Energy-Efficient Soho in South Jakarta with The Application of Adaptive Solar Facade

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Abstract. This study aimed to produce an energy-efficient SOHO that is able to accommodate the needs of space for creative workers and also to minimize the level of energy consumption by implementing adaptive solar facade. The research was carried out starting from the preparation stage, data collection stage, and then the analysis phase. The Research method used are quantitative and experimental methods. The analysis was performed by measuring the energy load consumption simulation with or without adaptive solar facade. It can be concluded that implementation of adaptive solar facade concept is a good solution for energy savings in SOHO buildings. (INSJ).

1 Introduction

Indonesia's location in the equator causes Indonesia to have a tropical climate. The indicator is hot air temperature coupled with high rainfall causing the air to become moist. The movement of the sun in Indonesia is also high which causes the temperature gap between day and night is not far. This remote temperature delay causes the wind movement in Indonesia to become low, causing the air to feel hot.

The average air temperature in Jakarta has a range of 24ºC up to 32ºC. Comfort temperatures in a space ranging from 24.9ºC - 28ºC. According to the above statement, it can be concluded that if room temperature is above 28ºC then it takes a way to reduce or decrease the temperature in the room. With this climate, to increase the physical comfort of a user in a room, the use of artificial evasion commonly called air conditioner or AC as a solution of temperature and also humidity of the air is quite high. The use of air conditioning is one of the largest electrical energy consumption factor that can reach 50-70 percent of all electrical energy usage of a building [1].

In today's modern era, the need for electric energy continues to increase annually resulting in the world's existing electrical energy sources are decreasing. In Indonesia, the largest source of electrical energy comes from coal and fuel oil derived from fossils which are unrenewable energy sources and require processes for hundreds of millions of years.

If the existing energy resources are continuously used without a more efficient savings or usage measures, the future can lead to an energy crisis. Many saving measures can be done and some of them have been applied such as the use of prepaid power systems, the use of solar panels, energy saving lamps, the utilization of natural resources, the configuration of elements of facades, double sheath and others [2].

The capital city of Jakarta is crowded with the population. Every year the population growth is growing rapidly, which is about 1.4 percent annually. Based on BPS data in 2014, the population of Jakarta is about 10 million people. However, during the day, the number increases with the coming of residents from Bekasi, Tangerang, Bogor, and Depok. The number of residents from outside Jakarta that aims to come to work or school is ranging from 1 to 2 million people so that during the day the population in Jakarta can reach 12 million people.

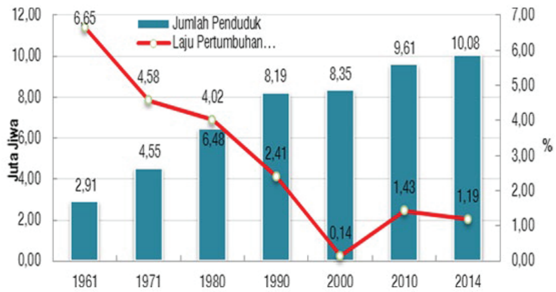

Fig. 1. Number and pace of population growth of DKI Jakarta, 1961-2014.

The population in Jakarta is coupled with a considerable congestion and with the diminishing of land in Jakarta plus the expensive office rental price currently makes the establishment of a home concept combined with an office known as SOHO or Small Office Home Office. This SOHO concept is growing in Jakarta and is hope to answer the needs of the workers who need a workspace that can fulfil their profession needs. With this SOHO concept, workers do not need to

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waste a lot of costs and time because the location of the work is already in place of residence and avoid the congestion of Jakarta so that the time can be used with more productive. Generally, there is only 1 sleeping room in the SOHO unit space because the target market from SOHO is more dominated by young couples or single people who run a business or a job that does not really need a lot of workers and flexible type of work.

The aspects of the office in SOHO must be designed to best meet the user's convenience in working [3]. These workers need an atmosphere that supports and also the condition of the room is comfortable to do their job activities, such as ideal room temperature and good view [4]. This good View is hope to inspire and eliminate fatigue in working for these workers. To produce a good view, materials that do not obstruct views such as glass or other transparent material should certainly be used. The use of glass material certainly has a big impact on increasing the temperature in the room, hence the artificial evasion or AC (air conditioning) is used [5].

The high air conditioning usage impacts the increased cost of electricity consumption. Some ways can be used to reduce the burden of electricity use for artificial avoidance, one of which is to use the concept of Adaptive Solar Façade on the building.

Fig. 2. Examples of adaptive solar facade.

Adaptive Solar Façade (ASF) is a set of solar panels with thin film sheets that can move independently on each panel. Its movements are based on sensors that track the movement of the sun and create precise control over the radiation that enters the building. On its realization, this can optimize solar harvesting and reduce the high load from coolant and artificial heating and artificial lighting.

2 Research methods

The method of research used is quantitative and experimental analytical methods. The quantity to be reviewed is the amount of the burden of the use of airing energy in conditions before and after the adoption of adaptive solar facade with the help of software to simulate the value of loading on the building. Data Collection methods include:

- Literature studies, this method is used to understand and review theories relevant to research and serves to strengthen the foundation of research. The results of the literature study were obtained from various sources such as books, websites, articles, journals, and so forth.
- A comparative study, this method is used as a tangible reference that can be directly seen and perceived in the research process. This method enhances the knowledge of researchers based on projects that have similar topics and themes to research.
- Using supporting software such as Google Sketchup 2016, Autodesk AutoCAD 2016, and Autodesk Ecotect.

The research variables used in this study are dependent and independent variables. A dependent variable or bound variable is used to measure cooling loads while the independent variable or free variable is used to measure thermal absorbent power over adaptive solar facade elements.

3 Results and discussion

3.1 Site overview

Fig. 3. Location of planning land.

Data and site needs analysis
Location : Jl. Dr. Ide Anak Agung Gde Agung, East Kuningan, South Jakarta 12950
Land size : ±1.5 ha (±15000 m^2)
KDB : 45% (15000 x 45% = 6750 m^2)
Max Floor : 24 Floors
KLB : 3.00 (15000 x 3.00 = 45000 m^2)
KDH : 30% (15000 x 30% = 4500 m^2)
KTB : 55% (15000 x 55% = 8250 m^2)
GSB : 8-10 meters
Allocation : Mixed Zone

3.2 Analysis of human aspects

3.2.1 Activity actors analysis

- SOHO residents. Party as a SOHO owner. There are two functions of activities for the residents of SOHO, that is function of residential and office functions.
- SOHO workers. Parties working together with SOHO owners.
- General Guest. Visitors who do not come to SOHO units but rather simply guests who use SOHO

facilities or conduct trading transactions in retail stores.

- Special Guest. Guest from SOHO unit which can be friends, family (occupancy function) or client or Office Guest (office function).
- SOHO Manager. The parties come to work and run the facilities that are in SOHO (not workers in the SOHO unit).
- Service personnel. The party in charge of maintaining the cleanliness and maintenance of service activities in SOHO.

3.2.2 Space needs analysis

To create space that is effective and according to required needs, it is necessary to examine who the perpetrator of the activity are and the activities specifically. The analysis aims to determine the needs and size of space needed based on the activities carried out from each party that has been in the sustainability of SOHO. The results of these analyses are made in the following table:

Table 1. Space needs analysis.

No.	**Perpetrators of activities**	**Activities**	**Space requirements**
1.	*SOHO* Residents	Sleep	Bedroom
		Bathing and urination	Bathroom
		Dining	Dining room, *Food Court,* restaurant, Cafe
		Cook	Kitchen
		Work	Workspace
		Shopping	Mini Market, *Retail,* ATM Centre
		Sports	*Fitness Center*
		Entertainment/Leisure and socialization	Swimming pool, Café, relaxing Area, balcony, garden
		Accepting guests/Clients	Living room
		Worship	Mosque
		Meeting	*Meeting Room*
		Need clean clothes	*Laundry Room*
		Need medicine	Pharmacies
		Parking	Parking Area
2.	*SOHO* Worker	Work	Workspace
		Worship	Mosque
		Dining	Dining room, *Food Court,* restaurant, Cafe
		Meeting	*Meeting Room*
		Parking	Parking Area
3.	General Guest	Wait	Lounge, Receptionist
		Shopping	Mini Market, *Retail,* ATM
		Dining and entertainment	*Food Court,* Resto, swimming pool, Cafe
		Parking	Parking Area
4.	Special Guest	Wait	Receptionist, *Lounge, Lobby*
		Shopping	*Mini Market*, Retail, ATM Centre
		Dining and entertainment	*Food Court,* Resto, swimming pool, Cafe
		Meeting	*Meeting Room*
		Meet Work Partners	Living room
		Parking	Parking Area
5.	*SOHO* Manager	Welcome guest	Receptionist
		Administration	Office Marketing
		Selling goods, Food and services	*Mini Market, Retail, Food Court, Café,* Restaurant, Laundry, Fitness *Center*
		Receive goods	*Loading Dock*, Warehouse
		Worship	Mosque
		Health services	Pharmacies

		Parking	Parking Area
6.	Service personnel	Hygiene	Janitor Room
		Building Maintenance	MEP Room
		Security	Security post, *CCTV*

Table 2. Dimensions of unit space need.

No.	Unit type	Space and dimension requirements	Number of rooms	Space area
1.	Loft Unit A	Work Area (Q = 7) 7.0 x 3.5 = 24.5 m^2	1	24.5 m^2
		Living room 3.0 x 2.5 = 7.5 m^2	1	7.5 m^2
		Dining Room 2.5 x 1.5 = 3.75 m^2	1	3.75 m^2
		Kitchen 2.5 x 2.5 = 6.25 m^2	1	6.25 m^2
		Balcony 2.0 x 1.2 = 2.4 m^2	1	2.4 m^2
		Toilet 2.5 x 1.25 = 3,125 m^2 Bathroom 3.0 x 1.5 = 4.5 m^2	2	7,625 m^2
		Bedroom 5.5 x 4.5 = 24.75 m^2	1	24.75 m^2
2.	Loft Unit B	Work Area (Q = 10) 7.0 x 4.5 = 31.5 m^2	1	31.5 m^2
		Living room 3.0 x 2.5 = 7.5 m^2	1	7.5 m^2
		Dining Room 2.5 x 1.5 = 3.75 m^2	1	3.75 m^2
		Kitchen 2.5 x 2.5 = 6.25 m^2	1	6.25 m^2
		Balcony 2.0 x 1.2 = 2.4 m^2	1	2.4 m^2
		Toilet 2.5 x 1.25 = 3,125 m^2 Bathroom 3.0 x 1.5 = 4.5 m^2	2	7,625 m^2
		Bedroom 6.5 x 4.5 = 24 M^2	1	29.25 m^2
3.	Unit Loft C	Work Area (Q = 11) 9.5 x 4.75 = 45,125 m^2	1	45,125 m^2
		Living room 3.0 x 2.5 = 7.5 m^2	1	7.5 m^2
		Dining Room 3.0 x 2.0 = 6.0 m^2	1	6.0 m^2
		Kitchen 3.5 x 1.5 = 5.25 m^2	1	5.25 m^2
		Family room 3.5 x 3.3 = 11.55 m^2	1	11.55 m^2
		Balcony Lt. 1 2.25 x 2.4 = 5.4 m^2 Balcony of master bedroom 2.1 x 1.2 = 2.52 Balcony of family room 3.5 x 1.5 = 5.25 m^2	3	13.17 m^2
		Toilet 2.5 x 1.5 = 3.75 m^2 Bathroom 3.5 x 2,750 = 9,625 m^2	2	13,375 m^2

3.2.3 Typical schematics, podium and land regulation calculations

From the schematic of the above unit plan, a podium plan schematic and a simple typical plan schematic is created to identify the typical floor area along with an estimate of how many units are available on a typical floor. This is to know the approximate number of floors adjusted to the KLB building so it does not exceed the existing rules. The results obtained by the researchers are:

- Podium: Level 1 = 3340 m^2 (max. KDB 6750 m^2)
  2nd Floor = 2281 m^2 Total = 5621 m^2
- 3rd Floor (Rental Office Unit):
  Tower A = 964 m^2
  Tower B = 964 m^2 Total = 1928 m^2
- Typical floor:
  Tower A: 20 floors x 964 m^2 = 19280 m^2
  Tower B: 16 floors x 964 m^2 = 15424 m^2
  Total = 34704 m^2
- Total Building Area: 5621 + 1928 + 34704 = 42253 m^2 (max. 45000 m^2).

3.2.4 Basement parking calculation analysis

Through the literature study data on some of the existing SOHO, the ratio of parking commonly used is the ratio of 1:1 where each of the 1 SOHO unit is provided with 1 parking area. However, because the location of SOHO is in a quite luxurious location, the ratio used is slightly larger, such as 1:1.3. So, if totaled, each typical floor is 13 units multiplied by total loft floor and parking ratio:

- Tower A: 10 storey loft x 13 units x ratio 1.3 =

169 units

- Tower B: 08 Floor loft x 13 units x ratio 1.3 = 135 units (Total Parking Unit 304 units)

From the results above, at least this SOHO design should provide parking as much as 304 units.

For car parking needs, a high percentage of 75% is taken because the location is quite luxurious so it is assumed that car users are quite high and motorcycle parking takes a percentage of 25% of the total parking units.

- Car park: 75% of 304 units = 228 units
- Motor parking: 25% of 304 units = 76 units

In the planning on the site, the basement will use three floor basement where second and third floor can accommodate about 90 cars and 40 motorcycles while the first floor accommodates fewer than 50 cars since the first floor basement is also used as a space for utilities.

3.3 Environmental analysis

3.3.1 Solar orientation analysis

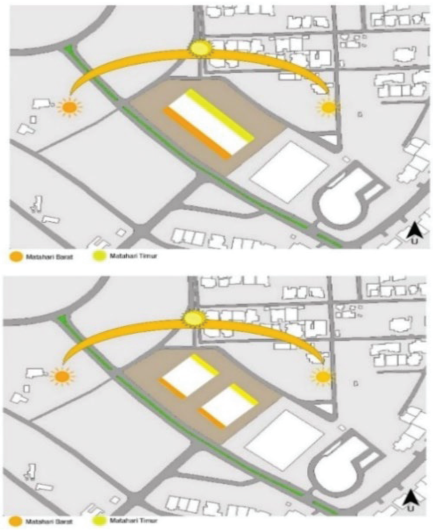

Fig. 4. Solar orientation analysis.

The design site has an elongated shape-oriented northwest and southeast. In a dwelling, thermal comfort needs attention especially in tropical regions. Good orientation is the orientation that can suppress the high radiation of the West-east Sun on the building, especially on the elongated side [6].

Then in the Sun analysis, 2 alternatives form mass material were obtained namely the mass of building A (the left) with a single mass and mass building B (right side) with the mass of compound. It can be seen above that the mass of building A has the side of the building which is exposed to radiation exposure to west-east sunlight is greater than the mass of building B. From the results of this solar analysis it is obtained that the mass of building B is more effective in reducing radiation levels so that the selected building mass is the mass building B.

3.3.2 Wind direction analysis

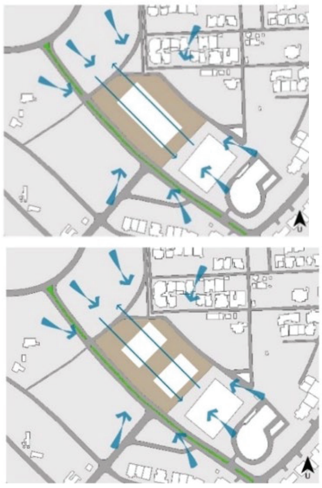

Fig. 5. Wind direction analysis on the site.

Jakarta has wind movement from southeast to northwest in the east monsoon and vice versa in the west monsoon. The wind movement corresponds to the orientation direction of the design site. Then the use of mass B was assessed more effectively because it has a wider side exposed to the wind and had the wind movement between the two masses.

From the results of solar orientation and wind direction analysis, alternative mass B is the best choice. The next analysis used only the mass B.

3.3.3 Entrance analysis

Fig. 6. Entrance analysis on site.

Entrance is the in and out circulation of users on the building. The entrance consists of motor vehicles and pedestrians. In the picture can be seen that site can be accessed through 3 side roads. Point A is Dr. Ide Anak Agung Gde Street, point B Mega Kuningan IV Street, and point C is Mega Kuningan Timur V Street.

The A and D points have the ultimate access potential which is best because it is a fairly large main road. Point A is used as an entrance entry into the site and point D is used as an exit. Then point C is used as the entrance to pedestrian in the site, this point is suitable as a pedestrian entry access because the road on this side is faced with housing and also public parking area so as to make it easier to access the site (no need to rotate too far to the main road to access the site).

3.4 Building aspect analysis

3.4.1 Mass building advanced

Through the results of an environmental aspect analysis the building mass was chosen which was divided into two building masses which followed the shape of the site and on the west and east sides of the building the width was minimized. This form of mass and orientation is developed again with Ecotect software to get optimum orientation.

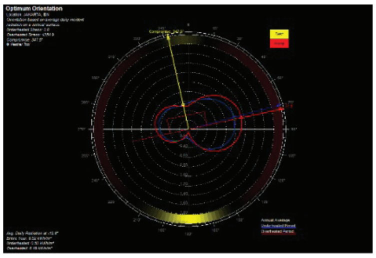

Fig. 7. Optimum orientation (ecotect).

The optimal orientation analysis result on Ecotect is that the best orientation is the orientation that is facing northwards. In the results of previous environmental analysis, it was the mass buildings oriented to the northwest-southeast. After going through this ecotect analysis results, the mass of the building is rotated to the orientation towards North-south. These changes can be seen in the following image:

Fig. 8. Mass orientation change.

3.5 Adaptive solar facade analysis

It refers to the journal titled "The Adaptive Solar Facade: From Concept to Prototypes" (2015) [7]. The first step in the design of adaptive solar facade is the placement of the ASF. On the mass of this SOHO building, ASF is placed in the wall area of the façade that covers the window of each SOHO unit. Each ASF module is placed on two floors of one type of loft unit.

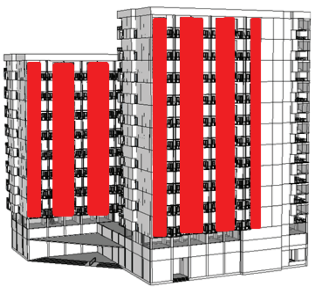

Fig. 9. The facade area applied by ASF.

Next is the selection of the supporting structures to withstand the module rather than adaptive solar facade. The support structure used is using frames and cables to operate ASF and coated with 4mm diameter stainless steel pipes for aesthetic reasons.

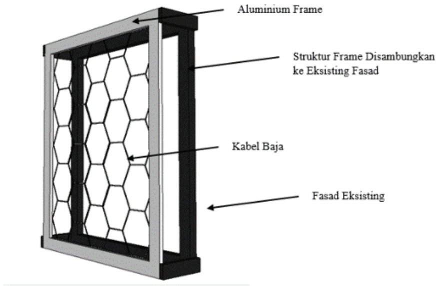

Fig. 10. ASF framework and wiring.

Next is the selection of grid sizes from the ASF panel. The grid used is tight spacing where the shading panels between ASF modules are adjacent so that they do not provide wide gaps and the operation will be more optimal and effective in blocking sunlight radiation. For the panel color selection and the shape taken is a honeycomb or hexagonal shape measuring 60cm x 60 cm. The choice of this form in addition to the aesthetic elements which is quite interesting when seen but also in the field of cross section is quite good and produces a view that is also quite good when viewed from indoors. The material used in the ASF panel module is 0.8 mm thick aluminium coated with thin solar sheets. The color used is black because it is the most effective way of absorbing solar radiation to be converted into energy and is able to increase the efficiency of solar tracking. The angle of the panel module is at a 45-degree tilt by default. For driving using pneumatic and using solar tracking.

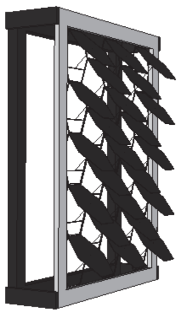

Fig. 11. Outline and module ASF default angle (45º).

3.6 Cooling energy loading rate simulation

3.6.1 Simulation of cooling energy differentiating without ASF

Material: Double Glass Low-E, U-value: 2,260

MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones
Comfort: Zonal Bands

Max Cooling: 6309262 W at 12:00 on 9th November

MONTH	HEATING (wh)	COOLING (WH)	TOTAL (WH)
Jan	0	1118069248	1118069248
Feb	0	1088564736	1088564736
Mar	0	1217968768	1217968768
APR	0	1109231872	1109231872
May	0	1204358016	1204358016
Jun	0	1060880768	1060880768
Jul	0	1116506624	1116506624
Aug	0	1243212416	1243212416
Sep	0	1228565632	1228565632
OCT	0	1351331200	1351331200
Nov	0	1240221952	1240221952
Dec	0	1317104256	1317104256
TOTAL	0	14296015872	**14,296,015,872**

PER M² 0 194646 194646
Floor Area: 73,446,305 m2

3.6.2 Simulation of cooling energy loading with ASF

Material: Stainless Steel 0.8 mm with Solar Thin-film
U-Value: 1.2, Solar Absorption: 0.9, Angle ASF: 45 º

MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones
Comfort: Zonal Bands
Max Cooling: 3713845 W at 12:00 on 9th November

MONTH	HEATING (wh)	COOLING (WH)	TOTAL (WH)
Jan	0	736842159	736842159
Feb	0	707337647	707337647
Mar	0	836741679	836741679
APR	0	728004783	728004783
May	0	823130927	823130927
Jun	0	679653679	679653679
Jul	0	735279535	735279535
Aug	0	861985327	861985327
Sep	0	847338543	847338543
OCT	0	970104111	970104111
Nov	0	858994863	858994863
Dec	0	935877167	935877167
TOTAL	0	9721290420	**9.721.290.420**

PER M² 0 194646 194646

From the simulation above, the result of the load of AC (cooling load) from the building without using ASF (Adaptive Solar facade) is 14296015872 (± 14.2 billion) Wh and after the use of ASF is 9721290420 (± 9.7 billion) Wh or there is difference in AC energy burden of 4574725452 (± 4.5 billion) Wh. If the difference in decline from the AC load is converted into percentages, there is a decrease of 32%.

4 Conclusion and suggestion

4.1 Conclusion

In the analysis discussed, adaptive solar facade can reduce the burden of AC usage significantly by 32% in a year through the results of simulation analysis. But that must be accompanied by the design of building mass and its orientation through environmental analysis so that the results obtained are more optimal. The results of the environmental analysis that have been carried out get the selected building mass form oriented north-south with a compound mass form (2 masses). Adaptive solar facade uses a size of 600 mm x 600 mm in hexagonal shape and placed in front of the window of each loft unit.

4.2 Suggestion

The design of a SOHO building should in addition pay attention to the configuration of a good space so that the relationship between the function of the house and office can run without disturbing each other. Building performance must also be considered in the design so that it is expected to become an energy-efficient building because in this modern era, the need for electrical energy continues to increase so we must start to make savings steps. The use of adaptive solar facade is very good to be used in residential offices because it has quite a variety of functions ranging from reducing heat radiation, sound insulation and wind pressure and can beautify the aesthetic outside the building.

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