, with variable time step (down to second), calculate heating and cooling system and power and generator system response. Feedback from the building system simulation module on unmet loads is integrated at the next load counting time step in the adjusted room temperature if necessary.

EnergyPlus has three basic components: simulation management, heat and mass balance simulation module, and building system simulation module. Simulation management controls the entire simulation process. The heat balance calculation is based on IBLAST Ð BLAST research version with integrated and simulated HVAC system at building load. (Crawley et.dkk., 2001)

C. Assessment of Energy Consumption Level at the Hospital

Different software packages such as EnergyPlus were developed to enable high precision building modeling and energy balance calculations, thus determining the amount of energy needed for heating and cooling, both for existing and existing objects in the design stage.

However, given that the program only provides consumption but is not a power-saving feature and Suggestion, it is necessary to find a new approach to the overall concept, a possible approach (besides consumption) of potential savings calculations using different intelligent energy control methods. In addition, this approach should be simple, as it is primarily intended for ordinary engineers and technical staff responsible for building maintenance (in this case in particular hospitals) and not for research purposes. (Čongradac at. al., 2012).

D. Building HVAC data using EnergyPlus

The HVAC model includes profiles of the various types of buildings, ie housing and commercial developed and analyzed. The EnergyPlus software is used for simulation and analysis. From detailed analysis, in residential buildings, electrical appliances will not be long used in everyday life, but the HVAC system runs for a long time. Thus, the weight on the total energy facility will be higher. Commercial buildings will be slightly different, as many types of electrical equipment are used during working hours. Energy consumption will be high, and consequently will cause the percentage of HVAC system energy consumption lower than residential building. Different experiments were performed, in terms of changing operating temperature, and changing the schedule. Differences in energy utilization are recorded. Between residential and commercial buildings, the latter shows the impact of the weekend on energy consumption. Thus, different scheduling for weekdays and weekends can be implemented in commercial buildings to get more energy savings. (Wang at. al., 2016)

III. RESEARCH METHODOLOGY

A. Methodology

The methodology proposed in this study is based on computer simulations using EnergyPlus. With regard to the simulation of hospital buildings, EnergyPlus is a good software and recognized in building energy analysis because it freely modeled heating, cooling, lighting, ventilation and other energy flows as well as water in buildings. (Boyano at. al., 2013) (Fumo at. al., 2010).

1) *Materials Research*

The materials used in the study are presented in Table 1.

TABLE I. MATERIALS RESEARCH

No	Material	Source
1	Picture of layout of RS Pandan Arang building design	Kantor Dinas Cipta Karya Boyolali
2	Picture of building pieces of Pandan Arang Hospital design	Kantor Dinas Cipta Karya Boyolali
3	Surakarta area weather data	Forum Grup Yahoo *EnergyPlus*
4	Standard Lighting and air conditioning system	SNI

2) *Tools and Research Data*

The tool used in the research is DesignBuilder software (EnergyPlus). This software is used to create models of building geometry and simulation process.

3) *Management Procedures*

In the stages of the implementation of the research stages are:

1. Library Studies,

This first stage is the first step before doing research that is by collecting the library materials either in the form of existing research, journals, standards used and modules that support the program used in research.

2. Data Collection,

The second stage is the data collection needed in the research that is the image data masterplan RSUD Pandan Arang obtained from the Office of Cipta Karya Boyolali, Surakarta weather data obtained from Yahoo EnergyPlus Group, then the collection of standards used.

3. Building Modeling with EnergyPlus,

Third stage is to model the geometry image RSUD Pandan Arang on software EnergyPlus.

4. Data Input Modeling,

The fourth stage is to process the data entry in the simulation, the data included in the form of weather data, lighting standards, cooling standards and simulation schedule.

5. EnergyPlus Simulation,

The fifth stage is to start running simulations on the energy plus software to process the data that has been inputted previously.

6. Analysis and Discussion of Results,

The Sixth Phase is to process the results of simulations performed by the energy plus software and discuss the results obtained.

7. Conclusion,

This seventh stage is to make conclusions from the analysis and discussion of simulation results data. The following is the flowchart of research procedures:

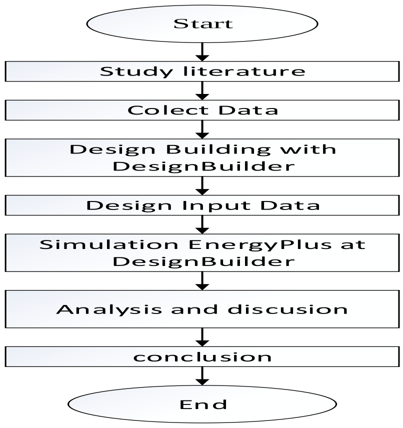

Fig. 1. Flow Chart of Research

IV. RESULTS AND DISCUSSION

A. *EnergyPlus Simulation Result*

Discussion of EnergyPlus simulation results is divided based on energy consumption for each system, ie system of air, lighting and electrical energy consumption of electrical equipment

B. *EnergyPlus Simulation Results with VAV Type HVAC Templates*

1) *Energy Consumption of Air System*

For the energy consumption of the air system in the Pandan Arang Boyolali Hospital building, the total energy consumption for the air system is 2,898,876.51 kWh. For air energy consumption per year includes components that operate on the air system, namely heating and cooling. The data for each component is presented in Figure 2.

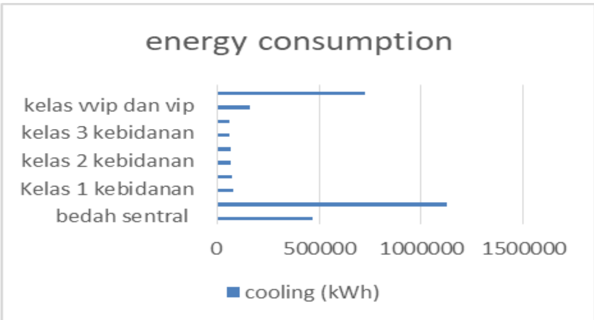

Fig. 2. Electrical Energy Consumption of Air System

The images provide information that the biggest consumption for the air system is in the ICU room, which is 1,125,288.83 kWh. While for the lowest consumption is in class 3, which is 62,588.68 kWh.

2) *Energy Consumption of Light System*

For the energy consumption of the lighting system at Build a Hospital Pandan Arang Boyolali presented for per-year. The energy consumption of the lighting system is divided according to the thermal zone using the interior lights, the ICU Polyclinic ER zone, the VVIP and VIP class zones, the 3rd class zone, the 3rd grade obstetrics zone, the 2nd class zone, the 2nd grade obstetrics zone, the 1st class zone, the class zone 1 obstetrics, ICU lab therapy zone, central surgical zone. The largest energy consumption for the lighting system is consumption in the ICU Lab Terapi zone, which is 64,197.74 kWh. While the lowest consumption is class 3 zone, that is equal to 3,297.25 kWh. The total energy consumption of the lighting system is 216,260.06 kWh per year. Energy consumption of lighting system can be seen in Figure 3

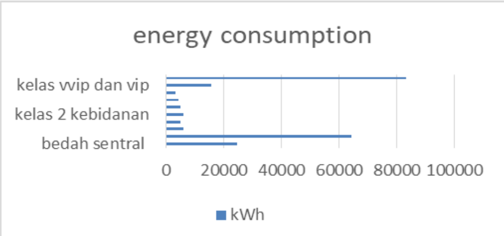

Fig. 3. Electrical Energy Consumption of Light System

3) Building Total Energy Consumption

Energy consumption for the whole building is divided into each system. The highest energy consumption is the air system with 93% and for the lowest is the lighting system with 7%. The distribution of overall energy consumption of buildings can be seen in Figure 4.

Fig. 4. Electrical Energy Consumption of All Buildings

4) Intensity of Building Energy Consumption

Energy Consumption Intensity (IKE) is one of the parameters used to determine the energy performance of buildings (building energy performance). IKE is the total value of building energy consumption divided by the floor area of the building for one year so that the unit to declare the value of IKE is kWh / m2 / year. The value of IKE for Pandan Arang Boyolali Hospital building that has been simulated is 252,70 kWh / m2 / year. This value is obtained from the total energy consumption value of Pandan Arang Hospital which is worth 3,115,136,57 kWh divided by total floor area equal to 12.327,54 m2.

C. EnergyPlus Simulation Results with CAV Type HVAC Templates

1) Energy Consumption of Air System

For the energy consumption of the air system in the Pandan Arang Boyolali Hospital building, the total energy consumption for the air system is 3,103,582.80 kWh. For air energy consumption per year includes components that operate on the air system, namely heating and cooling. The data for each component is presented in Figure 5.

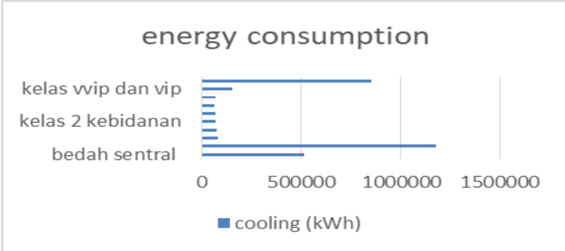

Fig. 5. Electrical Energy Consumption of Air System

The images provide information that the biggest consumption for the air system is in the ICU room, which is 1,176,469.22 kWh. While for the lowest consumption is in the class 3 class midwifery, which is equal to 61.058,76 kWh.

2) Energy Consumption of Light System

For the energy consumption of the lighting system at Build a Hospital Pandan Arang Boyolali presented for per-year. The energy consumption of the lighting system is divided according to the thermal zone using the interior lights, the ICU Polyclinic ER zone, the VVIP and VIP class zones, the 3rd class zone, the 3rd grade obstetrics zone, the 2nd class zone, the 2nd grade obstetrics zone, the 1st class zone, the class zone 1 obstetrics, ICU lab therapy zone, central surgical zone. The largest energy consumption for the lighting system is consumption in the ICU Lab Therapy zone, which is 92,611.85 kWh. While the lowest consumption is the 3rd-grade obstetric zone, which is 4,350.03 kWh. The total energy consumption of the lighting system is 280.241,13 kWh per year. The energy consumption of the lighting system can be seen in Figure 6.

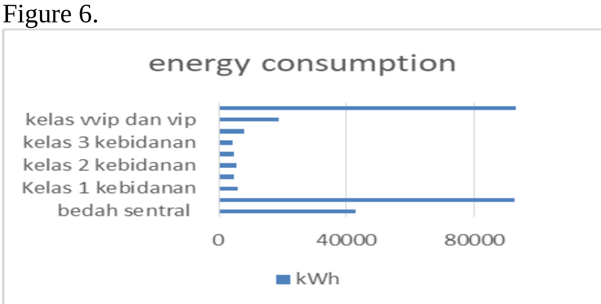

Fig. 6. Electrical Energy Consumption of Light System

3) Building Total Energy Consumption

Energy consumption for the whole building is divided into each system. The highest energy consumption is the air system with 92% and for the lowest is the light system with 8%. The distribution of the overall energy consumption of buildings can be seen in Figure 7.

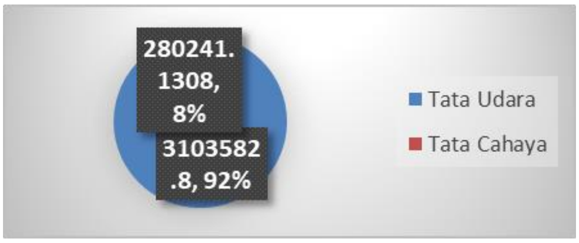

Fig. 7. Electrical Energy Consumption of All Buildings

4) Intensity of Building Energy Consumption

Energy Consumption Intensity (IKE) is one of the parameters used to determine the energy performance of buildings (building energy performance). IKE is the total value of building energy consumption divided by the floor area of the building for one year so that the unit to declare the value of IKE is kWh / m2 / year. The value of IKE for Pandan Arang Boyolali Hospital building that has been simulated is 274,49 kWh / m2 / year. This value is obtained from the total energy consumption of Pandan Arang Hospital which is worth 3,383,823.93 kWh divided by the total floor area of 12,327.54 m2.

D. Analysis of Constant Air Volume System (CAV) with Variable Water Volume System (VAV)

The energy consumption savings of Pandan Arang Hospital building with the application of CAV system is shown by Table II.

TABLE II. THE ENERGY CONSUMPTION SAVINGS OF PANDAN ARANG HOSPITAL BUILDING WITH THE APPLICATION OF CAV SYSTEM

	HVAC system		saving	
	CAV	VAV	kWh	%
Energy consumption of air system	3.103.582, 80	2.898.876, 51	204.706, 29	3, 41
Energy consumption of lighting system	280.241, 13	216.260,06	63.981, 07	12, 89
The overall energy consumption of the building	3.383.823, 93	3.115.136, 57	268.687, 36	4, 13

The energy saving value for the whole building system is 268,687.36 kWh or 4.13% per year. So that the conservation of energy consumption in Pandan Arang Boyolali Hospital building by applying VAV system reach 967,27 GJ / year, assuming basic social power tariff (subsidized) Rp. 925.00 / kWh then can save Rp. 248,535,805.60 per year. Comparison of Energy Consumption CAV and VAV Systems

V. CONCLUSIONS AND RECOMMENDATIONS

Based on the simulation using the EnergyPlus device with the assumptions given, the overall energy consumption of the Pandan Arang Boyolali Hospital building is 3,115,136,57 kWh (VAV) and 3,383,823,93 kWh (CAV)

The result of scenario implementation to the overall electrical energy consumption of Pandan Arang Boyolali Hospital building is obtained savings of 4.13% or equivalent to Rp. 248,535,805.60 per year.

Energy consumption for the air system is the largest consumption with 93% (VAV) and 92% (CAV) consumption value of total building energy consumption, followed by 7% (VAV) and 7% of the power consumption of the lighting system % (CAV). The value of Intensity of Energy Consumption (IKE) of Pandan Arang Boyolali Hospital building based on the simulation result is 252,70 kWh / m2 / year (VAV) and 274,49 kWh / m2 / year (CAV).

Variable Water Volume System (VAV) is a suitable system to apply in masterplan RSUD Pandan Arang Boyolali.

1. Applying Variable Air Volume (VAV) system to masterplan RSUD Pandan Arang Boyolali can create energy efficiency
2. The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first ..."

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