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Original Research Article

Comparison of Operational Efficiency of Air Conditioning Systems Using Air Cooled Chiller with Air Cooled VRF

Ivan Agustinus Kusmanto[1*], Isdaryanto Iskandar[1]

[1]Professional Engineering Program Department, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jl. Jenderal Sudirman 51, Jakarta, 12930, Indonesia

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***Corresponding author:** Ivan Agustinus Kusmanto

Abstract

Operational cost efficiency in each building in this case multi-storey buildings for offices is highly considered by the building manager. The main equipment used and incur considerable operational costs one of them is an air system or AC system device. In this writing will be explained the comparison of the efficiency of the use of cooled chiller type air with air cooled VRF (Variable Refrigerant Flow) both in terms of service.

Keywords: Air Conditioning, Variable Refrigerant Flow, Air Cooled Chiller, Total Load, Perday Operation, Investment, Maintenance, Operations.

1. INTRODUCTION

Air Conditioning is a system that is very commonly used widely which is generally used in high rise buildings in urban areas.

The use of an air conditioning system aims to regulate a comfortable air temperature and air humidity. In tropical areas such as Indonesia especially Jakarta, temperature control is carried out by cooling the room temperature, reducing room humidity and setting good ventilation [1].

The selection of a good cooling system is based on the following considerations [2]:

- Use of space and type of building;
- Building usage duration;
- *Heat Load* needed;
- Energy sources;
- Opportunities for using renewable energy resources;
- Power efficiency of components;
- Investment and operational costs.

The power supply used by the building's air conditioning system generally uses a supply that comes from PLN electricity. This study compares data on load usage and efficiency of two different air conditioning systems, namely Air Cooled *Chiller* and Air Cooled *Variable Refrigerant Flow* (VRF).

2. RESEARCH METHODS & DATA

Literature studies are carried out by studying technical data books sourced from PT. Mitsubishi Electric [3] and literature studies and reference books.

Preparation of research results based on the process of observation and data collection in the XXX building - Jakarta.

The following is a comparison of *Total Load* data based on the P*ower Input* of each condition in Kw obtained based on data collection from the Mitsubishi Electric system and *Chiller Unit* as shown in Table 1 and Table 2.

Table 1: Mitsubishi Electric VRF *System*

MITSUBISHI ELECTRIC City Multi System					POWER (KW)											
No	MODEL	Cooling Cap	QTY	Total Cool Cap.	100%	Total	90%	Total	80%	Total	70%	Total	60%	Total	50%	Total
1	PUCY-P600YSKA	68	1	68.00	17.790	17.790	14.730	14.730	12.160	12.160	9.900	9.900	7.940	7.940	6.280	6.280
2	PUCY-P750YSKA	81.5	1	81.50	24.470	24.470	19.560	19.560	15.720	15.720	12.420	12.420	9.670	9.670	7.450	7.450
3	PUCY-P1050YSKA	115	4	460.00	33.390	133.560	26.820	107.280	21.620	86.480	17.150	68.600	13.390	53.560	10.350	41.400
4	PUCY-P1100YSKA	121.5	2	243.00	35.210	70.420	28.470	56.940	23.070	46.140	18.390	36.780	14.430	28.860	11.190	22.380
5	PUCY-P1150YSKA	128	5	640.00	36.150	180.750	28.990	144.950	23.370	116.850	18.520	92.600	14.440	72.200	11.150	55.750
6	PUCY-P1250YSKA	136	3	408.00	41.270	123.810	32.630	97.890	26.030	78.090	20.390	61.170	15.730	47.190	12.040	36.120
7	PUCY-P1300YSKA	140	1	140.00	44.820	44.820	35.440	35.440	28.270	28.270	22.150	22.150	17.090	17.090	13.080	13.080
8	PEFY-P63VMA-E	7.1	2	14.20	0.120	0.240	0.120	0.240	0.120	0.240	0.120	0.240	0.120	0.240	0.120	0.240
9	PEFY-P80VMA-E	9	22	198.00	0.140	3.080	0.140	3.080	0.140	3.080	0.140	3.080	0.140	3.080	0.140	3.080
10	PEFY-P100VMA-E	11.2	32	358.40	0.240	7.680	0.240	7.680	0.240	7.680	0.240	7.680	0.240	7.680	0.240	7.680
11	PEFY-P125VMA-E	14	26	364.00	0.340	8.840	0.340	8.840	0.340	8.840	0.340	8.840	0.340	8.840	0.340	8.840
12	PEFY-P140VMA-E	16	82	1,312.00	0.360	29.520	0.360	29.520	0.360	29.520	0.360	29.520	0.360	29.520	0.360	29.520
13	PEFY-P200VMHS-E	22.4	5	112.00	0.630	3.150	0.630	3.150	0.630	3.150	0.630	3.150	0.630	3.150	0.630	3.150
Total Power (KW) for each condition					100%	648	90%	529	80%	436	70%	356	60%	289	50%	235
Diversfikasi (%)						100%		82%		67%		55%		45%		36%

Table 2: C-Brand AC Chiller System

C-Brand					POWER (KW)											
No	MODEL	Cooling Cap	QTY	Total Cool Cap.	100%	Total	90%	Total	80%	Total	70%	Total	60%	Total	50%	Total
1	C-Brand 1	351.3	1	351.30	114.800	114.800	114.800	114.800	85.260	85.260	85.260	85.260	61.170	61.170	61.170	61.170
2	C-Brand 2	351.3	1	351.30	114.800	114.800	114.800	114.800	85.260	85.260	85.260	85.260	61.170	61.170	61.170	61.170
3	C-Brand 3	351.3	1	351.30	114.800	114.800	114.800	114.800	85.260	85.260	85.260	85.260	61.170	61.170	61.170	61.170
4	C-Brand 4	351.3	1	351.30	114.800	114.800	114.800	114.800	85.260	85.260	85.260	85.260	61.170	61.170	61.170	61.170
5	AHU-1	7.1	2	14.20	0.132	0.264	0.132	0.264	0.132	0.264	0.132	0.264	0.132	0.264	0.132	0.264
6	AHU-2	9	22	198.00	0.154	3.388	0.154	3.388	0.154	3.388	0.154	3.388	0.154	3.388	0.154	3.388
7	AHU-3	11.2	32	358.40	0.264	8.448	0.264	8.448	0.264	8.448	0.264	8.448	0.264	8.448	0.264	8.448
8	AHU-4	14	26	364.00	0.374	9.724	0.374	9.724	0.374	9.724	0.374	9.724	0.374	9.724	0.374	9.724
9	AHU-5	16	82	1,312.00	0.396	32.472	0.396	32.472	0.396	32.472	0.396	32.472	0.396	32.472	0.396	32.472
10	AHU-6	22.4	5	112.00	0.693	3.465	0.693	3.465	0.693	3.465	0.693	3.465	0.693	3.465	0.693	3.465
11	Pump		4		20.000	80.000	20.000	80.000	20.000	60.000	20.000	60.000	20.000	40.000	20.000	40.000
Total Power (KW) for each condition					100%	597	90%	597	80%	459	70%	459	60%	342	50%	342
Diversfikasi (%)						100%		100%		77%		77%		57%		57%

3. DATA ANALYSIS

Based on observational data from system Mitsubishi Electric City Multi *System* VRF and *C-Brand* AC *Chiller System*, comparison of data can be done to see *Total Load*/*Power* used by each system every day based on the specified P*ower Input* simulation conditions. The *total load* data from the VRF system is shown in Table 3 and the data from the *total load* of the Chiller system is shown in Table 4.

The *Cooling Capacity* value of the VRF system is 599 TR dan AC *Chiller* adalah 476 TR. Daily usage simulation results from the VRF system and *Chiller System* show a significant difference in the total value based on the daily usage simulation of the two systems. Daily *Total Load* of VRF system is 4.874 kW and *Total Load* of the chiller system is 5.505 kW. There is a difference in the value of 630 kW ≈ 11% of the T*otal Load* of the second note system.

Table 3: Total Perday Operation VRF System

MITSUBISHI ELECTRIC City Multi System		
Partial Load VRF System		
Total Power Input	100%	648,13
Total Power Input	90%	529,3
Total Power Input	80%	436,22
Total Power Input	70%	356,13
Total Power Input	60%	289,02
Total Power Input	50%	234,97
Daily Operational Load		
Operational Hours	Load	Electricity (KWh)
08.00-09.00	60%	289,02
09.00-10.00	70%	356,13
10.00-11.00	80%	436,22
11.00-12.00	90%	529,30
12.00-13.00	90%	529,30

MITSUBISHI ELECTRIC City Multi System		
13.00-14.00	90%	529,30
14.00-15.00	100%	648,13
15.00-16.00	90%	529,30
16.00-17.00	80%	436,22
17.00-18.00	70%	356,13
18.00-19.00	50%	234,97
Total Perday Operation Load		4.874

Table 4: Total Perday Operation AC Chiller System

C-Brand Chiller System		
Partial Load AC Chiller System		
Total Power Input	100%	596,96
Total Power Input	90%	596,96
Total Power Input	80%	458,80
Total Power Input	70%	458,80
Total Power Input	60%	342,44
Total Power Input	50%	342,44
Daily Operational Load		
Operational Hours	Load	Electricity (KWh)
08.00-09.00	60%	342,44
09.00-10.00	70%	458,80
10.00-11.00	80%	458,80
11.00-12.00	90%	596,96
12.00-13.00	90%	596,96
13.00-14.00	90%	596,96
14.00-15.00	100%	596,96
15.00-16.00	90%	596,96
16.00-17.00	80%	458,80
17.00-18.00	70%	458,80
18.00-19.00	50%	342,44
Total Perday Operation Load		5.505

The *Total Load* value on the chiller system is only lower than the VRF sytem at pick hour which occurs from 2 pm – 3 pm. In total consideration *Per Day Operation*, The use of a VRF Air Conditioning system is more profitable than the use of a chiller system.

Visualization of the *total Load* Curve based on the operating hours simulation carried out can be seen in Figure 1.

In terms of additional equipment, the VRF system does not require additional equipment, while the chiller system requires a pump to pump cold water into the *Air Handling Unit* (AHU), so there is additional electric power required to get cooling from the *Chiller*.

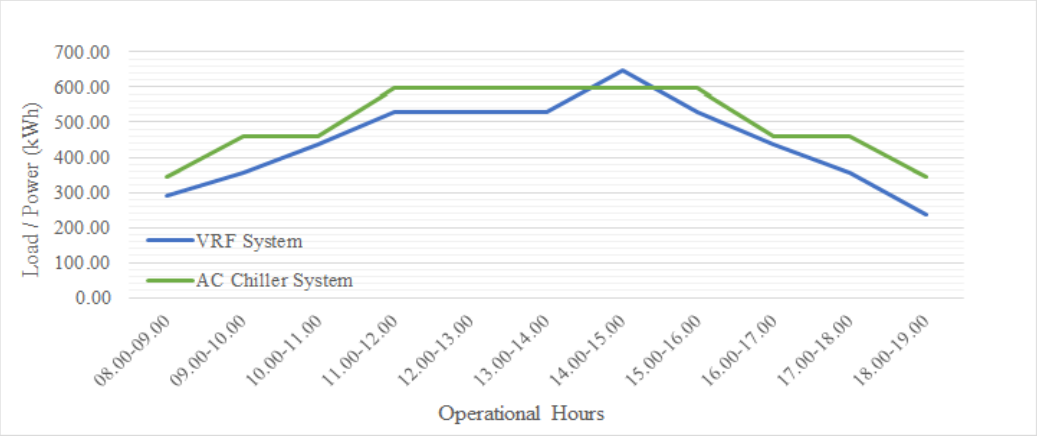

Figure 1: Total Load Simulation Curve

4. CONCLUTIONS

In calculating the daily operating expenses or *Total Per Day Operation*, the value of the VRF system is 4.874 kW and *Chiller* system is 5.505 kW. The total difference *Per Day Operation* is 630 kW ≈ 11% of the total value of the systems's second note. The VRF room cooling system has more advantages in terms of term use compared to the *Chiller* system with a power usage savings of 11%.

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