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Household electricity consumption in rural area: An occupant's behavior analysis to increase energy saving

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Abstract. This research investigates electricity consumption and typical occupants' behaviors for rural households in Indonesia. A questionnaire is composed to get important information from respondents through direct survey located in several rural areas in Bone, South Sulawesi province as a case study. The information included such as owned household appliances, occupants' behaviors regarding appliances usage, factors barriers in buying energy saving appliances (ESA), and general barriers in electricity saving. To get more information, regression analysis is also applied to identify relationship between perception and consumption habits. Results of this study show lamp, washing machine, and television are low watt appliances which majority owned by users with installed electricity at home is between 450 VA to 1,300 VA. A main barrier to have ESA is price, and lack information to support practising electricity saving. Next from regression results, perception variable is found affected usage behavior and also daily habit of occupants. Output of this study gives more insight in understanding characteristics of electricity consumption for rural households. They can be used as a basis in making effective energy saving program to dealing with issue related to growth load in power systems.

1. Introduction

Number of household in Indonesia tends to increase over the year including in South Sulawesi province which increase from 1.84 million households in year 2010 become 2.02 million unit in year 2019 [1]. The increasing number of household unit is a commonly factor that can enhance the usage of electricity energy for residential sector in one place such as in South Sulawesi. In relation to this issue about growth load and its fulfillment, efforts such as additional power plants or managing electricity usage is needed as a strategy to assure the balancing between production and electricity demand from time to time.

From consumer side, one common way to manage or to reduce household electricity usage is through energy saving action or increasing efficiency of energy usage. Therefore knowing related variables to support the action such as occupants' behaviors, owned of ESA, factors barriers in buying ESA, and barriers in electricity saving is meaningful for utility or government. However, information about these variables is relatively limited or data are not sufficiently available at certain places including rural areas in South Sulawesi. To dealing with this aforementioned condition, performing studies to get more detail information about typical consumption and habits of occupants using survey technique are needed. Many studies about energy consumption for rural households have been done in



several countries, for example Ref [2-3] for Thailand, in [4-5] for China, in [6] for Malaysia, in [7] for Indonesia, in [8] for Africa, and in [9] for Bangladesh.

Considering load driver in one place including habit of electricity consumers can be unique and as a part of our work to understand completely characteristics of residential sector in Indonesia, this paper focus to investigate aspects related to volume and consumption habit of residents for rural areas. Findings from this study can be used as a reference for energy saving planning program at rural households. There is limited work for Indonesian context as found in [7] which studied the needs of energy reserve for rural areas in Batang, Central Java concerning peak load, electricity consumption including reliability of electric system. Survey to collect data is done by the authors based on geographical altitudes of studied area. It is expected this study can fill the gap of information.

2. Survey methodology

Respondent in this study is household consumers located in rural areas in Bone regency, South Sulawesi. Questionnaire for survey is composed based on the prior studies [10-11] and it consists of four sections. Section A is questions about personal information. Section B is systematic questions about users' behaviours in using appliances. Meanwhile Sections C and D are about perception and behavior of occupants, respectively. Some items of the questions and statements in each section are indirectly shown in the results. For items in Sections C and D, they are evaluated by using 5 point Likert scale, namely 1 for 'strongly disagree' and 5 for 'strongly agree'.

Direct survey is done using purposive sampling technique in July 2020 for 50 respondents as a preliminary study. The respondents are family members who know energy usage in their homes for all category by means of installed electricity at home (450 VA and above). Reliability test and validation for questionnaire are performed using common approaches namely Cronbach's alpha value and expert validity, respectively. Next descriptive analysis is used, and regression method is further applied to the usable data with intention to identify relationship between perception and behavior of occupants in the surveyed area as in [11-12].

3. Results and discussion

3.1 Test of reliability

As the first step, Cronbach's alpha (α) value is applied to evaluate reliability of related items in the questionnaire. All respondents (50 participants) are used in this reliability assessment. From four dimension, there are three dimensions have α value above 0.6. This means, related items in the composed questionnaire have internal consistency in the three dimensions and appropriate to be used for next survey. Here, not reliable dimension is eliminated or not included in the analysis.

3.2 Characteristic of respondent

Table 1 shows demographic characteristic for all participants (50 respondents) in this study. A number of important information for respondents can be known from survey as seen the table. For example,

Table 1. Demographic of respondents

| No | Demographic Characteristic | Frequency | Percentage | Total | |
|----|----------------------------|---------------|------------|-------|------|
| 1 | Age | 20 –30 years | 30 | 60% | 100% |
| | | 31 – 40 years | 7 | 14% | |
| | | 41 – 50 years | 7 | 14% | |
| | | > 51 years | 6 | 12% | |
| 2 | Gender | Male | 13 | 26% | 100% |
| | | Female | 37 | 74% | |

| | | | | | |
|---|----------------------|-------------------------|----|-----|-----------------------------|
| 3 | Education | Junior High School | 7 | 14% | 100% |
| | | Senior High School | 27 | 54% | |
| | | Bachelor degree | 6 | 12% | |
| | | Others | 10 | 20% | |
| 3 | Monthly Income (IDR) | < 3 million | 46 | 92% | 100% |
| | | 3 – 6 million | 4 | 8% | |
| | | > 6 – 9 million | 0 | 0% | |
| | | > 9 million | 0 | 0% | |
| 4 | Household members | 1-2 persons | 0 | 0% | 98% (1 missing response) |
| | | 3-5 persons | 28 | 56% | |
| | | 6 persons and above | 21 | 42% | |
| 5 | House Size | < 45 m ² | 1 | 2% | 100% |
| | | 45 – 60 m ² | 6 | 12% | |
| | | 61 – 120 m ² | 43 | 86% | |
| | | > 120 m ² | 0 | 0% | |
| 6 | Electricity at Home | 450 VA | 19 | 38% | 100% |
| | | 900 VA | 24 | 48% | |
| | | 1,300 VA | 7 | 14% | |
| | | 2,200 VA | 0 | 0% | |
| | | 3,500 VA and above | 0 | 0% | |

majority for age of respondents is 20-30 years (60%) and for gender is dominantly female (74%). For educational background, most of respondents have education senior high school (54%). Next for family members, majority has 3-5 persons staying at their homes (56%). This is in line reported in [1] that average size per household in South Sulawesi for year 2019 is 4.4 persons. Concerning installed electricity, most of respondent has 900 VA (48%) at their homes and followed by 450 VA (38%) and 1,300 VA (14%).

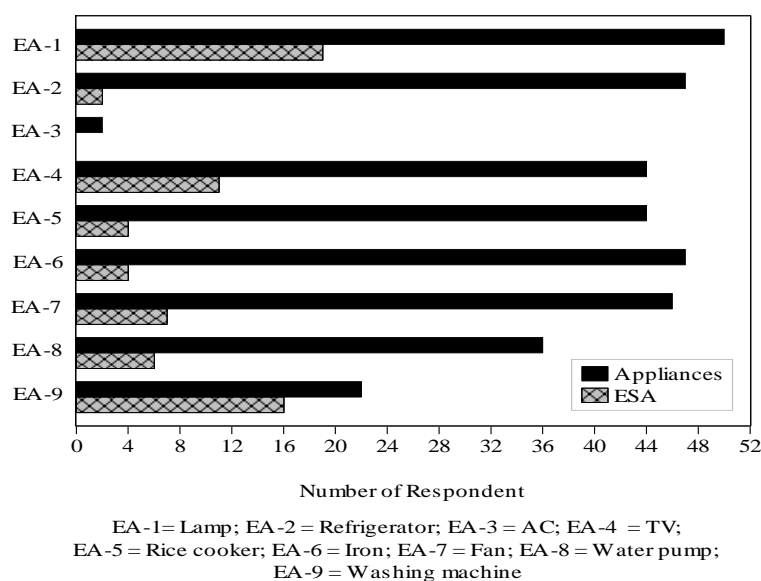


Figure 1. Owned electric appliances (EA) and ESA

3.3 Ownership home appliances

Figure 1 show owned standard appliances and ESA of consumers at observed places respectively. From the figure, lamp, refrigerator, iron, fan, and rice cooker are a number of appliances which is dominantly owned by consumers (over 88%). Meanwhile for ESA are lamp, washing machine, and TV. However, usage level for ESA is still low as the highest for lighting lamp namely 19 of 50 respondents (around 38% from all participants). To increase efficiency in energy usage from aspect of equipments, enhancing the usage number of low watt appliances at the observed rural area is important and mainly for equipments which consume high energy, for example refrigerator. Some studies focus on such equipments such as in [13].

3.4 Occupants' behaviors regarding appliances usage

Behavior of occupants affects volume of electricity consumption [14-15]. Efficient behavior in using various appliances will reduce consumption and vice versa. Therefore, several questions are included during survey to get information about this aspect as a basis to maximize electricity saving with results is graphically shown in Figure 2. In the figure, from 50 respondents who use lamp, most of them turn

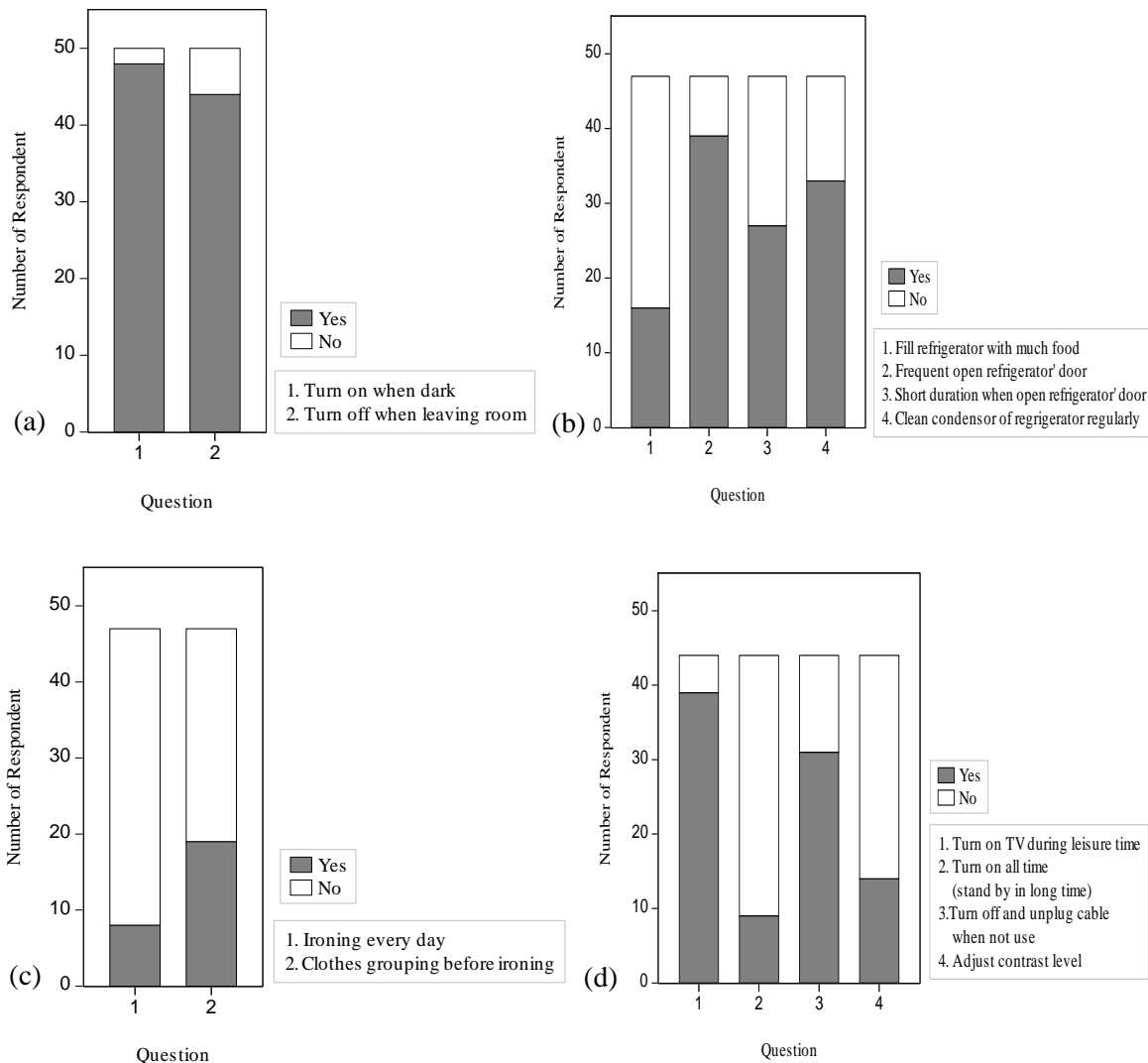


Figure 2 (a)(b)(c)(d). Habit of occupants when appliances usage.

on lamp when dark (96%) and 88% has habit turn off lamp when leaving room. Next from 47 respondents who have refrigerator, around 34% of them always fill their refrigerator with much food, 82% frequents open refrigerator door, 57% always open refrigerator door in short time, and 70% of respondents has habit clean refrigerator regularly. For iron (47 respondents), 17% uses it every day and 40% do grouping of clothes before ironing. Next, from 44 respondents who have TV at home, 88% of them watching TV when have time (at leisure time), 20% has habit turning on TV in long time or in stand by condition, 70% has habit turning off TV and unplug cable when not use, and 32% do adjusting kontras level when watching TV.

Based on this condition, improvement certain habit of occupants in using appliances is still open to enhance electricity saving in the surveyed area. This can be done by giving more information to users in many forms and media such as through radio and newspaper about the important of electricity saving and its practice. Not frequent open refrigerator door, clothes grouping before ironing, and unplug cable TV when not use are several examples for energy saving practice in using appliances.

3.5 Factor barriers in using ESA

To encourage further the using of ESA in rural areas, questions regarding barriers of occupants in using or buying ESA are also involved in the questionnaire. From survey result, it is found that majority of respondents (62%) feel the price of ESA is relatively expensive, and almost half of them (48%) answer do not have information about low watt appliances.

3.6 Other barriers in electricity saving

Next, general barriers for occupants towards electricity saving at home are also investigated. Four different questions are asked to respondents for this section and the results are graphically shown in Fig. 3. As seen in the figure, main barriers in electricity saving is lack of information (point 2, 72%) and followed by point 3 (62%), 1 (60%), and 4 (58%). Based on this, it is important to encourage users for electricity saving by giving more education or information in many aspects, for example, how to practice energy saving for a certain appliance including ESA. Besides that, giving incentive (in the context of point 2) and utilization of supporting system such as home energy management system (HEMS) are needed to be done. Solving these barriers will contribute in increasing electricity saving for observed rural households' area.

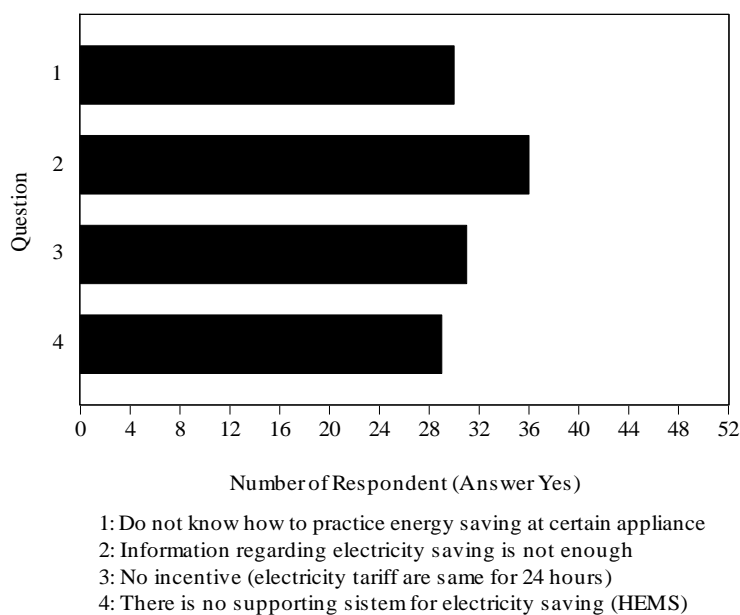


Figure 3. General barriers for electricity saving.

3.7 Perception and occupants' behaviors in rural area

By using mean score analysis, it is obtained value 4.25 of 5 Likert scale for consumers perception. This means occupants have good perception or interest in energy saving at home. Further analysis from perspective of some demographic aspects namely based on installed electricity at home, occupants with 1,300 VA show more positive perception (mean = 4.42) than occupants who have electricity 450 VA (mean = 4.40) or 900 VA at home (mean = 4.08). Next based on the income, respondents with income in the range of 3 to 6 million IDR per month have more positive perception (mean = 4.75) than others who have income less than 3 million IDR (mean = 4.21).

Next to identify the influence of perception of occupants' behaviors, two simple regression models are composed and the results are shown in Tables 2 and 3. From the table, perception has significance influence on usage behavior and habit of occupants in practicing energy saving in the surveyed rural area at 5% significance level. This is shown by p -value of the variable below 0.05 (0.0002 and 0.0092) for both models. However, perception variable influences higher usage behavior than habit of occupant. It is shown by coefficient value of perception for Model 1 (0.5176) which is bigger than for Model 2 (0.3242).

Table 2. Results for usage behavior model (Model 1)

| Variable | Coefficient | t-statistic | Prob. |
|------------|-------------|-------------|---------|
| C | 1.9983 | 3.6251 | 0.0007 |
| Perception | 0.5176 | 4.0580 | 0.0002* |

$R^2 = 0.2554$; R^2 adj. = 0.2399; *Significant at 1% level

Table 3. Results for model of occupant's habit (Model 2)

| Variable | Coefficient | t-statistic | Prob. |
|------------|-------------|-------------|---------|
| C | 2.9074 | 5.6300 | 0.0000 |
| Perception | 0.3242 | 2.7135 | 0.0092* |

$R^2 = 0.1329$; R^2 adj. = 0.1149; *Significant at 1% level

4. Conclusions

This study observed a number of aspects related to electricity consumption and consumers' behaviours for rural households in South Sulawesi. A questionnaire is composed for survey to get information from respondents located in rural areas in Bone as a case study. It can be concluded from study that lamp, washing machine, and television are mostly energy saving appliances (ESA) owned by observed users. Price for ESA which is relatively expensive compared to standard equipments is one of obstacles in using energy saving appliances. Next, perception level of users is an important factor to stimulate further the usage behaviour for ESA and habit in practicing energy saving in rural households. Future research will observe more rural areas in Indonesia and add some new analyses to get more complete information.

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