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Understanding the Drives for Electricity Consumption to Implement Green Building Concept for Single House in Urban Areas

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***Abstract*— Indonesia started to implement the concept of green building as an effort to achieve sustainability, but it should be underlined that in Indonesia the implementation of green building policy has not specifically targeting housing sector while in fact land cover of metropolitan cities in Indonesia were dominated by single homes. One of objectives of green building concept is to reduce carbon footprint and this research focuse on electricity usage in building operational phase. The awareness to reduce electricity consumption to lessen our carbon footprint is still relatively low. Previous studies on adopting green building concept in urban areas mainly focused on the construction phase of the residential areas, not on the operational side, which highly related to habbits of occupant running a greener household. This study shows the dominant factors that drive people to use electricity. It was conducted by interviewing 96 house owners with dwelling areas of about 50-600 m^2 on their electric consumption habits, and determining whether they were based on income, education, or awareness. Descriptive analysis and stepwise were employed to show what dominates the possible changes in electricity consumption and the correlation between the concerning factors in the consumption patterns. The models used in this study are expected to show that in order to develop a greener habit in Indonesian urban areas, we would need a socio-economic transformation.**

Keywords—consumption, electricity, green building, residential area, carbon footprint, education, income.

I. INTRODUCTION

To reduce our carbon footprint, one of the suspected culprits of the global warming, we need the participation of as many human beings as possible. One of such participation is to reduce the electricity consumption in households. This is also one of the most effective sectors to reduce energy consumption and greenhouse gas (GHGs) emissions in the context of global climate change mitigation(1). Electricity consumption in residential areas contributes to 30% of the total annual GHGs and absorbs up to 40% of all energy worldwide (2). In general, the ratio of the energy usage in this sector is: (i)15-25% during the construction phase of the residential building, and (ii)75-85% during the operational phase, which is when the building is occupied.

However, previous studies on this subject mostly discussed the construction phase of the residential building, which is how to build a greener dwelling for the public.

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One of the research trying to related between energy consumption and building density, typology, housing location, parcel size, floor area and construction materials were compared. This research was conducted at local level of Shiraz Metropolitan, Iran. There is no significant association exists between energy consumption and several other aspects of urban form including building age, building façade type, and construction materials. It was found that some physical variables such as parcel size, setback, and the number of floors played significant roles in explaining the variances existing in energy use level (3). Study in Nirobi state that increasing enforcement of urban land and planning policy by both the national and the local government in our context can increase levels of adoption of green building concepts coupled. Other than increased enforcement, education and training focusing on sustainability are some of the ways that are recommended to increase uptake with more investment in green building related research (4). But this research focus on awareness about green building in the whole concept, especially about how to enforce urban planning policy.

Based on those reviews, only a few of studies focused on the operational phase and how it would be related to social economic condition of the occupants, which is discussing how green the households are run, while it is actually the key element for a green lifestyle. Therefore, to support and implement a successful green movement, we also have to analyze how the residential buildings are run by the occupants.

The highest energy consumption and greenhouse gas emissions occur in most metropolitan cities due to the high population growth accompanied by a higher standard of living compared to those lived in the villages or small cities (5). However, current studies state that cities have more efficient energy consumption patterns compared to villages on per capita basis (6).

Cities have economic advantages from the concentration of population, large-scale infrastructure, and high economic activity, all of which encourage innovation and efficiency. The average energy consumption per capita in industrialized countries is often lower compared to other countries in the world (7).

However, the author of this study argues that cumulatively metropolitan cities still eat away the biggest chunk of energy

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and natural resources due to their high population. Therefore, to support a sustainable city, we also have to make an attempt at increasing the efficiency in energy and natural resources consumption among its dwellers.

This study aims to determine the factors that could influence the change in energy consumption in households or residential areas in Indonesia.

The demand for single-houses in Southeast Asia's urban areas experiences a large growth since the 1997 financial crisis. For instance, Indonesia requires as much as 735,000 new houses each year (8). Between 2006 - 2010, Malaysia needed to provide as much as 709,400 units of new houses (9). Meanwhile, the Phillipines experienced a housing deficit of 3.4 million units between 2001-2004 (8). Those data show that single-houses are the dominant buildings within the urban areas as opposed to commercial buildings.

The Indonesian Government has actually employed some policies to encourage the implementation of the green lifestyle, especially in urban areas. Greenship, a certification to acknowledge a green construction or building, has been issued to office, apartment, and commercial buildings; however, for single-houses, this certification is still under evaluation for its feasibility (10). Currently, the Greenship certification could only be granted to single-houses with an area of about 2,500m^2 (10). It goes to show that at least in Indonesia the green building requirements are still not targeted to single housing. Since this type of building actually dominates the urban areas in the developing countries, it means that if the housing sector fails to apply the green building concept, the world could face a multi-decade problem in energy consumption. One way to tackle this problem is to promote a green lifestyle and reduce the energy consumption among the urban dwellers.

Socio-economic factors are major determinants in implementing a green lifestyle. A lot of cases have pointed out that just because some kind of technology is considered as "sophisticated", "good," and "green", it doesn't necessarily mean that the people would enthusiastically accept and adopt it into their lives. For example, it is still hard in Indonesia to introduce a simple toilet in some rural areas because it is just not in their culture and they are not used to it, so it takes time to make them accept it into their daily lives.

The same thing applied to implement less energy consumption. Hence, before we could make a successful promotion of a green lifestyle, especially in urban areas, we need to understand the drives for electricity consumption among the dwellers. We need to assess the socio-economic factors that could support the sustainability concept.

These considerations were the background of this study: to analyze the socio-economic factors that would drive the occupants of single-houses that dominate the urban areas in developing countries to decrease their electricity consumption in order to develop more sustainable cities in the world..

II. RESEARCH AREA

From the many places in Indonesia that would be ideal to be analyzed is Jakarta and its Greater Areas, one of which is Tangerang Municipality area, because their dwellers could represent the behaviors of a metropolitan city's dwellers in consuming electricity.

Geographical Information System (GIS) analysis shows that the Tangerang Municipality is mainly dominated by settlement areas, followed by industrial and commercial areas, as shown in Figure 1. The building population is used to analyze how the implementation of the green building policy affects the city sustainability in the future. It is also used to describe the settlement patterns and their spatiality. GIS analysis also shows that there are about 430,094 building units in Tangerang Municipality in 2013.

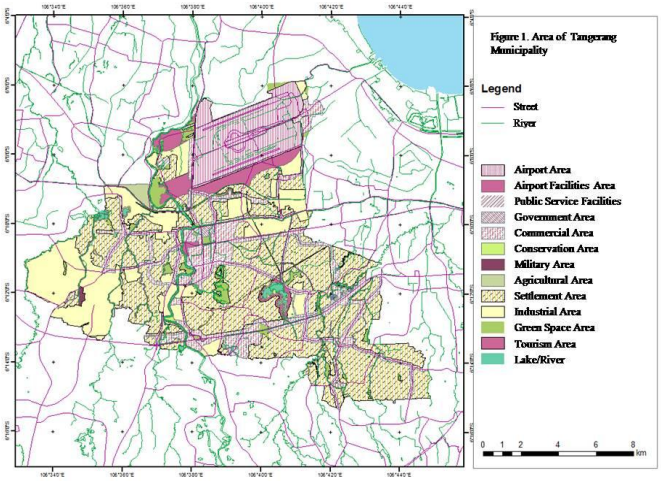

TABLE I. BUILDING COMPOSITION IN TANGERANG

No	Type of Buildings	Unit	Percentage
1	Historical Building	18	0.0042
2	Public Facilities	5,065	1.18
3	Government Office	364	0.08
4	Industries	5,938	1.38
5	Settlement	417,581	97.09
6	Schools	1,128	0.26
TOTAL		430,094	100.00

Source: GIS Analysis, 2014

Dessel in 2013 proposed a formula to estimate the sample size with a certained accuracy for a big population. Since in 2013 the settlement units in Tangerang were about 417,581 units, with a confidence interval of 10%, a confidence level of 95%, and a proportion of 50%, it was estimated that sample size should be about 96 units of housing.

III. METHODS

A. *Survey Design*

Identifying the key variables in electricity consumption was the first step taken in this research. These variables were distributed in a number of questions for the respondents. Then they were put into a scheme to explore the relationship between them with descriptive analysis.

These are key variables that were connected to each other in describing the electricity consumption pattern.

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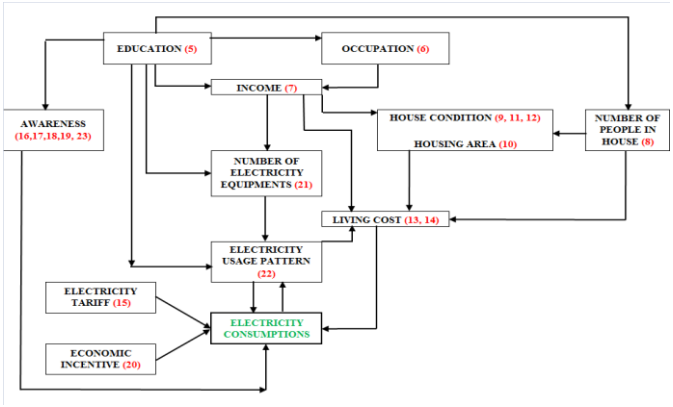

Figure 2. Key Variables

In order to distribute the samples evenly, the respondents' housing was categorized into three classes: simple housing, middle-class housing, and high-class housing. This classification is based on the Decree of the Indonesian Minister of Home Affairs, Minister of Public Works, and Minister of Public Housing No. 548-384/1992 that classifies the housing into three specifications as follows:

1. Simple Housing, with an area of about 54-200m^2.
2. Middle-class Housing, with an area of about 200-600m^2.
3. High-class Housing, with an area of about 600-2,000m^2.

GIS analysis shows that in Tangerang Municipality, Simple Housing dominates the settlement areas for more than 50%. There are also a lot of housing units that do not fit into the specifications described in the decree because they have an area smaller than 54 m^2.

TABLE II. GIS ANALYSIS OF HOUSING CLASSIFICATION

Classification	Area (m^2)	Total Area (m^2)	Percentage
Smaller than simple housing	<54	2,393,907.12	5.66
Simple housing	54 - 200	23,150,217.33	54.70
Middle class housing	200-600	6,359,894.48	15.03
High class housing	600 - 2, 000	10,415,981.07	24.61

Source: GIS Analysis, 2015

Samples were distributed in each district, depending on housing density and classification. The number of samples in each district was calculated based on the housing density in each area.

B. *Data Analysis*

Data from survey was analyzed by descriptive statistic and stepwise regression. The step-by-step iterative construction of a regression model that involves automatic selection of independent variables. Stepwise regression can be calculated by trying out one independent variable at a time and including it in the regression model if it is statistically significant, or by including all potential independent variables in the model and eliminating those that are not statistically significant, or by a combination of both methods.

IV. RESULT AND ANALYSIS

A. *Profile of Respondents*

Most of the respondent are male (72%) and between 40-50 years old (36%) followed with the age range of 30-40 years old (29%). Most of respondent level education is bachelor degree (68%) and the remaining is graduated from high school (30%) while post graduate only 2% of all respondent (Figure 4d). In this survey we categorized level of income in 5 class: (1) <Rp 1,000,000; (2) Rp 1,000,000 - 3,000,000; (3) Rp 3,000,000-5,000,000; (4) Rp 5,000,000-7,000,000; (5) > Rp 7,000,000. Survey shown that the respondents income in average is between Rp 5,000,000-7,000,000 (36%) and also more than Rp 7,000,000 for about 28%.

Most of the respondent has two storey house (31 respondents) and number of people live in a house is between 2-6 people with almost 50% of them has 3 bedrooms. It shows that number of people in house would be related to number of rooms and size of the house. Size of the house categorize based on the building area (1)House that smaller than 36m^2; (2)house between 36-70m^2; (3)house 70-120m^2; (4)House 120-200 m^2 and; (5)House more than 200m^2. Number of people in the house in average is about 5 persons. The increasing of people in a house would be followed by demand of space, that is why house with more than 5 persons usualy has two storey. Space availability for one person in a house could be an indicator to know socio-economic condition of the family. The more space available for one person show that the family has better socio-economic condition compare to family with less space availability for each person (11);(12); (13).

Most of the house has 5-10 electricity equipments as shown in Figure 3. All of the respondents own fan, refrigerator and TV, some of them has more than one of fan, TV or refrigerator. Air conditioner and computer are in the second rank equipments owned by respondent, only 1% of respondent has no air conditioner.

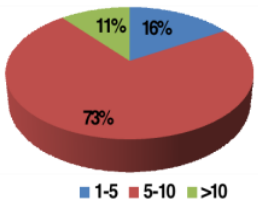

Figure 3. Number of Electricity Equipment Owned by Respondents (unit)

Ownership of electricity equipment in the house shown in Figure 4. All of respondent have fan, refrigerator, and TV. Computer and AC are type of electricity equipments that respondents plan to buy in future.

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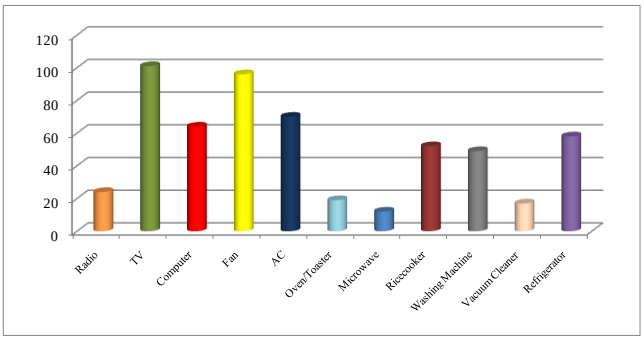

Figure 4. Electricity Equipments Owned by Respondent Nowadays
Source: Analysis, 2016

Figure 5. describe how many respondent plan to buy each type of electricity equipment in future if they had enough income to afford it. Most of respondent plan to have more electricity equipments if their income raise. Figure 5 show that most of respondent want to buy microwave, vacum cleaner and oven/toaster because most of them already had TV, computer, rice cooker and refrigerator as basic requirements.

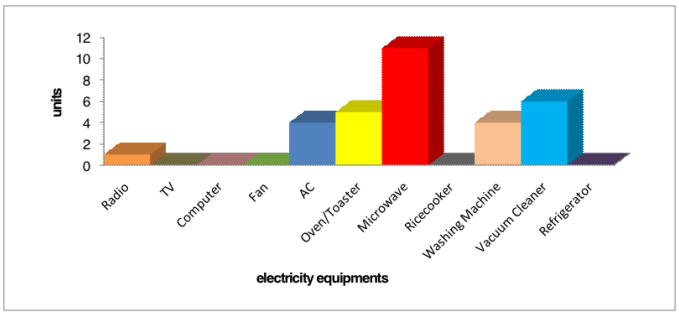

Figure 5. Type of Electricity Equipment that Respondent Plan to Buy
Source: Analysis, 2016

Electricity usage usually affected by two things: efficiency of each electricity equipments and number of electricity equipments used by the occupant. Demand to have more electricity equipments explain that in future there will be increasing of electricity consumption. Survey shows that 49,51% respondents plan to have more electricity equipment for about 6-10 units and 34,35% plan to have even more: 11-15 units.

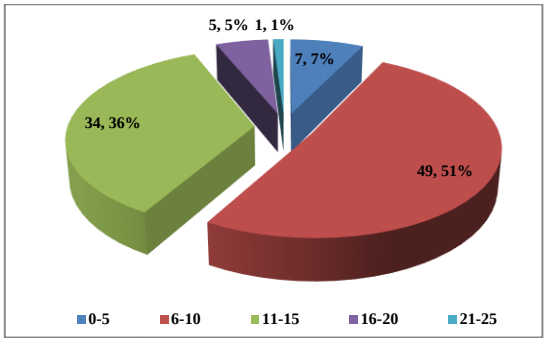

Figure 6. Number of Electricity Equipment that Respondent Plan to Buy
Source: Analysis, 2016

B. *Statistic Model*

In this section, we tried to explore how education could affect to awareness of electricity saving. There were 5 (five) main questions to be proposed to respondent as indicator of the awareness:

1. Do you concern about up and down of your electricity bill?
2. Do you think that your monthly electricity bill is too expensive?
3. Do you have plan to reduce your electricity usage?
4. If yes, how much your target in reducing electricity usage per month?
5. Do you think if your income rise then your electricity consumption would increase also?

All the questions answeres in two option yes/no. Respondents who answer more than 3 questions with 'yes' would be categorized as respondents with awareness in electricity consumptions. Education of respondent classified in two categorized: respondent with education higher than high school and respondents that has education level of high school or lower.

Correlation between awareness in saving electricity and education based on descriptive analysis was shown on the table below:

TABLE III. ELECTRICITY SAVING VS EDUCATION

			Education			Total
			Low	Middle	High	
Electricity saving awareness	yes	Count	11	26	41	78
		% within education	91,7%	89,7%	74,5%	81,2%
	no	Count	1	3	14	18
		% within education	8,3%	10,3%	25,5%	18,8%
Total		Count	12	29	55	96
		% within education	100,0%	100,0%	100,0%	100,0%

Source: Analysis, 2016

Stepwise was conducted to explore main variables effected electricity bill with level of confidence 90%. There were 10 (ten) variables included in the analysis: awareness, education, income, occupation, electricity usage pattern, number of electricity equipment, electricity tarif, economic incentive, total living cost and number of person living in the house. Result of stepwise analysis shown that there are 2 main variables affected electricity bill: tarrif and number of electricity equipments.

TABLE IV. STEPWISE FOR ELECTRICITY BILL MODEL

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-176,993.873	88,671.739		-1.996	.049
	Electricity Equipments	63,211.241	8,464.946	.610	7.467	.000
2	***(Constant)***	***-526,067.515***	***151,051.335***		***-3.483***	***.001***
	Electricity Equipments	***69,439.433***	***8,468.048***	***.670***	***8.200***	***.000***
	Tarrif	***177,126.003***	***63,150.759***	***.229***	***2.805***	***.006***

a. Dependent Variable: Electricity Bill
Source: Analysis, 2016

If y_2 = electricity bill
x_4 = number of electricity equipments
x_5 = electricity tarrif

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Vol. 6 Issue 03, March-2017

Then

$$y_2 = 69.439{,}43x_4 - 177.126x_5 - 526.067{,}52 \quad (1)$$

Number of electricity equipments owned by the occupants has significant correlation with income. Linear regression between Number of electricity equipments and income describe as below:

TABLE V. MODEL SUMMARY INCOME * NUMBER OF ELECTRICITY EQUIPMENTS

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.607[a]	.368	.362	2.900

a. Predictors: (Constant), Income
Source: Analysis, 2016

Tabel V shows that income could increase demand to buy new electricity equipment for about 36,8%.

TABLE VI. COEFFICIENT[A] INCOME * NUMBER OF ELECTRICITY EQUIPMENTS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.362	.923		3.643	.000
	Income	1.795	.243	.607	7.402	.000

a. Dependent Variable: Electricity Equipment
Source: Analysis, 2016

With level confidence 95%, income significantly effected to risen of additional electricity equipments. The higher the income, occupant will have more electricity equipments

If x_4 = electricity equipments
x_2 = income

Then

$$x_4 = 3{,}362 + 1{,}795\, x_2 \quad (2)$$

V. DISCUSSION

Some respondents tend to buy additional electricity equipments in future if they had higher income. Figure 6 shows that most of respondent who has plan to add their electricity equipment choose microwave, followed with vacuum cleaner and oven/toaster. Most of respondent already have TV, computer, fan, rice cooker and refrigerator as they are basic home appliances.

Some literatures give description that air conditioner is the most productive in emitted CO_2, followed by electric oven and washing machine. Most of respondent hasn't owned microwave yet since this electrical appliance categorized as tertier goods in Indonesia. Heating and cooking food by microwave is still uncommon in Indonesia. So having microwave is not something to fullfil their needs, but rather to increase their lifestyle.

TABLE VII. HOME APPLIANCES AND CARBON EMITTED/YEAR

Appliance	Usage/day (hours)	CO2/year (Kg)	Notes
Washing Machine	1.5	227	4 washes/week
Electric Oven	1	396	
Microwave Oven	0.2	62	
Vacuum Cleaner	0.5	18	twice a week
AC	8	1368	20 days/month

Source: http://www.reduceyourcarbonfootprint.com/2.html

As developing country, economic development is important for Indonesia, but from statistical analysis, increase in income would lead to desire in buying more electricity equipments. If people tend to more home appliances then there would be increasing amount of carbont footprint emmited in Tangerang. In Indonesia, income affected by education. Higher level of education, would lead to higher income. Equation (2) show that income have positive impact to number of electricity equipments they owned in their house. The higher the education, the higher the income earned. Higher financial ability make them feel unburdened by the increase in electricity bills and also the increase in electricity tariff. This behaviour lead to unimportance of having plans and targets to reduce electricity consumption. People who have lower income, even they don't have knowledge and awareness about the importance of saving electricity, trying hard to reduce their electricity consumption because of their limited financial ability to pay the electricity bill. They don't have any plan also to add their electricity equipments because of their ability to buy new appliances is low.

VI. CONCLUSION

Considering all the fact explored above, the implementation of green building concept in single houses would face to significant obstacles. Green building trying to reduce electricity consumption by replacing electrical appliances with more energy-efficient appliances, but on the other hand the desire to buy new electrical appliances still lead to the increasing of electricity consumption. So that the carbon footprint emitted will remain high. Recently Indonesia still on progress to improve level of education and economic levels of the society, but concerning to those analysis, carbon footprint emitted by single houses will still rise in the years to come. Economic incentives could encourage lowered electricity consumption, but a very important thing to do is to increase awareness about the importance in saving electricity especially for people with middle to high incomes because they have high electricity consumption. Social economic transformation needed to support for the successful implementation of green building in single houses to lower carbon footprint emitted in Tangerang.

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