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Designing HVAC System Of VRV-A in Residential Unit by Cooling Load calculation from DACS-HKGSG Software v 2.05 and HAP Software v 4.90

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Abstract *- Air Conditioning System is the process of treating the air to simultaneously control temperature, humidity, cleanliness & distribution to meet the requirements of a room, such not only at office buildings, malls, airports but also at residences. Indonesia, with its tropical climate, which has hot, dirty (dusty, smoky) air and erratic winds, needs a way to get comfortable using air conditioning equipment. In this paper, the calculations were carried out, taking into account the ASHRAE standards. For Space references and calculations, the plan is developed by AUTO CAD. Along with the development of Air Conditioning technology and the increasing awareness of climate change, energy consumption, and also more flexible layout of Air Conditioning placement so as to get comfortable, making the use of VRV - A continues to grow not only in office buildings but also in residential areas. This paper will explain how to design an Air Conditioning system of VRV-A by selected indoor unit and an outdoor unit with connection ratios between 50% - 200%. The cooling load calculation is carried out by using HKGSG v 2.05 software and HAP software v 4.90, which is available in the worldwide market. Nowadays, people are estimating the cooling load calculation by approximation method, i.e., by giving dimensions of the building, which the sellers are estimating roughly the cooling capacity.*

Keywords - *ASHRAE, AUTOCAD, Residences, Tropical, VRV, HKGSG Software, HAP Software*

I. INTRODUCTION

Residential is housing that functions as a place to live or a residential environment equipped with facilities and infrastructure to accommodate the environment. The ideal housing is housing that is not only assessed from the exterior and interior of the building, its location towards the workplace, education area, shopping area and is easily accessible from the main route but also from the Air Conditioning System. With the selection of a good and reliable Air Conditioning System that will provide comfort and affect the psychology of the occupants so that every activity can be carried out properly.

Indonesia is a tropical country with a high level of temperature and humidity, and this greatly affects the level of comfort in the room, the standard of comfort in the room against the surrounding air conditions (thermal comfort) is obtained at temperature 62 ^{o}F (19,6 ^{o}C) – 82 ^{o}F (27,9 ^{o}C) [2] with relative humidity less than 65% [3].

Air Conditioning system with the latest technology, namely VRV (Variable Refrigerant Volume) or VRF (Variable Refrigerant Flow). The term VRV (Variable Refrigerant Volume) or VRF (Variable Refrigerant Flow) refers to the ability of the Air Conditioning system to control the amount of refrigerant flowing into each evaporator, allowing the use of multiple evaporators of different capacities and configurations, controlling comfort, heating and cooling simultaneously. In different zones and heat recovery from one zone to another [4]. VRV system where one outdoor unit can be used for several indoor units; in other words, the general arrangement of the VRV AC system does not require a large space for many outdoor units, resulting in neatness and beauty in the residential area. Since the release of the first VRV system in 1982, Daikin continuously added new features to meet evolving market demands. From increasing the capacity load to incorporating more recovery technologies, they continue to improve the VRV system to achieve the best in comfort, efficiency, and reliability.

By using the HKGSG software v 2.05 and HAP Software v 4.90 to calculate the cooling load requirement for air conditioning (cooling capacity) in a residential by paying attention to heat sources in the room that can increase temperature and air moisture content. Sources of heat can come from outside or inside. Heat sources from outside the room can come from the conduction of heat through roofs, windows, floors, and partition walls. Heat

sources from inside the room can come from humans and room equipment such as cupboards, lights, and others.

II. TECHNOLOGY OVERVIEW

A. VRV-A

VRV-A offers technological improvements over the VRV-IV (previous generation). These technological improvements are to meet various needs while increasing energy savings, ease of installation, and systems with high reliability. The following is a discussion of what the technology improvements are:

- Energy Savings
  Unlike previous generations of VRV, VRV-A combines advanced Software and Hardware for greater energy savings during system operation. The combination of VRV (Variable Refrigerant Volume), VRT (Variable Refrigerant Temperature), and VAV (Variable Air Volume) technologies can be achieved both in terms of energy-saving and comfortable air conditioning.
- Automatic Refrigerant Function
  The automatic refrigerant function automatically determines the optimal amount the refrigerant tone charged. This function prevents a capacity shortage or energy loss due to excessive or insufficient refrigerant.
- High Reliability
  The control functions of inverter technology have been integrated on printed circuit boards. As well as improving reliability, this has reduced the number of parts and enabled downsizing.

B. Indoor Unit VRV-A (FXMQxy-PAVE)

One of the types of VRV-A indoor units is ceiling mounted duct type, or usually, we call it the FXMQ-PAVE type. The following is the description of FXMQxy-PAVE:

- F = Unit Category of indoor unit cooled type.
- X = Series Category of the inverter.
- M = Ceiling Mounted Duct.
- Q = Using Refrigerant R410-A.
- xy = Capacity Indication from (20(0.8 HP) -140(6 HP)).
- PAVE = Power Supply 1 phase, 220 – 240 VAC, 50 – 60 Hz.

This type of indoor unit has adjustable external static pressure from 30 Pa to 100 Pa, and all models of this type have a height of 300 mm. Ceiling mounted duct typed facilitated by separating the drain pipe from a maintenance inspection panel for the drain line and also equipped with silver ion which serves to prevent the growth of mucus, fungi, and bacteria that can blockages and odors smell in the drainage path [4].

Fig 1. Ceiling Mounted Duct.[4]

These are the specification of indoor units ceiling-mounted duct:

MODEL			FXMQ20PAVE	FXMQ25PAVE	FXMQ32PAVE	FXMQ40PAVE	FXMQ50PAVE
Power supply			1-phase, 220-240 V/220 V, 50/60 Hz				
Cooling capacity		Btu/h	7,500	9,600	12,300	15,400	19,100
		kW	2.2	2.8	3.6	4.5	5.6
Power consumption		kW	0.056 *1	0.056 *1	0.060 *1	0.151 *1	0.128 *1
Casing			Galvanised steel plate				
Airflow rate (HH/H/L)		m^3/min	9/7.5/6.5	9/7.5/6.5	9.5/8/7	16/13/11	18/16.5/15
		cfm	318/265/230	318/265/230	335/282/247	565/459/388	635/582/530
External static pressure		Pa	30-100 (50) *2	30-100 (50) *2	30-100 (50) *2	30-160 (100) *2	50-200 (100) *2
Sound level (HH/H/L)		dB(A)	33/31/29	33/31/29	34/32/30	39/37/35	41/39/37
Dimensions (H×W×D)		mm	300x550x700	300x550x700	300x550x700	300x700x700	300x1,000x700
Machine weight		kg	25	25	25	27	35
Piping connections	Liquid (Flare)	mm	ϕ6.4	ϕ6.4	ϕ6.4	ϕ6.4	ϕ6.4
	Gas (Flare)		ϕ12.7	ϕ12.7	ϕ12.7	ϕ12.7	ϕ12.7
	Drain		VP25 (External Dia, 32/Internal Dia, 25)				

MODEL			FXMQ63PAVE	FXMQ80PAVE	FXMQ100PAVE	FXMQ125PAVE	FXMQ140PAVE
Power supply			1-phase, 220-240 V/220 V, 50/60 Hz				
Cooling capacity		Btu/h	24,200	30,700	38,200	47,800	54,600
		kW	7.1	9.0	11.2	14.0	16.0
Power consumption		kW	0.138 *1	0.185 *1	0.215 *1	0.284 *1	0.405 *1
Casing			Galvanised steel plate				
Airflow rate (HH/H/L)		m^3/min	19.5/17.5/16	25/22.5/20	32/27/23	39/33/28	46/39/32
		cfm	688/618/565	883/794/706	1,130/953/812	1,377/1,165/988	1,624/1,377/1,130
External static pressure		Pa	50-200 (100) *2	50-200 (100) *2	50-200 (100) *2	50-200 (100) *2	50-140 (100) *2
Sound level (HH/H/L)		dB(A)	42/40/38	43/41/39	43/41/39	44/42/40	46/45/43
Dimensions (H×W×D)		mm	300x1,000x700	300x1,000x700	300x1,400x700	300x1,400x700	300x1,400x700
Machine weight		kg	35	35	45	45	46
Piping connections	Liquid (Flare)	mm	ϕ9.5	ϕ9.5	ϕ9.5	ϕ9.5	ϕ9.5
	Gas (Flare)		ϕ15.9	ϕ15.9	ϕ15.9	ϕ15.9	ϕ15.9
	Drain		VP25 (External Dia, 32/Internal Dia, 25)				

Fig 2. Type of indoor units FXMQ-PAVE[4]

C. Outdoor unit VRV-A (RXQxy-AYM)

There are three (3) types for Outdoor unit VRV-A, which are single-unit outdoor, double unit outdoor, and triple unit outdoor. For single-unit outdoor usually, we called it RXQ-xyAYM. The following is the description of RXQ-xyAYM:

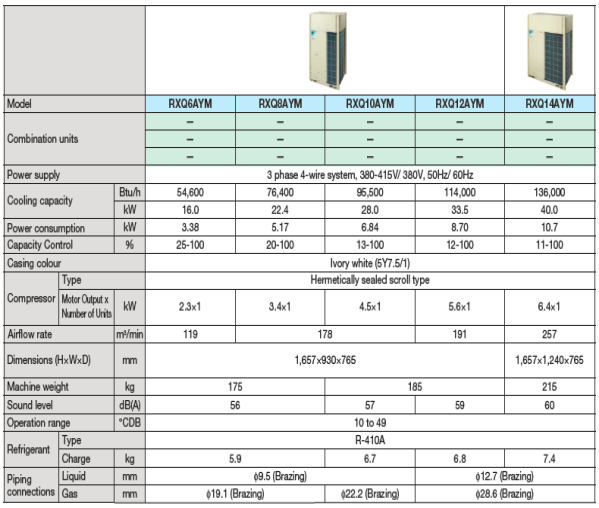
- R = Unit Category of Outdoor unit for the air-cooled type
- X = Series Category of an inverter.
- Q = Using Refrigerant R410-A.
- xy = Capacity Indication from (6 HP – 20 HP).
- A = Single Unit
- YM = Power Supply 3 phase, 380 – 415 VAC, 50/60 Hz.

The VRV-A outdoor has low operation sound, between 50 to 60 dB. For areas with stringent restrictions placed on outdoor sound levels, the outdoor unit can be set for low operation sound during the nighttime to meet sound restrictions. The unique 4-sided all-around heat exchanger ensures sufficient surface area for the heat exchanger.

This improves the heat exchanger performance without increasing the footprint [4].

Daikin VRV-A series incorporates a simplified and efficient test operation function that not only greatly accelerates the installation process but also effectively improves the field setting quality like [4]:

- Automatically checks the wiring between outdoor units and indoor units to confirm whether there is defective wiring.
- Automatically check whether the stop valve in each outdoor unit is functioning normally to ensure the smooth operation of the air conditioning system.
- Confirms piping length to optimize operation.



Model			RXQ6AYM	RXQ8AYM	RXQ10AYM	RXQ12AYM	RXQ14AYM
Combination units			–	–	–	–	–
			–	–	–	–	–
			–	–	–	–	–
Power supply			3 phase 4-wire system, 380-415V/ 380V, 50Hz/ 60Hz				
Cooling capacity		Btu/h	54,600	76,400	95,500	114,000	136,000
		kW	16.0	22.4	28.0	33.5	40.0
Power consumption		kW	3.38	5.17	6.84	8.70	10.7
Capacity Control		%	25-100	20-100	13-100	12-100	11-100
Casing colour			Ivory white (5Y7.5/1)				
Compressor	Type		Hermetically sealed scroll type				
	Motor Output x Number of Units	kW	2.3x1	3.4x1	4.5x1	5.6x1	6.4x1
Airflow rate		m³/min	119	178		191	257
Dimensions (HxWxD)		mm	1,657x930x765				1,657x1,240x765
Machine weight		kg	175		185		215
Sound level		dB(A)	56		57	59	60
Operation range		°CDB	10 to 49				
Refrigerant	Type		R-410A				
	Charge	kg	5.9		6.7	6.8	7.4
Piping connections	Liquid	mm	ϕ9.5 (Brazing)			ϕ12.7 (Brazing)	
	Gas	mm	ϕ19.1 (Brazing)		ϕ22.2 (Brazing)	ϕ28.6 (Brazing)	

Fig 3. Type of single outdoor units. [4]

III. METHODOLOGY

A. Residential House Layout and Location

The objective of this project is to design an HVAC system VRV-A which serves an area of the residential house Mrs.S which is located in Jakarta, Indonesia. The floor plan for this portion of the layout is shown in Figure 5. It is comprised of a Bedroom, WIC (Walk In Closet), and Bathroom on the 2'nd floor, but this project only designs an HVAC system for Bedroom and WIC (Walk In Closet). The rooms in this portion will be air-conditioned by one packaged rooftop.

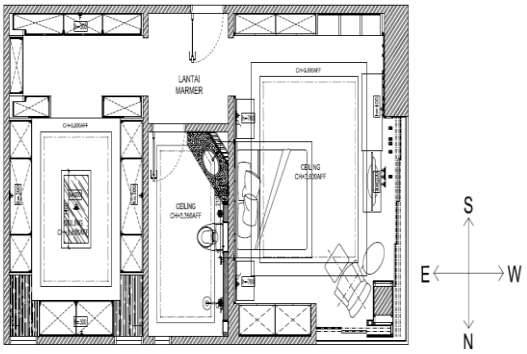


Fig 5. Residential House Layout of Mrs.S

These are the space characteristic of bedroom and WIC:

Table 1: The floor, Ceiling, Wall, and Partition Dimensions

Room Name	Floor Area (m^2)	Ceiling Height (m)	Occupancy (Person)	The outer wall (m)			The inner wall (m)		
				N	E	W	E	S	W
Bedroom	30.2	3.9	2	5.0		6.2	6.2	7.5	
WIC	22.3	3.9	1	3.8	6.2			3,8	6,2

Table 2: The Window Characteristic

Window name	Widht (m)	Height (m)	Quantity	Material	Window (m^2)	
					N	W
Window Bed (N)	2.6	2.7	1	Clear 5mm	7.0	
Window Bed (W)	4.7	2.7	1			12.7
Window WIC (N)	0.8	2.7	2		4.3	

Table 3: The U-Value Outer wall

Partition (Inner Walls)	thickness (m)	Conductivity (*k*), (W/m.K)	1/k , (m.K/W)	R (m^2.K/W)	U (W/m^2.K)
Inside Air				0.11	
Plaster	0.025	0.79	1.27	0.032	
Normal Concrete	0.15	1.4	0.72	0.11	
mortar	0.019	1.5	0.67	0.013	
Plaster	0.006	0.79	1.27	0.008	
Inside Air				0.11	
Total R Value				0.383	
U Value					2.62

Table 4: The U-Value Inner wall

Wall	thickness (m)	Conductivity (*k*), (W/m.K)	1/k , (m.K/W)	R (m^2.K/W)	U (W/m^2.K)
Inside Air				0,12	
Insulation	0.01	0.19	5.27	0.05	
Normal concrete	0.2	1.4	0.72	0.15	
Mortar	0.02	1.5	0.67	0.013	
Plaster	0.003	0.79	1.27	0.004	
Outside Air				0.03	
Total R-Value				0.367	
U Value					2.725

Table 5: The U-Value Roof (With Ceiling Board)

Roof (with Ceiling board)	thickness (m)	Conductivity (*k*), (W/m.K)	1/k , (m.K/W)	R (m^2.K/ W)	U (W/m^2. K)
Gypsum Board	0.012	0.17	5.89	0.08	
Air Gap				0.52	
Total R Value				0.62	
U Value					1.66

Table 6: The U-Value of Glass

Window/Glass Type	thickness (mm)	Shading Factor (SC)	U (W/m^2.K)
Clear Glass	5	0.63	4.97

Fig 4. Bedroom Space

Fig 5. WIC Space

B. Cooling Load Calculation

A cooling load calculation determines total sensible cooling load from heat gain through opaque surfaces (walls, floors, ceilings, and doors), through transparent fenestration surfaces (windows, skylights, and glazed doors), caused by infiltration and ventilation, and because of occupancy. The latent portion of the cooling load is evaluated separately. Although the entire structure may be considered a single zone, equipment selection, and system design should be based on room-by-room calculations. For proper design of the distribution system, the conditioned airflow required by each room must be known [5].

A. Cooling Load Calculation by DACS-HKGSG Software v 2.05.

The DACCS-HKGSG Software ver 2.05 program uses a steady-state load calculation method to compute heat load over a 24-hour period (1 day) on a summer day and a winter day. It also applies effective temperature differences in consideration of the effect of the heat accumulated in the walls since the heat load, which is received from strong sunlight through the outer walls and roofs in summer, is substantial. The program contains the 24-hour weather condition data of major cities in summer and winter (TAC 5%). The standard design data include weather data of 140 countries, which is contributed by the climate data of the British Meteorological Office and Japan Meteorological Agency. The software computes cooling load according to the following flowchart:

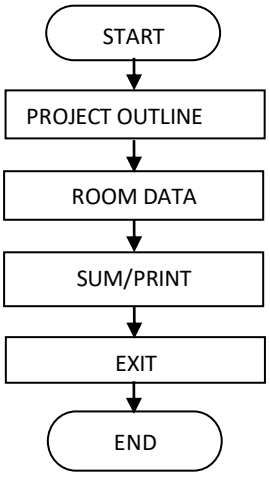


Fig 6. Operational Flowchart DACS-HKGSG Software

These are the cooling load calculation of residential Mrs.S by DACS-HKGSG Software v 2.05:

- Project Outline
  Input the project name, country/city names, address, outer wall assembly, water data, and design data such as overall heat transfer coefficient.

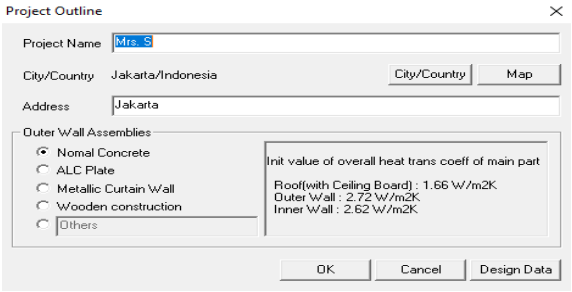


Fig7. Project Outline Mrs.S DACS-HKGSG Software

- Room Data
  Determine the room specification of Mrs.S, such as room name, floor number, usage of room, ventilation system, overall heat transfer

coefficient, design temperature and humidity, schedule, and so on.

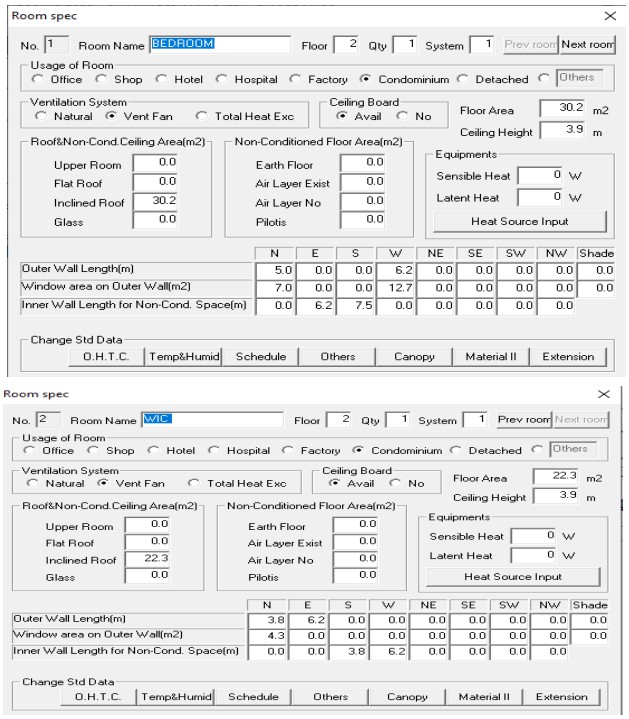


Fig 8. Room data of bedroom and WIC Mrs.S DACS-HKGSG Software

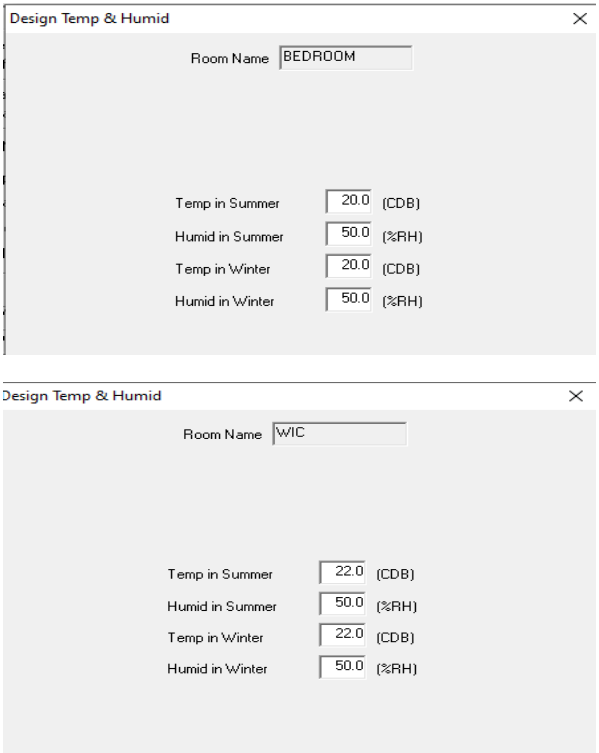


Fig 9. Design Temperature and humidity bedroom and WIC Mrs.S DACS-HKGSG Software

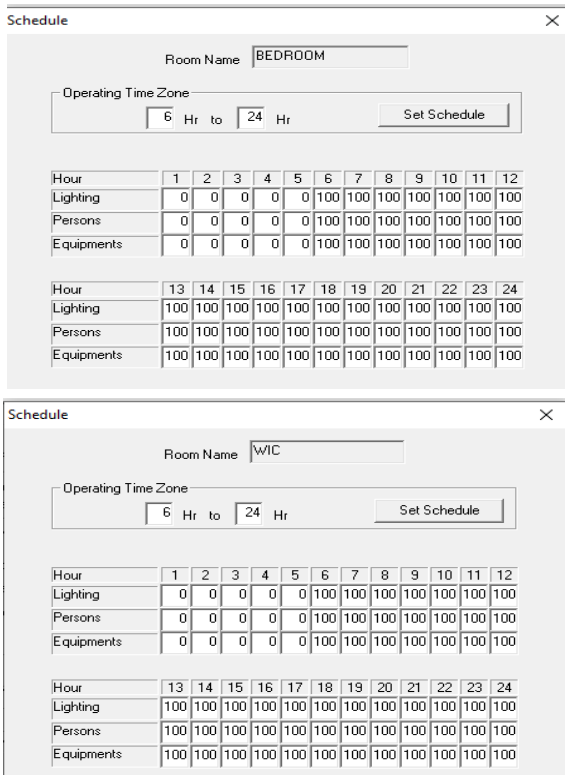


Fig 10. Schedule bedroom and WIC Mrs.S DACS-HKGSG Software

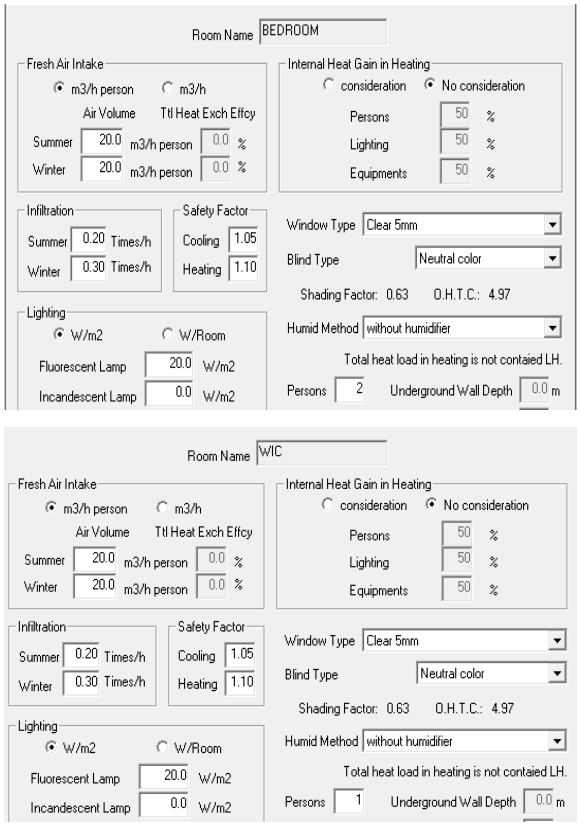


Fig 11. Window Type bedroom and WIC Mrs.S DACS-HKGSG Software

- Sum/Print
  Perform calculations and print its results

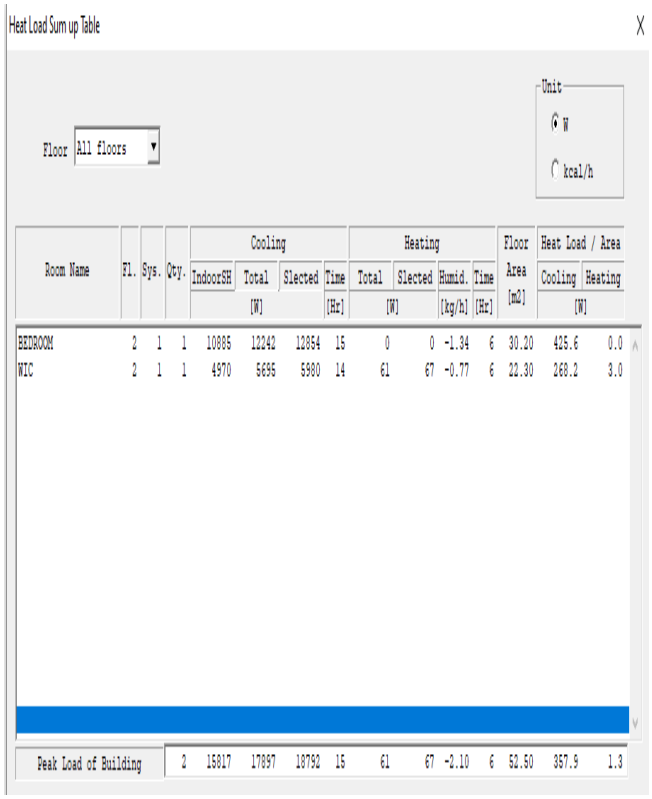


Fig 12. Result Calculation cooling load DACS-HKGSG Software

- Exit
  After all the room, calculate, exit, and save the program.

B. Cooling Load calculation by HAP Software v 4.90

Hourly Analysis Program (HAP) is a computer tool that assists engineers in designing HVAC systems for commercial buildings for estimating loads and designing systems. HAP estimates design cooling and heating loads for commercial buildings in order to determine the required sizes for HVAC system components. Ultimately, the program provides information needed for selecting and specifying equipment. Specifically, the program performs the following tasks:

- Calculates design cooling and heating loads for spaces, zones, and coils in the HVAC system.
- Determines required airflow rates for spaces, zones, and the system.
- Sizes cooling and heating coils.
- Sizes air circulation fans.
- Sizes chillers and boilers.

The software computes cooling load according to the following flowchart:

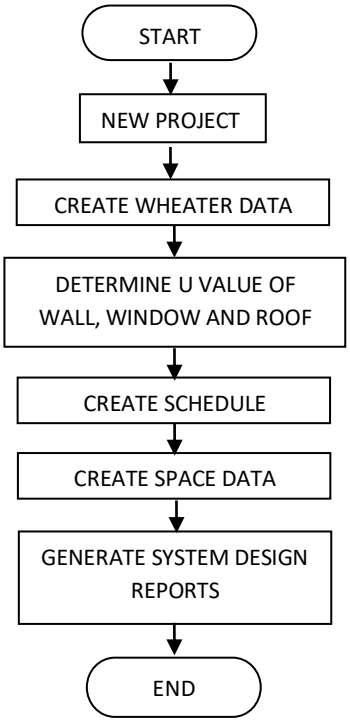


Fig 13. Operational Flowchart HAP Software.

These are the cooling load calculation of residential Mrs.S using Hap Software v 4.90:

- New Project
  creates a new project, in this case, create Mrs. S Project. This Function is to hold and save your data.

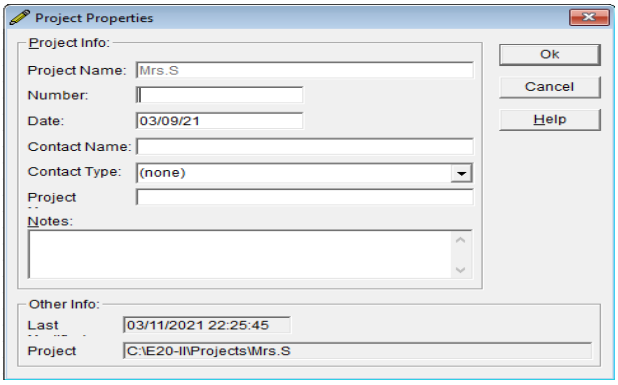


Fig 14. Create Project Mrs.S with HAP Software

- Create Weather Data
  Input the weather data Mrs.s

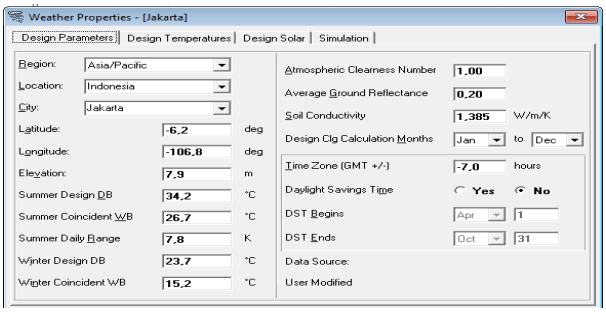


Fig 15. Create weather Data Mrs.S with HAP Software

- Determine U value of wall, window, and roof

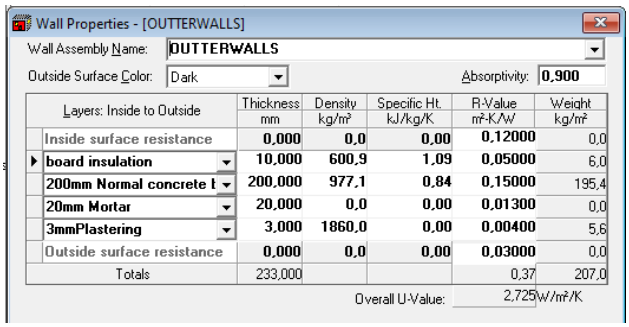


Fig 16. U Value Outerwall Mrs.S with HAP Software.

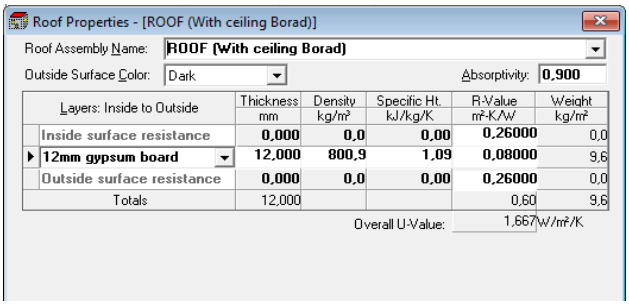
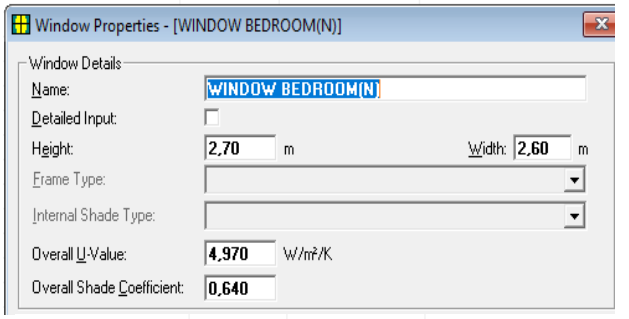
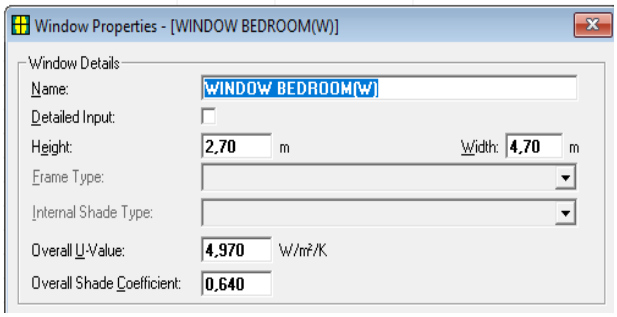


Fig 17. U Value Roof (With Ceiling Board) Mrs.S with HAP Software.





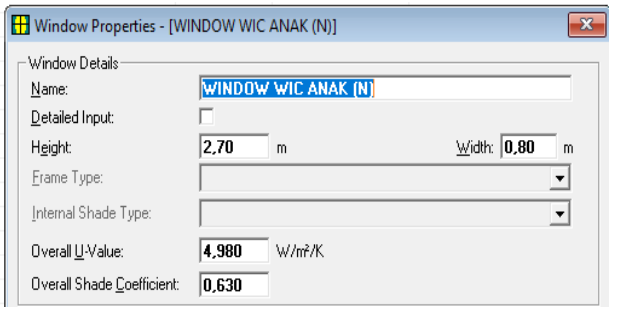
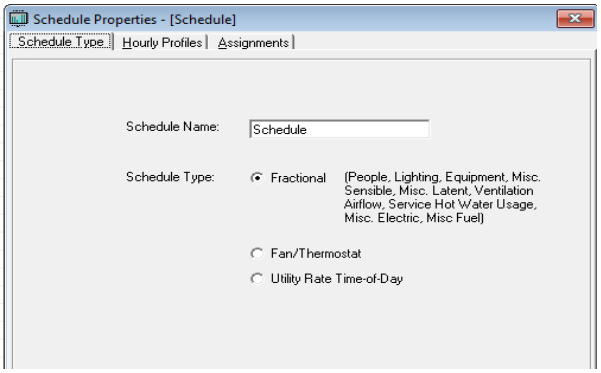


Fig 18. Window Specification Mrs.S with HAP Software

- Create Schedule



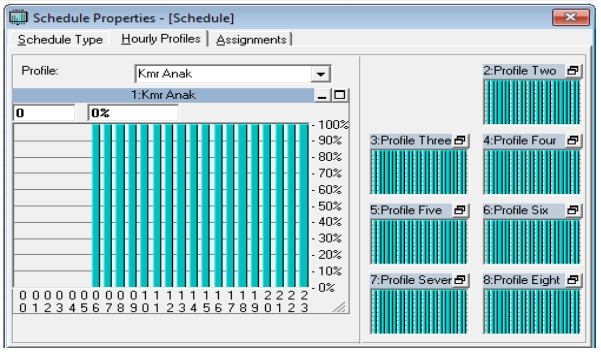
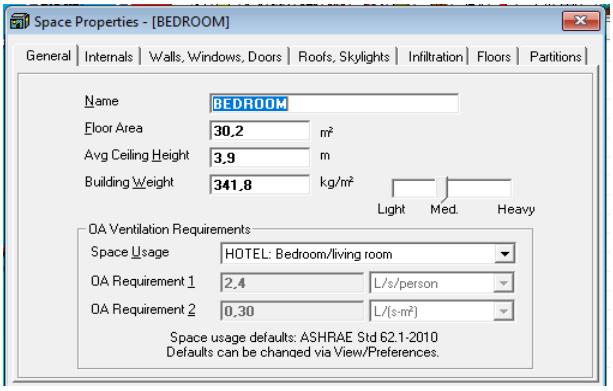
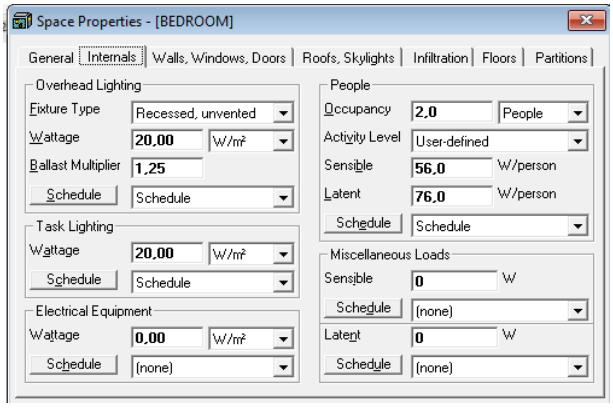


Fig19. Schedule Mrs.S with HAP Software.

- Create Space Data





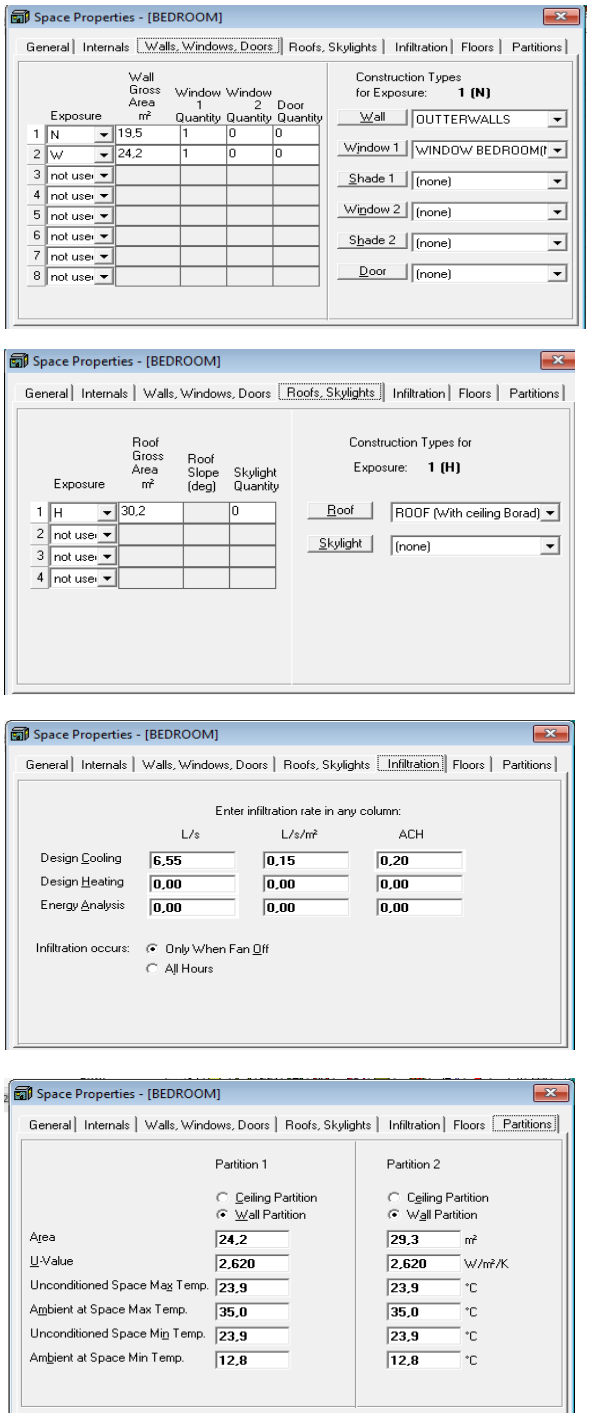
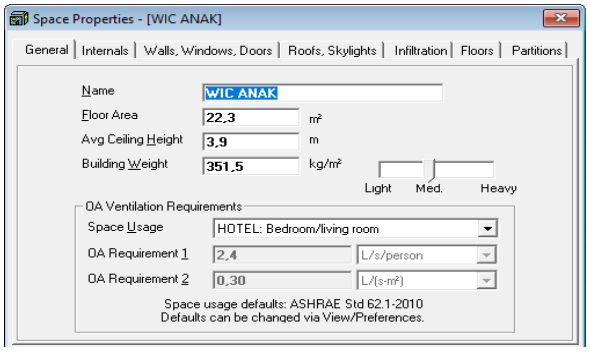


Fig 20. Room Specification Mrs.S for Bedroom with HAP Software.



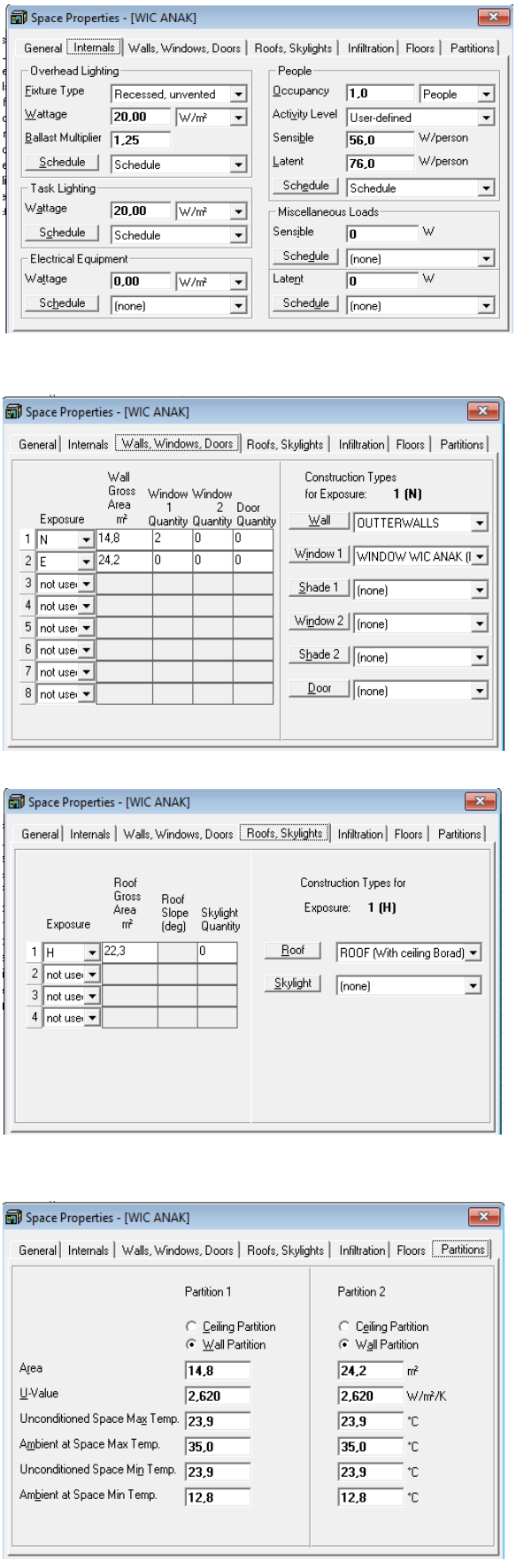
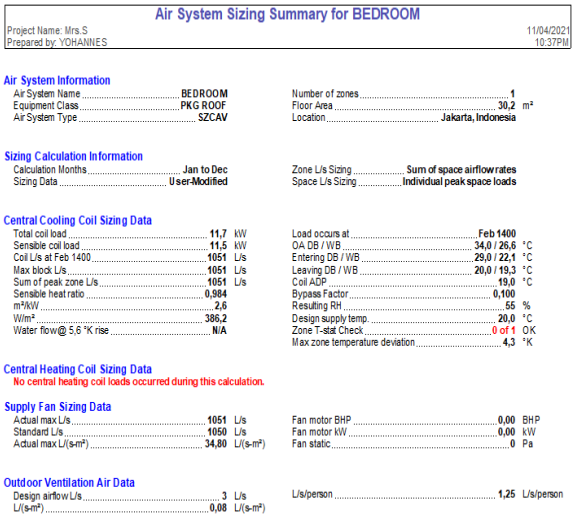


Fig 21. Room Specification Mrs.S for WIC with HAP Software.

- Generate System Design Report



Air System Sizing Summary for BEDROOM

Project Name: Mrs.S — 11/04/2021
Prepared by: YOHANNES — 10:37PM

Air System Information

Air System Name	BEDROOM	Number of zones	1
Equipment Class	PKG ROOF	Floor Area	30,2 m²
Air System Type	SZCAV	Location	Jakarta, Indonesia

Sizing Calculation Information

Calculation Months	Jan to Dec	Zone L/s Sizing	Sum of space airflow rates
Sizing Data	User-Modified	Space L/s Sizing	Individual peak space loads

Central Cooling Coil Sizing Data

Total coil load	11,7 kW	Load occurs at	Feb 1400
Sensible coil load	11,5 kW	OA DB / WB	34,0 / 26,6 °C
Coil L/s at Feb 1400	1051 L/s	Entering DB / WB	29,0 / 22,1 °C
Max block L/s	1051 L/s	Leaving DB / WB	20,0 / 19,3 °C
Sum of peak zone L/s	1051 L/s	Coil ADP	19,0 °C
Sensible heat ratio	0,984	Bypass Factor	0,100
m²/kW	2,6	Resulting RH	55 %
W/m²	386,2	Design supply temp.	20,0 °C
Water flow@ 5,6 °K rise	N/A	Zone T-stat Check	0 of 1 OK
		Max zone temperature deviation	4,3 °K

Central Heating Coil Sizing Data

No central heating coil loads occurred during this calculation.

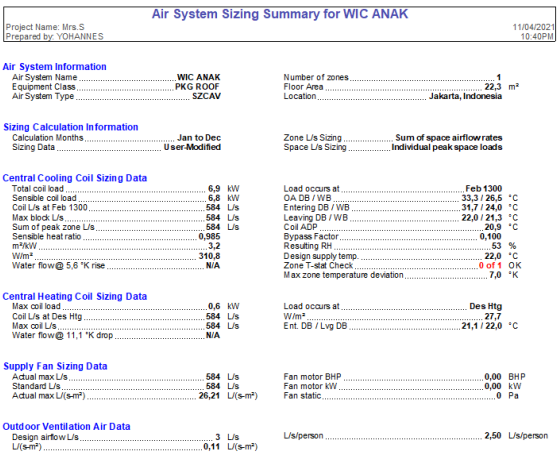
Supply Fan Sizing Data

Actual max L/s	1051 L/s	Fan motor BHP	0,00 BHP
Standard L/s	1050 L/s	Fan motor kW	0,00 kW
Actual max L/(s-m²)	34,80 L/(s-m²)	Fan static	0 Pa

Outdoor Ventilation Air Data

Design airflow L/s	3 L/s	L/s/person	1,25 L/s/person
L/(s-m²)	0,08 L/(s-m²)		

Fig 22. Design Report Mrs.S for Bedroom with HAP Software.



Air System Sizing Summary for WIC ANAK

Project Name: Mrs.S — 11/04/2021
Prepared by: YOHANNES — 10:40PM

Air System Information

Air System Name	WIC ANAK	Number of zones	1
Equipment Class	PKG ROOF	Floor Area	22,3 m²
Air System Type	SZCAV	Location	Jakarta, Indonesia

Sizing Calculation Information

Calculation Months	Jan to Dec	Zone L/s Sizing	Sum of space airflow rates
Sizing Data	User-Modified	Space L/s Sizing	Individual peak space loads

Central Cooling Coil Sizing Data

Total coil load	6,9 kW	Load occurs at	Feb 1300
Sensible coil load	6,8 kW	OA DB / WB	33,3 / 26,5 °C
Coil L/s at Feb 1300	584 L/s	Entering DB / WB	31,7 / 24,0 °C
Max block L/s	584 L/s	Leaving DB / WB	22,0 / 21,3 °C
Sum of peak zone L/s	584 L/s	Coil ADP	20,9 °C
Sensible heat ratio	0,985	Bypass Factor	0,100
m²/kW	3,2	Resulting RH	53 %
W/m²	310,8	Design supply temp.	22,0 °C
Water flow@ 5,6 °K rise	N/A	Zone T-stat Check	0 of 1 OK
		Max zone temperature deviation	7,0 °K

Central Heating Coil Sizing Data

Max coil load	0,6 kW	Load occurs at	Des Htg
Coil L/s at Des Htg	584 L/s	W/m²	27,7
Max coil L/s	584 L/s	Ent. DB / Lvg DB	21,1 / 22,0 °C
Water flow@ 11,1 °K drop	N/A		

Supply Fan Sizing Data

Actual max L/s	584 L/s	Fan motor BHP	0,00 BHP
Standard L/s	584 L/s	Fan motor kW	0,00 kW
Actual max L/(s-m²)	26,21 L/(s-m²)	Fan static	0 Pa

Outdoor Ventilation Air Data

Design airflow L/s	3 L/s	L/s/person	2,50 L/s/person
L/(s-m²)	0,11 L/(s-m²)		

Fig 22. Design Report Mrs.S for WIC with HAP Software.

IV. RESULT AND DISCUSSION

Fig 11. shows the calculation cooling load result using DACS-HKGSG Software v 2.05 for the bedroom was 12.85 kW and for WIC was 5.98 kW. And Fig 21. shows the calculation cooling load result using HAP Software v 4.90 for the bedroom was 11.7 kW and figure 22 shows the calculation cooling load result using HAP Software v 4.90 for WIC was 6.9 kW.

Based on the result cooling load of both software, the suitable indoor unit for the bedroom is FXMQ125PAV, and the indoor unit for WIC is FXMQ63PAV. With a connection ratio of 94%, the suitable outdoor unit is RXQ8AYM.

Table 7: Selection Units

NO	LOCATION	TEMP (°C)	TYPE		CAPACITY		MODEL	SYSTEM
1	OUTDOOR UNIT							8 HP RXQ-8AYM
2	Bedroom	20	FXMQ	125	5	HP	Ceiling Mounted Duct	125
3	WIC	22	FXMQ	63	2.5	HP	Ceiling Mounted Duct	63
							TOTAL INDEKS LOAD	188
							CONNECTION RATIO	94%

The defined selection units for the VRV system are tested using Multi-Use USB Temp & RH Data Logger – Temp U03 from Tzone.

Table 8: Temp U03 Specifications [9]

Temperature Scale	°C or °F
Accuracy	± 3 % RH; 0.5 °C (-20 °C ~ +40 °C), ± 1.0 °C (kisaran)
Resolution	0.1 °C atau 0.1 °F; 0.1% RH
Communication	USB
Measuring Range	*Temp:* -30 °C ~ 60 °C; *Humidity:* 0% RH – 100% RH

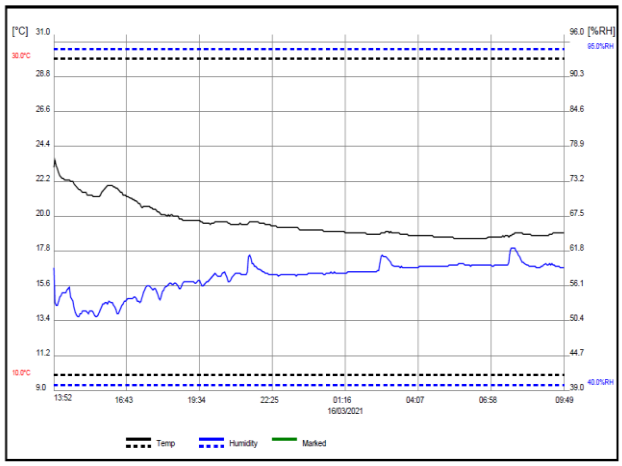


Figure 23. Relative Humidity and Temperature of Bedroom[9]

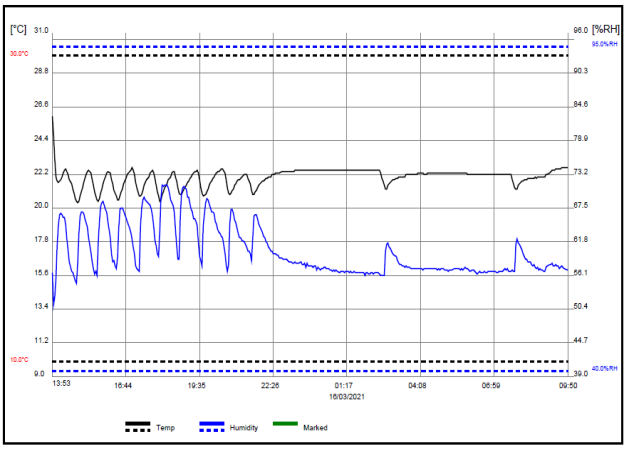


Figure 24. Relative Humidity and Temperature of WIC [9]

In figure 23, the average relative humidity and temperature of the bedroom is 57.6 % (RH), 19.6 ºC. In figure 24, the average relative humidity and temperature of the bedroom is 60.1 % (RH), 22.0 ºC. The result from Temp U03 shows that all the rooms are in thermal comfort conditions.

V. CONCLUSIONS

In this paper, both software is designed to find the cooling load estimation. To design the VRV system with a standard thermal comfort zone by ASHARE. The design for indoor type unit using approximation method of cooling load form HAP Software v 4.90 and DACS – HKGSG Software v 2.05.

Table 9: Summary cooling load

NO	SOFTWARE	LOCATION	COOLIG LOAD (kW)	INDOOR TYPE
1	HAP SOFTWARE 4.90	Bedroom	11.7	FXMQ125
		WIC	6.9	FXMQ63
2	DACS - HKGSG SOFTWARE 2.05	Bedroom	12.8	FXMQ125
		WIC	5.9	FXMQ63

As per the tabulated summary sheet (Table 9) following conclusions have been made.

- Based on the result of cooling load from both software by using approximation method, the designing of indoor type for VRV system is same.
- Figure 23 and figure 24 show that the designing of VRV system corresponding with ASHRAE standard.

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