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Optimize Energy Saving by Air-Conditioning in Education Building

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Abstract- Energy requirement for air conditioning applications bears a huge share of total energy consumption around the world. The existing building consists of the HVAC system, Ventilation, and Air-conditioned. Negotiate deals with an actual performance of air conditioning systems in the mentioned below case studies.

Energy saving is the basic approach that engineers are used in modern construction to achieve sustainable and environmentally friendly construction (green buildings).

The new roads reveal the importance of energy saving in general, efficiency and savings in particular. Through this study, we explain the way energy saving through the indoor air conditioning system is not the modern buildings, but through the educational buildings built and have an air conditioning system.

Keywords- *Power Saving, Air Conditioning, Higher Efficiency*

I. Introduction

The condenser is most often a tube-and-shell heat exchanger that transfers heat from the system to the atmosphere or to the cooling water.

More than six million units, air conditioners used in residences and smaller commercial buildings are sold per year.

Manufacturers must comply with the minimum efficiency standards for unitary equipment, meaning that very inefficient models can no longer be produced and sold.

However, there is still a wide efficiency range available in the marketplace. For example, for split system air conditioners under 19.05 kWh in cooling capacity, the current minimum standard is a seasonal energy efficiency ratio (SEER) of 10.0. New models, on average, have a SEER of about 11.0, but the top-rated models have a SEER of 15.0 or greater.

Thus, there is substantial potential to cut electricity use and pollutant emissions associated with such use by promoting the purchasing of highly efficient unitary air conditioners.

A. *Energy Management and Energy Auditing.*

Due to an increase in energy consumption worldwide, energy management and energy auditing are considered to be a global challenge. Energy management is termed as the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total cost of producing the output of the systems while the users leave permanent access to the energy they need. The main objectives of energy management are resource conservation, climate protection, and cost saving.

B. *Electricity Consumption.*

The electricity consumption of the existing appliances and the proposed appliances was computed by multiplication of the number of equipment's N, power rating W and the operating hours OH. The mathematical expression is given below:

$$\text{Electricity Consumption} = \frac{N \times W \times OH}{1000}\ .\ \text{K watt}$$

C. *Energy Saving.*

Energy saving is the differences between the energy consumption of existing appliances and the proposed appliances.

$$\text{Energy Saving} = \text{Electricity Consumption}_{\text{Existing}} - \text{Electricity consumption}_{\text{proposed}}$$

D. *Payback Period.*

The payback period is defined as the time (usually expressed in years) required for the cumulative operator

Choosing an option (or equipment) to equal the investment cost of the option

$$\text{Simple payback period (year)} = \frac{\text{incremental cost}}{\text{Annual energy cost saving}}$$

E. *Project objective.*

Current situation stays and comprehension.

The ability of power consumption, according to the study cases comprehension. Ideal suggestion.

II. Case Study

Study area: In this case, we take the room inside SEGi University.

This room dimension is: 11,70×11, 80 meter we do the measure the temperature and the average relative humidity outdoors and inside the room (Figure 1).

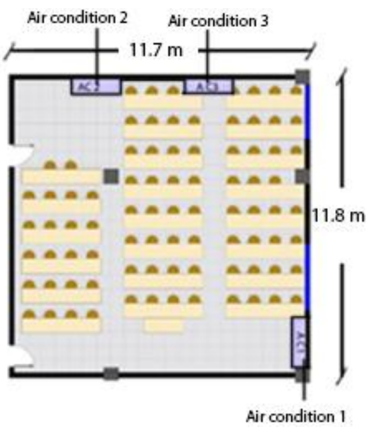

Figure 1. Room Layou10t of case room

A. *Objective thermal measurements*

1) Outdoor microclimate.

Outdoor microclimate data consisting of air temperature, relative humidity, and wind speed at case study sites for November (2017), the recorded average temperatures were 29°C, 32°C and 28.3°C with an average humidity of 76.7%, 82.4%, and 76.8%. Wind speed was around 3 m/s for all three case study sites. (Figure 2, Figure 3, Figure 4)

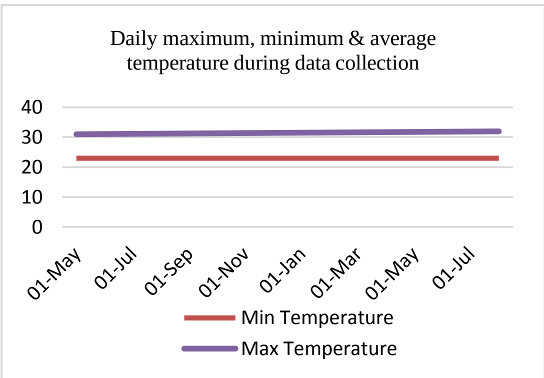

Figure 2. Average temperatures of the month February until April 2017 (in Malaysia-Damansara) (Accu Weather)

In figure 2, the temperature it's ranged from 29 to 32 °C (Annual Weather Averages 2017-2018)

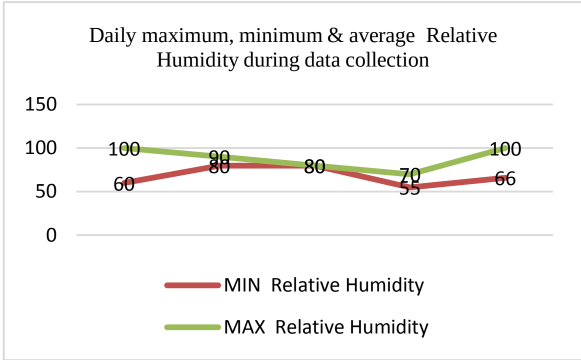

Figure 3. Humidity between the month of February until April 2017 (in Malaysia-Damansara) (Accu Weather)

In figure 3, the average Relative Humidity moving around 50 to 100 during the year (Annual Weather Averages)

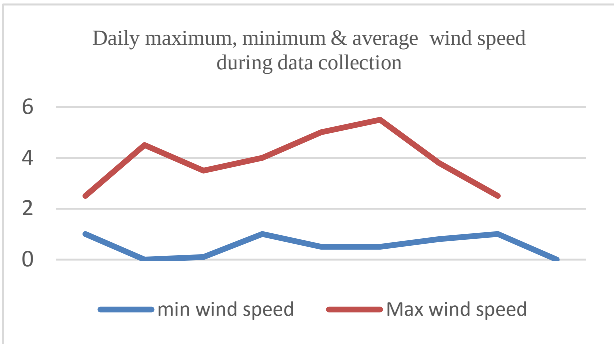

Figure 4. The wind speeds in Damansara (Accu Weather)

In Figure 4, the wind speed moving around 2 to 10 Km/h during the year (Annual Weather Averages 2017-2018)

2) Measuring the Energy in Interior room:

The entire tutorial rooms have three things in common; which are; the air-conditioning system, the projector, and the lightning. The air conditioning system has the highest power consumption of 91.82%, followed by the projector system at 7.39% and then the lightening bulbs 0.79%. But the projector system and the Lighting are not included in this case study. (Figure 5)

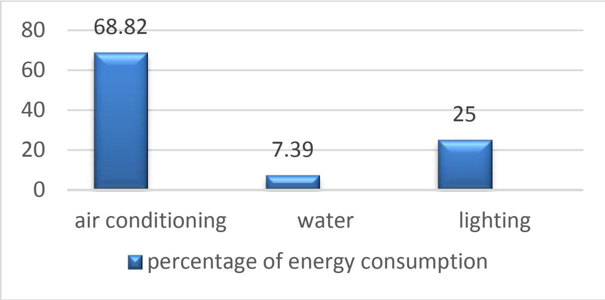

Figure 5. Percentage of energy consumption in the period between the month of February until April 2017 in Damansara area-Malaysia (CEIC data Malaysia)

B. Temperature and relative humidity.

1) Without-air-conditioning.

In this case, we measure the room without a condition. This room was containing three air conditions designed to be suspended from a ceiling or mounted low on a wall in areas where wall space is limited. Aesthetically pleasing, it is a great fit beneath windows.

Units can be operated by infrared remote control or wired controller for maximum flexibility. And the volume of the room is 484 m_3 if we turn off fall air conditions the temperatures and the relative humidity was be like (Table I) in this schedule, we measured internal temperature fluctuations during November during working hours. (Related to Figure 2)

TABLE I. THE TEMPERATURE AND HUMIDITY INSIDE THE ROOM

	01/02/2017			11/04/2017		
	T	RH	WS	T	RH	WS
Mean	32.8	65.3%	-	32	65.9%	-
Min	24.5	51%	-	24.5	51%	-
Max	35.1	92.0%	-	35.1	92.0%	-

where:

T: temperature.RH: Relative Humidity. WS: wind speed

2) With air conditioning

Study of room temperature when you turn the air conditioner on all the possibilities available and follow the heat fluctuations during the month of November.

III. ENERGY AND COST SAVING POTENTIAL IN AIR CONDITIONERS

Presently, there are many packaged air conditioning units at many facilities used for cooling office and production areas. Today, manufacturers produce air conditioners with much higher efficiencies than those currently installed at many facilities. The energy cost savings resulting from these new higher-efficiency units will help pay for the replacement of the older air conditioners.

Energy savings are due to the higher efficiency rating of the new air conditioners. The monthly demand, saving, DS, to be achieved by installing new high-efficiency air conditioners can be estimated as the difference between the current power demand, CED, and the proposed power demand, PED:

$$DS = CED - PED \quad (1)$$

The CED and PED values can be estimated as follows:

$$CED{=}N\times (CC/SEER_{ci}) \times K1 \quad (2)$$

$$PED{=}N\times (CC/SEER_{pi}) \times K1 \quad (3)$$

Where N is the number of units, CC is the cooling capacity (kW/h), the SEER is the seasonal energy efficiency ratio (kW h −1 W−1), K1 is the energy conversion factor (0.001 kW/W), I am the current SEER rating, and pi is the proposed SEER rating.

The annual usage savings, US, can be estimated as the difference between the current energy usage, CEU, and the proposed energy usage, PEU:

$$US= (CED-PED) \times CLH=CEU-P\,EU \quad (4)$$

Where CLH is the cooling load hours (h/ month). In order to estimate the annual cost savings due to usage reduction, UCS, the following equation will be used:

$$UCS=US\times \text{(average usage cost)} \quad (5)$$

The estimated demand savings, EDS, are calculated as:

$$EDS=DS \times CF \quad (6)$$

In order to estimate the annual cost savings due to demand reduction, DCS, the following equation will be used:

$$DCS=DS\times\text{(average demand cost)} \times M\times CF \quad (7)$$

Where M is the number of months the A/C units are running and CF is the coincidence factor. The total annual cost savings for these units, CS, is estimated at:

$$CS=UCS+ DCS \quad (8)$$

The total annual energy savings (ES), in kWh/month, are estimated as

$$ES= US \quad (9)$$

It is recommended that new air conditioners be installed only when existing units reach the end of their life because the cost of implementation is based on the cost difference between the existing air conditioners and the new higher-efficiency air conditioners.

A. Case Study

In this case, we wanted to obtain the appropriate temperature that helps to feel comfortable in addition to the expense of the energy spent at each stage to reach the energy saving to be used. In this study, we must operate three air conditioners with us and the degree of cooling each air conditioner according to the British temperature unit is 28000 (But) Horsepower 2.8 (HP) This means the power conditioner for cooling equal to 2 (RT) and in the following table (II) shows the specifications of the air conditioner.

TABLE II. THE SPECIFICATIONS OF THE AIR CONDITIONER

Cooling Btu/HR	Total Power (W)	Power Source (V)	Size indoor (m)
28,000	2,777	220-240	11,70×11,80×3,00

In addition, you should know that tons (RT) of refrigeration are either electrical power is measured either by (KW) or horse (HP) either ton measured Btu British heat unit is.

It's wrong to say how much is RT cools KW but correct to say how much horsepower HP it takes to produce power x RT.

1) Status 1

The first study is the current state of the hall:

In the current state of the hall, the three air conditioners are in operation and the working hours of the three air conditioners are nine hours a day, knowing that the air conditioners work together at the same time as shown in the Figure (6).

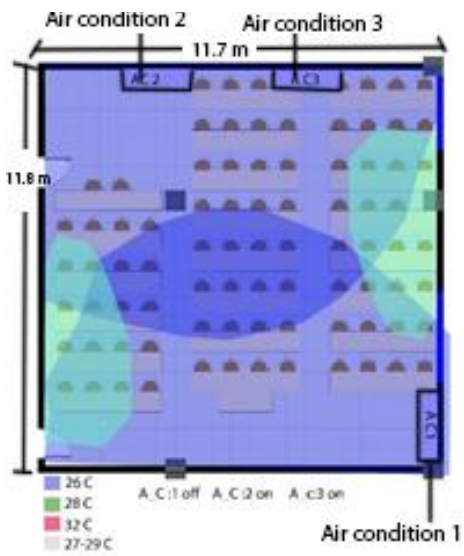

Figure 6. The three air conditioning switched on

Here is the table (III) shows us the cooling area of the air conditioners in addition to the existing temperatures as well as the number of hours worked and the amount of energy exchange per hour.

The amount of energy exchange per conditioner is calculated as follows:

1 (RT) = 12000 BTU = 3.5 KW

2 (RT) × 3 = (2X3.5) × 3= 21 KW/H

TABLE III. THE SPECIFICATIONS OF THE AIR CONDITIONER

Temperatures	Cooling area	Working hours	The amount of energy exchange per conditioner
26 ℃	80%	9 Hours	21 KW/H
28 ℃	15%		
32 ℃	5%		

The energy will be studied on the basis of three air conditioners and the number of working hours 9 hours by adding the amount of energy per air conditioner calculated on the basis of each (1 RT) consumption is 3.5 kW which means that (3 RT) equals 10.5 kW per air conditioner per hour.

That means that it is spent on 9 hours of work per day to be convertible.

9×21 KW = 189KW one day

One month the consumption is 189 × 30= 5670KW

In the year the consumption is 5670 ×12= 68040 kW

2) Status 2

The air conditioner is placed first and second in run mode and turns off the air conditioning III like Figure (7).

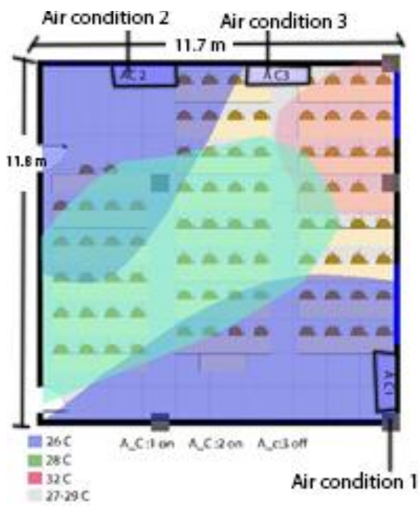

Figure 7. The air conditioning is switched on first and second and third air-turn off.

Here is the table (IV) shows us the cooling area of the air conditioners in addition to the existing temperatures as well as the number of hours worked and the amount of energy exchange per hour.

The amount of energy exchange per conditioner is calculated as follows:

1 (RT) = 12000 BTU = 3.5 KW

2 (RT) × 2 = (2×3.5) × 2= 14 KW/H

TABLE IV. TEMPERATURES IN THE DAY AND THE AMOUNT OF ENERGY EXPENDED

Temperatures	Cooling area	Working hours	The amount of energy exchange per conditioner
26 ℃	45%	9 Hours	14 KW/H
28 ℃	30%		
32 ℃	25%		

The energy will be studied on the basis of two air conditioners and the number of working hours 9 hours by adding the amount of energy per air conditioner calculated on the basis of each (1 RT) consumption is 3.5 kW which means that (2 RT) equals 7 kW per air conditioner per hour

That means that it is spent on 9 hours of work per day 126 kW

One month the consumption is 3780.KW

During the year, the consumption is 45360. KW

If we analyze the results obtained in this study and to get the desired temperatures to reach the feeling of comfort inside the room, we have to operate the air conditioners 10 hours and the soiled areas occupy 30% of the room space in addition to the energy consumption during the month is 3780 KW

3) Status 3

In this case, we run both AC II and III and fireman first conditioned as shown in Figure 8.

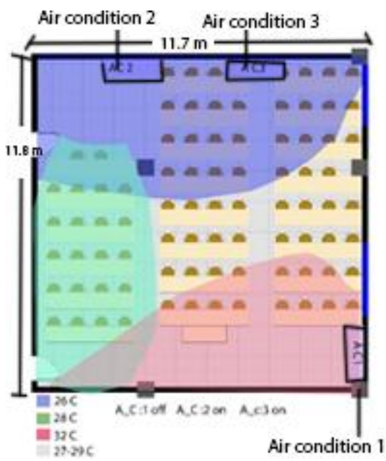

Figure 8. The second and third air conditioner is turned on and the air conditioning I matte

Here is the table (V) shows us the cooling area of the air conditioners in addition to the existing temperatures as well as the number of hours worked and the amount of energy exchange per hour.

TABLE V. TEMPERATURES IN THE DAY AND THE AMOUNT OF ENERGY EXPENDED

Temperatures	Cooling area	Working hours	The amount of energy exchange per conditioner
26 ℃	30%	10 Hours	14 KW/H
28 ℃	20%		
32 ℃	50%		

The energy will be studied on the basis of two air conditioners and the number of working hours 9 hours by adding the amount of energy per air conditioner calculated on the basis of each (1 RT) equivalent to 3.5 kW which means that (2 RT) equals 7 kW per air conditioner per hour

That means that it is spent on 9 hours of work per day 140 kW

One month the consumption is 4200 kW

In the year the consumption is 50400 kW

If we analyze the results obtained in this study and to get the desired temperatures to reach the feeling of comfort inside the room, we have to operate the air conditioners 10 hours and the cooled areas occupy 30% of the room space in addition to the energy consumption during the month 140 KW

4) Status 4

Is to put the first and third air conditioner in the operating mode and turn off the second air conditioner as shown in the figure (9).

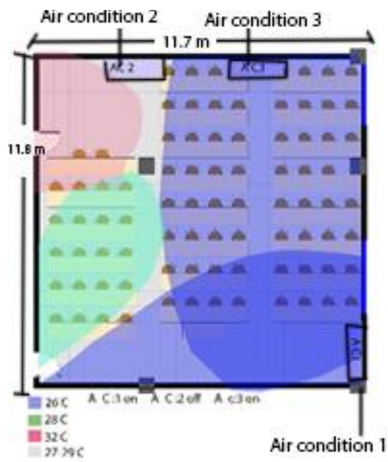

Figure 9. The first and third air conditioner is turned on and the second air conditioning matte

Here is the table (VI) shows us the cooling area of the air conditioners in addition to the existing temperatures as well as the number of hours worked and the amount of energy exchange per hour.

TABLE VI. TEMPERATURES IN THE DAY AND THE AMOUNT OF ENERGY EXPENDED

Temperatures	Cooling area	Working hours	The amount of energy exchange per conditioner
26 ℃	60%	7 Hours	14 KW/H
28 ℃	20%		
32 ℃	20%		

The energy will be studied on the basis of two air conditioners and the number of working hours 7 hours by adding the amount of energy per air conditioner calculated on the basis of each (1 RT) equivalent to 3.5 kW which means that (2 RT) equals 7 kW per air conditioner per hour

That means that it is spent on 7 hours of work per day 98kW

One month the consumption is 2940 kW

In the year the consumption is 35280 kW

If we analyze the results obtained in this study and to get the desired temperatures to reach the feeling of comfort inside the room, we have to operate the air conditioners 7 hours and the cooled areas occupy 30% of the room space in addition to the energy consumption during the month 2940 KW

B. Comparison

According to the current air conditioners location in the hall, all proposed causes are mentioned the case studies in order to get the ideal result of hall cooling, results are as mentioned below:

Case 1: monthly consumption is 5670KW /

Case 2: monthly consumption is3780 KW / Equivalent to the provision of the current situation 33.3% KW

Case 3: monthly consumption is 4200KW / Equivalent to the provision of the current situation 25% KW

Case 4: monthly consumption is 2940KW/ Equivalent to the pro

The vision of the current situation 48.1 %KW

We notice that the third case is the most efficient arrangement in regard to power.

We have to note that in each of the second, third and fourth studies, we've only operated two air conditioners out of three.

In addition to saving in KW, there is a single air conditioner. In the first study, we have operated three air conditioners, i.e. All the air conditioners in the room.

IV. OUR SOLUTION FOR A CASE STUDY

A. Status A

In case we need to get the best places for air conditioners now in conditions inside the room of the dimensions and the external temperature and the humidity is to be in the form as in the figure (10) in this case, we've got the following results.

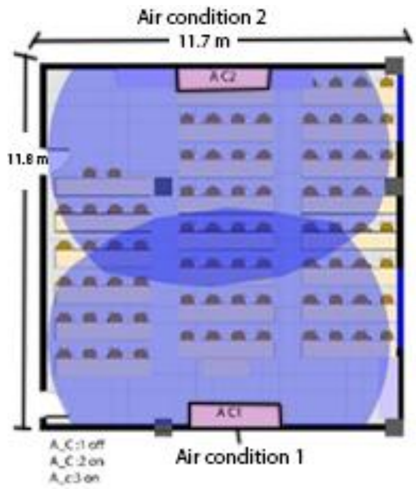

Figure 10. Way to put air conditioning in the room

Here is the table (VII) shows us the cooling area of the air conditioners in addition to the existing temperatures as well as the number of hours worked and the amount of energy exchange per hour.

TABLE VII. TEMPERATURES IN THE DAY AND THE AMOUNT OF ENERGY EXPENDED

Temperatures	Cooling area	Working hours	The amount of energy exchange per conditioner
26 ℃	80%	6 Hours	14 KW/H
28 ℃	20%		
32 ℃	-		

The energy will be studied on the basis of two air conditioners and the number of working hours 6 hours by adding the amount of energy per air conditioner calculated on the basis of each (1 RT) equivalent to 3.5 kW which means that (2 RT) equals 14 kW per air conditioner per hour

That means that it is spent on 6 hours of work per day 84 kW

One month the consumption is 2520kW

In the year the consumption is 30240 kW

B. Status B

The second place for two air conditions inside the room of the dimensions and the external temperature and the humidity is to be in the form as in the figure (11) in this case, we've got the following results.

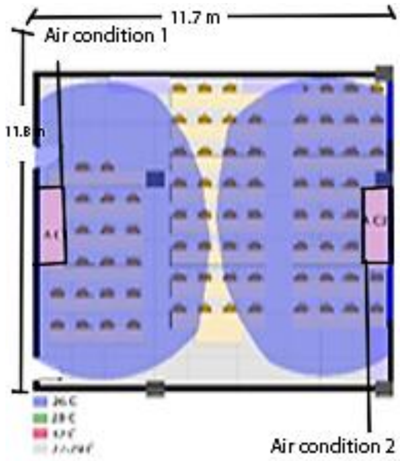

Figure 11. Way to put air conditioning in the room

Here is the table (VIII) shows us the cooling area of the air conditioners in addition to the existing temperatures as well as the number of hours worked and the amount of energy exchange per hour.

TABLE VIII. TEMPERATURES IN THE DAY AND THE AMOUNT OF ENERGY EXPENDED

Temperatures	Cooling area	Working hours	The amount of energy exchange per conditioner
26 ℃	70%	8 Hours	14 KW/H
28 ℃	30%		
32 ℃	-		

The energy will be studied on the basis of two air conditioners and the number of working hours 8 hours by adding the amount of energy per air conditioner calculated on the basis of each (1 Rt) equivalent to 3.5 kW which means that (2 Rt) equals 14 kW per air conditioner per hour. That means that it is spent on 8 hours of work per day 112 kW.

One month the consumption is 3360kW

In the year the consumption is 40320 kW

If we analyze the results obtained in this study and to get the desired temperatures to reach the feeling of comfort inside the room, we have to operate the air conditioners 6 hours and the cooled areas occupy 70% of the room space in addition to the energy consumption during the month is 3360 KW

C. Recommendation from Case study

According to the current air conditioners location in the hall, all proposed causes are mentioned the case studies in order to get the ideal result of hall cooling, results are as mentioned below: current situation: monthly consumption is 5670KW.

- Status A: monthly consumption is2520 KW Equivalent to the provision of the current situation 55.5% KW
- Status B: monthly consumption is3360 KW Equivalent to the provision of the current situation 40.7% KW

For this, we can determine that the situation is the best place because we were able to provide not only energy as we were able to provide 55 % but we were able to provide.

The air conditioner of three air conditioners so that we now only operate two air conditioners such as the Figure (10) .

V. INSTALLING NEW HIGHER-EFFICIENCY AIR CONDITIONERS:

Here is the table (IX) shows us the cooling area of the air conditioners in addition to the existing temperatures as well as the number of hours worked and the amount of energy exchange per hour.

TABLE IX. TEMPERATURES IN THE DAY AND THE AMOUNT OF ENERGY EXPENDED

Temperatures	Cooling area	Working hours	The amount of energy exchange per conditioner
26 ℃	80%	6 Hours	10 KW/H
28 ℃	20%		
32 ℃	-		

The energy will be studied on the basis of two air conditioners and the number of working hours 6 hours by adding the amount of energy per air conditioner calculated on the basis of each (1 Rt) equivalent to 2.5 kW which means that (2 Rt) equals 10 kW per air conditioner per hour.

That means that it is spent on 6 hours of work per day 60 kW.

One month the consumption is 1800kW

During the year, the consumption is 21600kW

If we analyze the results obtained in this study and to get the desired temperatures to reach the feeling of comfort inside the room, we have to operate the air conditioners 6 hours and the cooled areas occupy 80% of the room space in addition to the energy consumption during the month is 1800 KW 68.2%save.

By comparing between new higher efficiency and the current situation at the table (X):

TABLE X. COMPARISON BETWEEN THE CURRENT SITUATION AND NEW HIGHER EFFICIENCY

	Number of air conditioners.	Working hours.	Daily in KW	Monthly in KW	Total amount
Current situation	3	9	189	5670	2721.6
New Higher Efficiency	2	6	60	1800	864

VI. CONCLUSION

Through the comparison of all available cases, we find that saving between 20% to 50%, while studying (A) I've got 55% savings, but if we bring a new high-efficiency air conditioning and put them in the public and proposed in this case we can provide 68% of the current situation.

We have three important points:

- First: reducing the number of air conditioners from three air conditionings in the hall to two air-conditions.
- Second: changing places and air conditioners to suit the correct position for each hall.
- Third: power saving average about20%- 50% for each Hall.

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Ir. Prof. Dr. Jeffrey Chiang Choong Luin is currently the Dean of the Faculty of Engineering & the Built Environment, at SEGi University. He graduated from Wollongong University NSW Australia with BEng (Hons) Civil in 1991 and Ph.D. in 1995. Before embarking into a career in the academia, he was a Structural Engineer with Arup Jururunding Sdn Bhd (KL). He is actively involved in drafting the Malaysian Standards on the design of concrete structures (as TC Secretary) and has also served as Chairman of TC on Earthquake. He was the previous Chairman of IEM-TC Wind Loading. He was approved as MIEM and P.Eng in Civil in 2003 and he was elected as a Fellow Member of IEM in 2015 and was approved as Honorary Fellow of AFEO in 2015.

He was the Past Chairman of IEM Civil & Structural Engineering Technical Division and has served as IEM Honorary Secretary and Treasurer from 2008 to 2016. He is presently serving again as one of the elected Vice-President of IEM. In the international arena, he was an active member of the International Committee on Concrete Model Code for Asia, as the WG Coordinator on design. His research interests are in structural behavior and design of concrete structures in shear as well as under wind loads and earthquake actions.

Mr. Ghayath Dbes is a Master Degree graduate of Architectural Studies from Damascus University in Syria in 2012, after having completed his basic degree in 2010. He went on to take on and completed his Master Degree in Project Management in Malaysia in 2015, and is now pursuing his Ph.D. studies at SEGi University in the area of Environmental Engineering with emphasis on Green Building Conversion of Existing Building Facilities. He has prior industrial experiences in Syria working as a Design Architect and Interior Design Consultant in Syria, Kuwait and most recently in Malaysia. Ghayath has a keen interest as a student of Architectural Engineering in the search for solutions to combat global warming and green technology to enhance home and work comfort for the masses.