International Journal of Civil Engineering and Technology (IJCIET)
Volume 10, Issue 10, October 2019, pp. 115-123, Article ID: IJCIET_10_10_012
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=10&IType=10
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

ENERGY CONSERVATION OF THE AIR-CONDITIONING SYSTEM OF HOTELS BUILDING IN MAKASSAR CITY

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ABSTRACT

Available of hotel building in Makassar is supported by the climate condition which wet tropical climate. The rain season which significant as part of moth in a year. The dry season which sufficient compare with rain season. The function of building envelope in external of hotel building architecture appointment of energy conservation criteria which become comparison in design process of hotel building, particularly include the exterior field design in relation with the building performance. That cause require of method to be less of external load such as suitable with Indonesia National Standardization in appoitnment of criteria about building envelope design which stated in Overall Thermal Transfer Value – OTTV $\leq$ *45 Watt/m*^{2}*.The research approach are mix between qualitative and quantitative methods. Location of research in Makassar City, with reason the researcher stay there and observed of rise the hotel building which to be interested related with energy conservation system of air to see the saving energy and thermal comfort of hotel building. Data analyzed in qualitative descriptive, analyzed of building envelope, cooling load and thermal comfort. The result of research found the energy conservation system of air have used on five hotel building which showed the energy from AC in the room which effected of OTTV. Analyzed of conservation control energy saving from air-conditioning system from the hotel building appointment by cooling weight analysis in internal or external. The efficiency control of energy saving conservation not yet applied with good because the used of AC in everyday, that can* *to be efficient suitable with the rooms were filled. The thermal comfort of energy conservation system of air from the room suitable with SNI standard 6390:2011.*

Keywords: Energy Conservation, Air-Conditioning System, Cooling Load, Thermal Comfort

Cite this Article: Nasrullah, Ramli Rahim, Baharuddin Hamzah, Rosady Mulyadi, Energy Conservation of the Air-Conditioning System of Hotels Building in Makassar City. *International Journal of Civil Engineering and Technology* 10(10), 2019, pp. 115-123.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=10&IType=10

1. INTRODUCTION

Along with urban developments in Makassar City, each year was increased marked by the growing utilization of urban spatial planning. The emerging of several types of buildings, such as hotel buildings, offices, hospitals, apartments and shopping centers, shows that the city of Makassar has shown rapid progress in building activities from time to time. This is in line with the vision and mission of Makassar City. The vision is "Establishing a World Class City for All" with the mission: 1) reconstructing people life toward world-standard prosperous society; 2) reforming the ineffective bureaucratic system toward world-class public services; and 3) restoring an uncomfortable city toward world-class comfort city [1].

Available of building hotels in Makassar is supported by the climate conditions which are tropical climate. There is significant rainfall in most parts of the year. The dry season is quite longer than the rainy season. The climate of Makassar City classified as am climate in the Kopper-Geirger system. The average temperature in Makassar City is 26.2 ° C with the average precipitation of 2,875 mm. The driest month is in August with 14 mm of rainfall in the average of 671 mm, almost all precipitation fall in January [5].

The tendency of users to choose environmentally friendly hotels based on the energy-saving concept and has the thermal comfort of the room [2]. Therefore a representative hotel is a building that creates comfortable spaces for its residents [3]. One of the important things of a representative hotel concept is efficient energy utilization. Energy-saving design, building materials and all device and equipment are needed as an effort to limit wasteful energy use in hotel buildings [4].

Energy conservation is one of the efforts to streamlined building energy use, because it requires ability in engineering or creating energy efficient air-conditioning system. Energy conservation law or commonly called the Law of Thermodynamics states that "energy can change from one form to another (energy conversion) but cannot be created or destroyed" [16]. On this basis, energy engineering is needed by using air conditioning (AC) in buildings by using energy conservation of air-conditioning system [6].

The distribution of energy use in a hotel can be known that the biggest component of energy use is the cooling system, air conditioning/fan reaches 50 - 70 percent of all electrical energy used, while lighting 10 - 25 percent, elevators only 2 - 10 percent [7]. For this reason, need consideration to do energy-saving efficiently in buildings by implementing the air-conditioning system improvement. Through this energy convention of the air-conditioning system can be done by reducing the cooling load and choosing the right system and air control [8].

The initiative to develop an energy-saving program at the hotel is the first step in creating an "Energy Management System (EMS)" that allows the hotel management to manage energy use rationally and improve its performance (efficient use of energy) without affecting the quality and quantity of services [7]. The initiative can emerge from the Top Management level or from the Chief Engineer who is directly responsible for energy utilization and management [15].

There are five hotels are researched namely Grand Clarion Hotel, Aryaduta Hotel, Sahid Jaya Hotel, Swiss Bell inn Losari Hotel, and Aston Hotel show that the air-conditioning system used in rooms of hotel building was in accordance with cooling loads utilization. The cooling load of the hotel building must be conditioned according to the internal and external load requirements of the hotel. Internal load is the burden caused by the hotel from the lights utilization, occupants and other equipment that causes heat. The external load of the hotel is heat entering the building due to solar radiation and conduction through the building envelope. Efforts to deal with hotel building loads, especially limiting external loads, need to have the building envelope, a roof area as an important building element to be taken into account in energy utilization.

The function of the building envelope externally is to determine the energy conservation criteria that are taken into consideration in the design process of the hotel building, especially concerning the design of the exterior field in relation to the building appearance [9]. Therefore it is necessary to think the ways to reduce the external burden such as following the rules of the Indonesian National Standards in determining the building envelope design criteria which are stated in the Overall Thermal Transfer Value (OTTV) where the necessary OTTV is < 45 Watt / m2. This clause is intended for conditioned buildings which are intended to obtain a building envelope design in reducing external loads, so as to reduce the cooling load [10]. The utilization of OTTV must be designed as a protective element against external weather environmental conditions which is one of the important factors in determining the air-conditioning system [11].

The importance in implementing the energy conservation in the hotel building air-conditioning system stated above, the case assessment of hotel building design was assessed based on the form of energy conservation of the air-conditioning system viewed from the utilization of OTTV by assessing the building wall area and thermal displacement. This includes analyzing the efficiency of energy-efficient control of the hotel building air-conditioning system from the analysis of cooling loads utilization based on internal and external heat loads [12].

Then the researcher continued to analyze the air-conditioning system energy to realize the thermal comfort of hotel buildings based on SNI 6390: 2011 standards which included the TTP assessment standards and cooling loads, so that thermal comfort assessments according to the effective temperature index can be carried out to assess effective air temperature comfort, assess thermal comfort based on the Predicted Mean Vote (PMV) index to predict room temperature based on human body heat, and the predicted percentage of dissatisfied (PPD) index to predict the percentage of dissatisfaction with the perceived room condition [13].

Based on the gap between the empirical conditions found and the ideal conditions based on the theory, then there are two gaps namely the gap explicitly and the gap implicitly. Gap explicitly states that energy-saving is one of the smart solutions to be applied to buildings, especially hotel buildings that consume 50% to 70% energy. The gap implicitly states that buildings must be designed to meet energy-saving prerequisites, the value of OTTV calculated in the initial stages of planning does not exceed the values in the applicable standard (SNI 6390: 2011) [6].

Based on the gap, the formulation of the problem are: 1) energy conservation of the air-conditioning system used in hotel buildings in the city of Makassar 2) efficiency of conservation control of energy-saving air system in the design of hotel buildings in the city of

Makassar 3) conservation energy of the air-conditioning system in manifesting the thermal comfort of hotel buildings in the city of Makassar.

2. RESEARCH METHOD

The research approach are mix between qualitative methods and quantitative methods. Qualitative methods in this study is to explain descriptively about the focus of the study observed in the form of energy conservation systems, efficiency of conservation control energy-saving air system and thermal comfort in the building of a hotel. The type of research used is a case study of a hotel building business, by choosing five hotels as the object of research. The case study is reviewing various things related with energy conservation of the air-conditioning system in the hotel building.

The role management in this research is as a participatory instrument, namely researchers go directly and present in conducting research settings as full participation, observer participation and to capture various information data found at the research location, make direct measurements and process primary data and look for secondary data in accordance with standard system of energy conservation

The data analysis technique used in this study consisted of two, qualitative descriptive analysis, building envelope, cooling load and thermal comfort. First, descriptive analysis is to explain the data about the focus of the study observed in the form of energy conservation, air conditioning systems and thermal comfort in the building of a hotel. Data analysis in qualitative research consists of three activities that occur simultaneously in accordance with the data collected which then through data reduction, data presentation and conclusion (verification). As a consequence of this, data collection and analysis should always run at the same time.

Energy consumption in hotel buildings through the calculation of Energy Consumption Intensity and Room Energy Intensity (REI), building envelope analysis through calculation of Overall Thermal Transfer Value (OTTV) according to SNI 6390: 2011, analysis of cooling load is the total amount of heat energy that must be removed in time units from the cooled room, thermal comfort analysis is the comfort limit for the condition of the hotel building observed according to SNI 6390: 2011 to see the effective temperature, PMV and PPD.

3. RESULTS AND DISCUSSION

3.1. Energy Consumption Intensity

Viewed from the energy consumption intensity aspect, energy utilization in the five hotels observed is classified as very efficient. This is evidenced by the energy consumption intensity average of 12.45 kWh / m2 / month. The energy consumption intensity value set by SNI 6390: 2011 for the conditioned room is 8.5-14 KWh / m2/ month2. The five hotels observed included in the category of energy-efficient hotel buildings [14].

3.2. Profile of Daily Energy Load

The energy load profile shows that there is a discrepancy between the operation hours of each hotel building and the operating hours set. The energy load depends on the condition of turning on and off the Air Conditioning [18]. Between hotel entry hours and AC operating hours, with the maximum load of 1542,600 watts and the minimum load of 1151,300 watts, it can minimize the difference between the hotel entry hours and AC operating hours. Thus, the opportunity the energy-saving is by turning off the air conditioner when leaving the room. The savings amount is approximately 275 kW x 30 days. If the price assumption of electric energy per kWh is IDR 880.00, the amount of energy-saving per month is 8,247 kWh x Rp 880.00 = Rp. 7,257,360.00 per month or Rp. 87,088,320.00 per year.

3.3. The AC Quality

To see the load profile and AC quality have been measured on the electrical panels in each hotel. The measurements produced a cos phi value of 98%, the average voltage imbalance of <3%, the average current imbalance value of <20%, and the frequency of 49.9–50.6 Hz. The voltage harmonics on each mass and current harmonization are within the standard limits [19]. These results indicate that AC quality is classified as good. However, the maximum value of current imbalance and maximum harmonic value has exceeded the standard caused by load imbalances especially [20].

3.4. The Energy Conservation in Building Envelope

Based on the observations of building envelope systems, there are some findings. First, window glass, solar radiation is external thermal load for the air-conditioning system so that the air system cannot work optimally because of the high indoor temperature caused by solar radiation through the window glass. For anticipation, the five hotels observed have installed window film and shading or overhangs. Second, Overall Thermal Transfer Value (OTTV). The air-conditioning system in the building uses 50–70% of the energy from the entire electrical energy used in a hotel building. The cooling load of a building consists of internal loads, namely the load caused by lights, occupants, and other equipment that causes heat, and external loads, namely heat entering the building caused by solar radiation, conduction and ventilation / infiltration through the building envelope. To reduce the external burden, SNI 6389: 2011 determines the design criteria, namely Overall Thermal Transfer Value (OTTV) must be smaller than 35 Watt / m2. The OTTV value is obtained by searching for building's Window to Wall Ratio (WWR), as in Table 1.

Table 1 Value of Window to Wall Ratio (WWR)

Hotel Building Orientation	Wide (m2)		WWR	SF
	Window	Total		(Adjusted to the building direction)
Grand Clarion	879	1836	0.39	342
Aryaduta	594	1836	0.32	160
Sahid Jaya	658	1836	0.24	154
Swiss Bell	547	1836	0.32	132
Aston	563	1836	0.32	101

Based on the calculations results, the OTTV value of starred hotel buildings is 29.45 watt / m^2, the OTTV value is still below the SNI OTTV standard value (<35 watt / m^2). This is because the entire building uses window film and there is also shading to block the emission of solar radiation. The use of window film and shading aims to reduce the heat of the sun entering the room without reducing natural light. The existing vegetation system is also good enough so that the value of OTTV is still below the SNI standard. The vegetation system is important to reduce the air temperature around the building. The vegetation system can be obtained by planting plants and / or making water ponds around the building.

3.5. The Air-Conditioning System

Power profile of the air-conditioning system is based on Air Conditioner turned on 24 hours per day with the operating system of AC unit using a centralized remote control. From the results of observations and measurements, it was found that the operation of the AC unit in the building was carried out with cooling mode at temperature setting of 21 °C.

The AC profile measurement result shows that the AC split operating pattern in the work space of hotel building operates with the maximum power of 840 Kw. The operation of the air conditioner is done manually, where the maintenance section turns on the air conditioner every day and the monitoring system is carried out automatically from the control room.

3.5.1. Thermal Comfort Quality

In general, the air-conditioning system in multi-store hotel buildings has met SNI 6390-2011 standards with temperatures ranging from 24-26 °C with the humidity values range from 56–65%. The level of comfort thermal in a room is very important to support the functions of the room in the hotel building. The comfort level is an expression of thermal air conditions which are represented by two proportions of air present in the room, namely temperature and humidity. Meanwhile, the comfort level of the room temperature in the hotel building is 25.5 °C ± 1.5 ° C (24–27 °C) and air humidity 60% ± 5% (55–65%).

3.5.2. Installed System and Capacity

Capacity equipment of installed Air Conditioner in the building is in the average of 37.85 watts / m^2. Equipment capacity of conservative rated to serve a room in a building can be defined as the energy input requirements of an air conditioning system per unit area served by the equipment. Based on SNI, the capacity of installed equipment that can service a load thermal in a room conditioned in a conservative assessment must be at <50 Watt / m^2.

3.5.3. Performance of Air Conditioner (AC)

Other factors used as an analysis of air conditioning equipment to support thermal comfort conditions, namely the assessment of AC performance. In general, the average COP of AC system in the hotel building is in optimal condition, even though it is already below the name plate. This is caused by regular maintenance, three times a year. Air conditioning equipment applies the same as other equipment. The service life factor greatly influences the performance of the equipment, which generally coincides with the time of operation, resulting in derating or fouling which causes the equipment to not have the same effect as the previous situation, unless regular and / or modification is carried out. More details are shown in Table 2.

Table 2 AC Performance

No	Load Name	Consumption	Cooling	COP				Condition
		Power(kW)	Effect (kW)	Existing	Name Plate	Existing	Name Plate	
1	Chiller 1 Cap 150 TR	144.10	482.81	3.66	4.00	0.96	0.88	<standard
2	Chiller 2 Cap 150 TR	152.81	455.27	3.45	4.00	1.02	0.88	<standard
	Conclusion	296.91	938.08	3.56	4.00	0.99	0.88	<standard

3.6. The Air-Conditioning System

Power utilization of energy profile shows that there is excess utilization of AC usage hours, which is turned on two hours before the guest arrival level increases and the condition of the guest room decreases. Therefore, the chiller should be turned on at any time, by turning off the room air conditioner that the guest has not booked, so that the savings value obtained is quite large. Table 3 shows the calculation simulation of the energy conservation opportunities that can be obtained through step 1.

Table 3 Energy Conservation Opportunities of the Air-Conditioning System through Reduction of AC operational hour

Description	Value	Unit
Average AC power every hour	:696	kW
Operating time	:1	Hour
Total energy consumption	:15,311	kWh / month
Electricity fee	:13,580,443.00	Rp / month
Change the AC off hour		
Estimated savings (%)	:100	%
Energy savings	:15,311	kWh / month
Electricity cost savings (months)	:13,580,443	Rp / month
Electricity cost savings (years)	:162,965,316.00	Rp / year

This conservation opportunity can be achieved if residents in each room space are cooperate in using air conditioning according to the needs and agreed time. Suggestions from ESDM for hotel buildings are calls for central air conditioning to be turned on every day and the fan AC unit is turned on according to the needs and time of visiting guests. This method can reduce the amount of energy utilization significantly. This is because the largest component in energy utilization in buildings 50-70% is Air Conditioner [17]. Table 4 is a conservation opportunity that can be obtained if the AC or chiller is turned off by every guest leaving the room.

Table 4 Energy Conservation Opportunities of the Air-Conditioning System through Changes of AC off Hour

Description		**Value**	**Unit**
Average AC power every hour	:	630	kW
Operating hour	:	0.5	Hours
Total energy consumption	:	6,927	kWh / month
Electricity costs		: 6,143,983.00	Rp / month
Change the AC off hours			
Savings Estimation (%)	:	100	%
Energy savings	:	6,927	kWh / month
Electricity cost savings (month)		: 6,143,983.00	Rp / month
Electricity cost savings (years)		: 73,727,796.00	Rp / year

4. CONCLUSION

The results of the study found that energy conservation of the air conditioning system has been used in all five hotel buildings and showing the energy utilization of the air-conditioning system is using AC in residential rooms, strongly influenced by OTTV according to the wall area and thermal displacement that occurs.

The results also show that analyzing the efficiency of conservation control of energy-efficient air-conditioning systems in the five hotel buildings, for a room is largely determined by the analysis of the cooling load utilization, especially with regard to internal and external heat loads. The results of the study found that the efficiency of controlling energy-saving conservation has not been applied properly because the utilization of AC energy is done every day, it can only be used efficiently in accordance with the room used.

The results of the study found that to realize thermal comfort for the utilization of energy conservation of the residential rooms air-conditioning system must conform to SNI 6390: 2011 standards to detect comfort aspects based on effective temperature index, predictive mean vote (PMV) and predicted percentage of dissatisfied (PPD) index, where the results of analysis of the five hotel buildings have been met the building's thermal comfort requirements.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the financial support provided by DRPM-RISTEKDIKTI of Indonesia. The authors would also like to acknowledge the support from Hasanuddin University to this study. Thanks to Managers of Hotel Five Stars in Makassar City for recommendation about data and documentation. And especially thanks to my Promotors, for their contributions to the research.

REFERENCES

[1] ASHRAE. (1993). Handbook Fundamentals, American Society of Heating Refrigerating and Air Conditioning Engineers, Inc. Atlanta.

[2] ASHRAE. (2010). ASHRAE standard 55-2010: Thermal environmental conditions for human occupancy.American Society of Heating, Refrigerating and Air-Conditioning Engineers. 228

[3] ASHRAE. (2010). ASHRAE standard 62.2-2010: Ventilation for acceptable indoor air quality in low-rise buildings. American Society of Heating, Refrigerating and Air-Conditioning Engineers.

[4] ASHRAE. (2010). ASHRAE standard 90.1-2010: Energy standard for buildings except low-rise residential buildings. .American Society of Heating, Refrigerating and Air-Conditioning Engineers. Ehrlich, dan Holden, Frank, 2007. Climate change impacts on building heating and cooling energy demand in Switzerland. Energy and Buildings 37 (2005) pp 1175-1185

[5] Badan Standardisasi Nasional. (2011). Building Energy Conservation. SNI 6390:2011 Jakarta Indonesia.

[6] Banyuaji Kencana, Imas Agustina, Richard Panjaitan dan Totok Sulistiyanto. (2015). Practical Guide to Saving Energy in Hotels. United States Agency for International Development.

[7] Badan Standardisasi Nasional. (2011). Building Energy Conservation. SNI 6390:2011 Jakarta Indonesia.

[8] Benedictus Biatma Syanjayanta, Victor Sampebulu, Baharuddin Hamzah. (2002). Thermal Conditions of Spaces in High Buildings.

[9] Bernard Aebischer. (2007). Impact of Climate Change on Thermal Comfort, Heating and Cooling Energy Demand in Europe. ECEEE 2007 Summer Study – Saving Energy, Energy Efficient Building Panel 5.

[10] Fanger, P. O. (1982). Thermal comfort. Copenhagen: Danish Technical Press.

[11] Gibbs, J. (1978). Architectural design methodology for tall office buildings based on ecology. CTBUH World Congress, Seoul, Korea.

[12] Glenn, B. A. (1980). Effect of interior mass surfaces on the space heating and cooling load of a single-family residence. Proceedings of the Ashrae/DOE/BTEC Conference—Thermal Performance of the Exterior Envelopes of Buildings III.

[13] Kamil, B. (2012). Options and applications of passive cooling. Energy and Buildings, 7(4), 297-300. doi: http://dx.doi.org/10.1016/0378-7788 (84) 90075-6

[14] Lawson, Mwale Ogoli. (2010). Energy – Efficiency and Comfort Conditions throught Thermal Mass in Passive Solar Buildings at Equatorial High Altitudes.

[15] Loekita, S. (2005). Energy Conservation Analysis through Building Envelopes in Office Buildings in Jakarta. Tesis No. 01000082/MTS/2005. Civil Engineering Postgraduate Program, UK Petra Surabaya.

[16] Mediastika, Christina E. (2013). Energy Saving and Environmentally Sustainable through Buildings. Andi, Yogyakarta.

[17] Nasrullah. (2019). Model of Energy Conservation in Air Conditioning Systems in Hotel Buildings. Case Study: Makassar City. Dissertation. Postgraduate Program Hasanuddin University, Makassar.

[18] Joseph, Balaras, C. A. (2009). The role of thermal mass on the cooling load of buildings an overview of computational methods. Energy and Buildings, 24(1), 1-10. doi: http://dx.doi.org/10.1016/0378-7788 (95) 00956-6.

[19] Kamil, B. (2012). Options and applications of passive cooling. Energy and Buildings, 7(4), 297-300. doi: http://dx.doi.org/10.1016/0378-7788(84)90075-6 .

[20] Kurokawa, Grace Kwok. (2007). Thermal Comfort in Naturally-Ventilated and Air Conditioned Classroom in the Topics. Dissertation University of California at Berkeley