Urban Household Electricity Consumption: A Study of Providing Information for Energy Policy Planning

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Abstract - Providing information comprehensively regarding drivers for household electricity use is important for power system operation and more realistic planning for energy conservation policies. This paper has focus to provide information related to household electricity consumption and behaviour of users in Makassar, Indonesia. For this purpose, a questionnaire was developed for survey to get data from users such as family characteristics, house building, owned energy efficient appliances (EEA), user behaviour in using appliances, obstacles in practising energy saving, etcetera. To derive more information, obtained data were also analyzed using regression approach. Some important information from survey results are demand for larger installed electricity power capacity (IEPC) is increased and mainly for house with IEPC 900 VA. For EEA, lamp, refrigerator, and air-conditioner (AC) are mostly owned by respondents. Obstacles in practicing daily electricity saving include such as users do not have not enough information regarding energy saving behaviour. From regression analysis, it is found that perception is a key factor to enhance the utilization level of EEA and to improve habit of the users for electricity saving. Presented information is useful as a reference for energy policy planning for residential sector in Indonesia.

Keywords: Electricity saving, energy policy, household electricity consumption, information, Makassar.

1. Introduction

Residential sector in many places is confirmed as a main electricity sector because load demand from this sector has significant portion to the total load which tends to increase by year. To maintain stability of power system and service to users, it is important to know condition and characteristics of load demand. Knowing pattern and factors affect household electricity energy consumption is needed as a basis to manage daily power system operation and to compose energy conservation policy. Several factors which may related to volume energy consumption at home are weather condition, users' behavior, house size, structure of family, architectural design, types of home appliances (equipment efficiency), economic level of user [1-5]. However, information such these factors are quite limited in some places such as in Indonesia. In other words, available information is not detail or insufficient. To handle this problem, it is needed to conduct studies that can provide more detail data regarding users and their electricity usage that may used for composing policy. Next to implement target policy, information to consumers is required [6].

To get specific and complete data as needed regarding electricity users, household survey using questionnaire as instrument can be done. Some studies that discussed similar cases can be found in [4,5,7-9]. For example in [4] conducted

online survey in China to get detail information regarding residential building characteristic, energy consumption, and user's behaviour. Study in [5] performed survey to get general pattern of Turkish residential electricity load in summer and winter for energy management system needs. In [7], the authors conducted survey to get information about residential electricity consumption in rural and urban areas of Northwestern China. In [8] used survey results to observe a number of variables (such as building variables, socio-demographic, user's behaviour, etcetera) and the influence of each variable on English household electricity consumption. In [9] performed survey to analyze the utilization of solar home system in Thailand and the fulfillment of growing electricity demand in the studied rural area.

In this research, observations to the variables that may affect household electricity consumption in Makassar, Indonesia are done through survey using questionnaire to get more data regarding consumers. To derive more complete information, the data were also analyzed using regression approach. Contribution of this study lies in providing more detail information that can be used for many purposes such as in designing more realistic energy conservation policy or electricity saving program for residential sector in Indonesia. Electricity saving program can give positive effect to the users' behaviours and their awareness for energy saving [4]. Therefore, suitable policy can give effective impact to reduce continuously load growing in residential area [10]. As number of residential consumers is the highest (compared to commercial or industrial sector) in Makassar, thus through energy saving action, more load reduction from residential area is possibly achieved as another effort to maintain the balance between supply and electricity demand which increased by year. Data from power utility in Makassar, number of household consumers is 657,977 in Year 2016 with electricity consumption volume is 1,298 million kWh.

This paper consists of four parts. Part 1 presents background of the study, literature review, and objective of the study. Part 2 explains the developed questionnaire and applied analyses. Part 3 presents important information from survey results and regression analysis. Meanwhile in Part 4 is conclusion and implication for policy.

2. Methodology

To get needed data, a questionnaire is firstly designed. The content of the questionnaire is based on the previous studies and modifications are made for Indonesian context [4,11,12]. A number of items are involved in the questionnaire to have more specific information related to consumers. The questions items consists of some main parts include such as family characteristic, house building information, power capacity and owned appliances, behaviour in using appliances, obstacles in practicing electricity saving, utilization of EEA and habit of users. For example, 'family characteristic' questions include number and structure of family, age of youngest family member. For 'house building information', include such as house size, old building construction. For 'power capacity and appliances' include questions related to IEPC at home, owned appliances and EEA. For 'user's behaviour' ask typical habit of the users in using a number of different appliances. For 'obstacles in practicing electricity saving' include statements such as do not know how do electricity saving for certain equipments. Items at certain part in the questionnaire are assessed using 7 Likert scale. For validation, it is used expert validity approach.

Conducted survey is focused on the residential consumers in Makassar with IEPC 900 VA and above. Purposive sampling technique is used to get data from 150 users in September 2018. Target of respondents are family members that known electricity energy usage in their houses. Obtained data are also analyzed using regression method to derive more information.

3. Results and Discussion

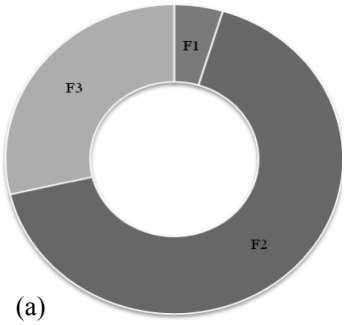
As basic data based on the survey using developed questionnaire, from 150 respondents, 66.7% is male and 33.3% is female. Meanwhile distribution age for respondents namely, 34.7% is between 20-30 years, 20.7% is between 31-40 years, 23.3% is between 41-50 years, and 21.3% above 51 years. Other important information such as family composition of the users, house condition, owned appliances, user's behaviour, obstacles in practicing further energy saving which can be related to volume electricity energy at home in Makassar are given as follows.

3.1. Family Characteristic

Family characteristic included such as number of (family) member and its structure may affect volume of electricity consumption. As each person has electricity needs, therefore, the more family members, the higher the electricity consumption in one home. Moreover, electricity needs for children, adults, old person, and disabled people can be different as well. Here, the observed characteristics based on the family condition in Makassar are shown in Fig. 1 (a)-(d). Some important information from survey is obtained. For example, majority of respondent has family with member 3-5 persons (66.7%) and structure family is couple with their children (62%). Besides that, dominant respondent has family member with the youngest age is below 5 years (29.3%), and around 96% of the respondent has no family sick or disabled in their homes.

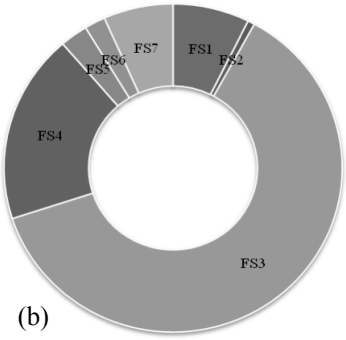
3.2. House Building Information

Others factors which may influence household electricity consumption are condition of the users' houses such as size and category. House category can affect a number of aspects in one home such as used lighting or air handling systems, therefore, it may influence volume of energy consumption. From survey as in Table 1, dominant of respondent resided in permanent house (92%) and with old building more than 11 years (57.3%). Majority of the respondents has house size between 60 m^2 and 120 m^2 (48.7%). However, the demand for bigger house is found increased which can be related to economic factor. For example, family which has house size smaller than 60 m^2 commonly expected house with size between 60 m^2 and 120 m^2. The same to family which



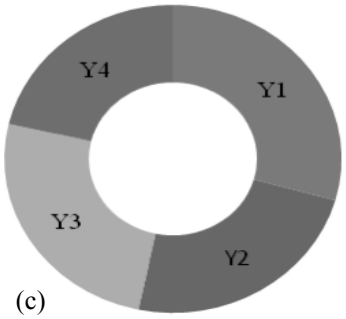
(a)

F1 (4.7%) = 1-2 persons
F2 (66.7%) = 3-5 persons
F3 (28.7%) = >6 persons



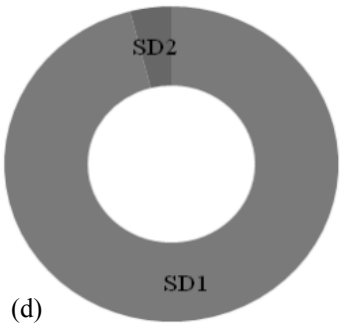
(b)

FS1 (7.3%) = single
FS2 (0.7%) = couple
FS3 (62%) = couple+kids
FS4 (18.7%) = couple+ kids+parents
FS5 (2.7%) = couple+ parents
FS6 (2.0%) = couple+ sibling
FS7 (6.7%) = others



(c)

Y1 (29.3%) = 0-5 years
Y2 (24.0%) = 6-12 years
Y3 (25.3%) = 13-19 years
Y4 (21.3%) = > 20 years



(d)

SD1 (96%) = None
SD2 (4%) = Yes

Fig. 1. Distribution characteristics (a) Family size; (b) Structure of respondent family; (c) Age of youngest family member; (d) One of family member is sick or disabled.

has house between 60 m^2 and 120 m^2, they are commonly expected larger houses (121 m^2 and 180 m^2) as seen in the Table 1. In general the bigger of a house, the more needed appliances. Therefore, house building factor is a variable that must be considered in influencing electricity demand.

3.3. Power Capacity and Owned Appliances

Installed electric power capacity (IEPC) and owned type appliances in terms of EEA or not EEA are also observed in this study. From survey for IEPC at home (group 900 VA; 1,300VA; 2,200 VA; 3,500-5,500 VA; and over 6000 VA), majority of the respondent has IEPC 1,300 VA (45.3%). The demand for larger IEPC is also increased and mainly for house with current IEPC 900 VA. The group of users are expected IEPC 1,300 VA or above. This can be related to the increasing living standard of users as in Fig. 2. Types of owned home appliances by consumers are graphically shown in Fig. 3. From obtained data, lamp, refrigerator, television (TV), iron, and fan are the five most appliances owned by consumers in Makassar, meanwhile the least owned is electric stove which is newly introduced to the wider community. Particularly for EEA, lamp, refrigerator, and air-conditioner (AC) are mostly bought or owned by participants. Lamp is used every day, meanwhile refrigerator

Table 1. House building information

Variable		Frequency	Perc.
House old	0 – 5 years	20	13.3%
	6 - 10 years	44	29.3%
	> 11 years	86	57.3%
	Total	150	100%
House category	Permanent	138	92.0%
	Semi permanent	9	6.0%
	Not permanent	3	2.0%
	Total	150	100%
House size	< 60 m^2	21	14%
	60 – 120 m^2	73	48.7%
	121- 180 m^2	49	32.7%
	> 180m^2	7	4.7%
	Total	150	100%
House size (expectation)	< 60 m^2	15	10.0%
	60 – 120 m^2	71	47.3%
	121- 180 m^2	51	34.0%
	> 180m^2	13	8.7%
	Total	150	100%

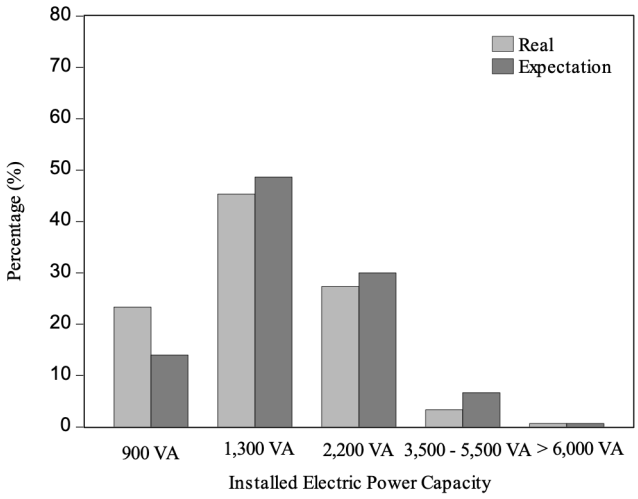


Fig. 2. Installed power capacity at users' homes and their expectations.

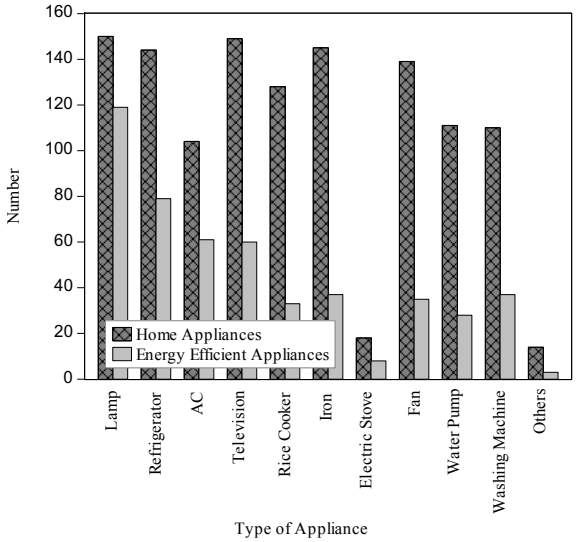


Fig. 3. Owned appliances and EEA.

and AC are two main appliances which are known consume highly electricity energy. These make related consumers tend to buy EEA category for these equipments to reduce their monthly electricity consumption. However, it is needed to encourage other consumers intensively to use EEA not only for lamp, refrigerator and AC, but also other common electricity equipments which are daily used at home.

3.4. User's Behaviour in Utilization Appliances

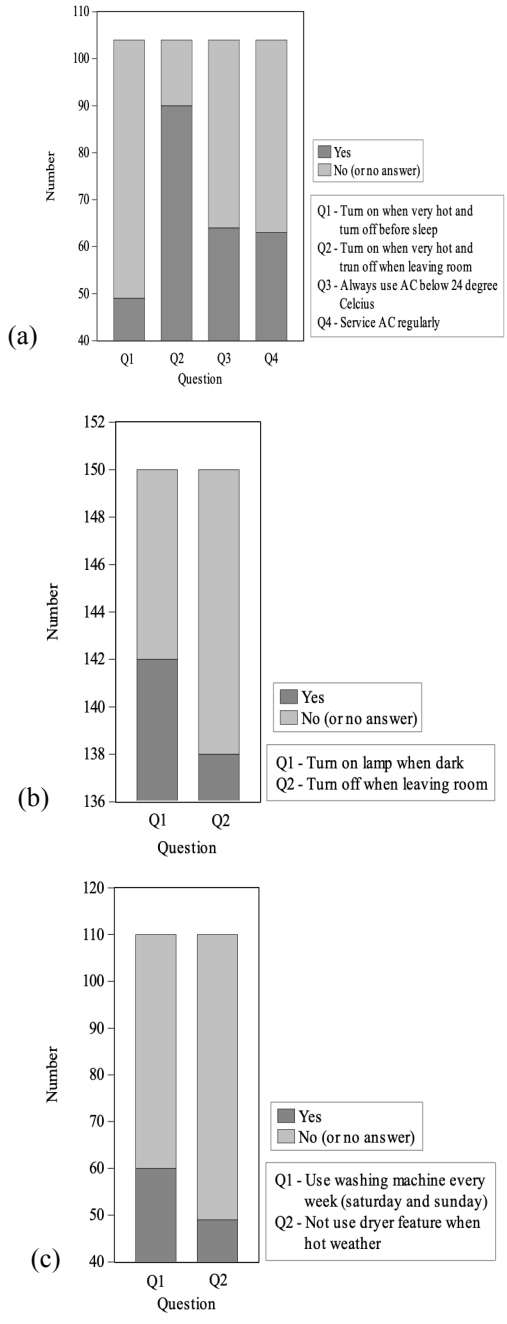
Habitual behaviour of user is another aspect that affected electricity consumption. Practicing saving energy everyday by all users will reduce electricity consumption significantly in one place. To identify typical users' behaviour in using certain electricity devices (namely cooling device, lamp, washing machine, refrigerator, TV, and iron) a number of questions are also asked to respondents as in Fig. 4. As seen in Fig. 4 (a), from 104 respondents who have AC; 47.1% of them use AC during very hot condition and they turn off the AC before sleep (Q1); 86.5% of them use AC when very hot and turn off when leaving room (Q2); 61.5% of respondents use AC below 24 degree Celsius (Q3), and 60.5% of them do check (service) AC regularly (Q4). From the survey, a number of respondents using AC during sleep, and dominant of them comfort in room temperature below 24 degree Celsius as a response to the weather condition. Temperature and humidity can be related to load in some places including in Makassar [13-15].

For lamp which all participants have (150 respondents); 94.7% of them have habit turn on lamp when dark (Q1), and majority of them (92%) turn off lamp when leaving room (Q2). Mostly respondents use light-emitting diode and or compact fluorescent lamp for lighting in their houses, and only few family use incandescent lamps. Used energy for lighting is a main part of household energy consumption [16].

For 110 respondents who have washing machine (WM); 54.5% of them use WM in Saturday and Sunday (Q1); 44.5% of them not use dryer when hot weather (Q2). Respondents (who do not have WM) wash clothes by hand or use laundry service. As only 54.5% use WM every week, a number of respondents use WM everyday or several times a week which are caused by several variables such as family structure or economic factor.

For 144 respondents who have refrigerator; 33.3% of respondents are usually filled their refrigerator with too much food or drink (Q1); 88.8% of them have habit open the refrigerator door when needed and not for long (Q2); and 84.7% of them arrange the placement of refrigerator at home (Q3). Besides volume of food or drink, frequency of door opening, temperature setting of refrigerator can influence electricity consumption [17]. Improvement user's habit or proper utilizing can increase highly energy saving at home from refrigerator.

For 149 respondents who have TV; 87.9% of them watch TV during leisure time (Q1); 32.8% of them turn off



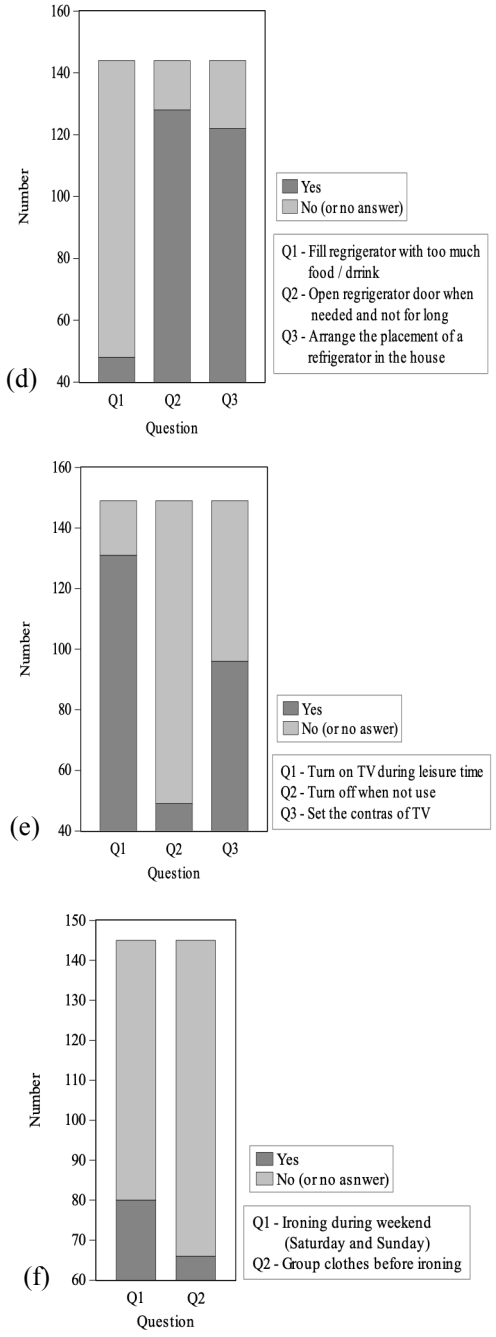


Fig. 4. Typical behaviour of users in using appliances.

TV when not use (Q2); and 64.4% of respondents adjust contras of TV (Q3). Based on this, encourage people to turn off TV when not needed, and adjust contrast level of TV when watching can give more energy saving.

Next for ironing, from 145 respondents who have iron as in Fig. 4 (f); 55.2% of them do ironing activities on Saturday and Sunday (Q1); 45.5% of respondents group clothes before ironing (Q2). As level temperature iron affect electricity consumption, therefore, information to people about doing group clothes before ironing is useful.

Generally from survey results, improvement habit in using each appliance is a way to increase energy saving at household level in Makassar. Besides that, utilization pattern of appliances such as washing machine, iron which give contribution to daily load profile can be known. The knowledge can improve our understanding regarding typical habit pattern of users.

3.5. Perception Level of Users

Perception level of observed user is determined based on mean value using 7 point Likert scale. From data for all participants, perception of users regarding electricity saving is good as mean average value of the calculation is 6.11.

3.6. Obstacles in Practicing Energy Saving

Identification of users' obstacles in practicing energy saving is needed to support implementation of energy conservation program at certain places. In relation to this, four different questions regarding obstacles are also asked to the participants as seen in Fig. 5. Survey results shows from 150 respondents for Question 1 (Q1), 38.7% of them do not know how to do saving energy for certain electricity appliances; for Q2, 73.3% of respondents have not enough information regarding energy saving behaviour; for Q3, 74% of respondents are not performing more energy saving because of electricity tariff are same for all time (24 hours); and for last question (Q4), 88.7% of respondents need support system such as home energy management system (HEMS) to control or to manage their daily energy usage. Based on this, residential consumers not only need to encourage in using EEA fully in their homes, but also need more information about how to do saving energy for more type of appliances and habit in using electricity wisely. Besides that, HEMS should be introduced, and electricity tariff scheme which are not same for all time should be considered to be designed and applied. Overcome these barriers can increase energy saving in this sector.

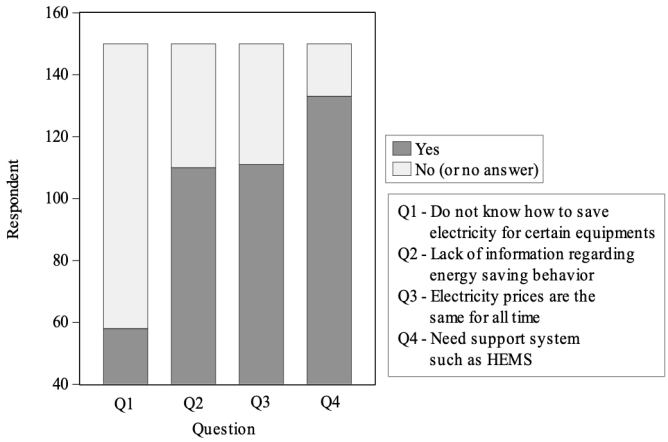


Fig. 5. Obstacles in encouraging (practicing) energy saving.

3.7. Relationship between Perception, Utilization of EEA, and Habit of users

To identify the influence of perception to the utilization level of EEA at home and to habit of users as in [12], regression analysis is used. Next, obtained results are summarized in Table 2. From the Table 2, EEA utilization is

Table 2. Regression results

Variable	EEA Utilization (Model-1)			
	Coefficient	Std. error	t-statistic	*p*-value
α	0.6228	0.4516	1.3790	0.1700
PE	0.8554	0.0730	11.7181	0.0000
R^2	0.4812			
adj. R^2	0.4777			
Variable	Habit of Users (Model-2)			
	Coefficient	Std. error	t-statistic	*p*-value
β	0.7547	0.4710	1.6020	0.1113
PE	0.8374	0.0761	10.9972	0.0000
R^2	0.4496			
adj. R^2	0.4459			

significantly affected by level perception of users (PE variable). It is shown by *p*-value of the perception variable below 0.05 (*p*–value is 0) which have significant at 5% level. The adjusted R^2 value of EEA utilization model is quite good (47.77%). Similar to Model-1, habit in practicing energy saving when using all home appliances (Model-2) is also influenced by the perception of users as indicated by *p*-value is 0. Based on the results, perception of user regarding electricity saving is an important factor to increase more utilization level of EEA or to improve habit of the existing users. In other words, the variables have strong relationship. The better perception, the higher electricity saving can be achieved.

4. Conclusion

This study is conducted to provide information regarding a number of factors that can be related to volume household electricity consumption in Makassar. A questionnaire is developed to obtain data from respondents and a part of them are analysed using regression technique to get more information. It is concluded from results that a number of important information such as characteristics of family, house building, IEPC, owned and type of appliances, user behaviour, obstacles in practising saving energy, and influence of perception to the utilization level of EEA at home and also to habit of users can be known more detail or more specific. The use efficient appliances and daily practice energy saving attitude are two important things to enhance energy saving. Presented information may give more insight regarding pattern electricity consumption and typical users' behaviours which can be as a basis in designing energy policy. Future research will investigate larger electricity area in Indonesia and other sectors.

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