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Article

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Measurement of the Rebound Effect on Urban Household Energy Consumption Savings

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ABSTRACT

This research investigated consumer behavior patterns on energy conservation and energy efficiency. We investigated the factors that influence the rebound effect based on common characteristics and Socio-economic household characteristics in urban communities. This paper also explored the conservation of electricity through the idea of "nudge." The authors used the word "encouragement" in the chosen architectural program, designed to reduce household electricity consumption so that the rebound effect did not occur in household consumption. By utilizing the "social norms and curtailment," households given a "nudge" can save more on their electricity consumption costs. The condition of "nudge" that we included was through information on the costs incurred by households, "social norms and curtailment," and energy efficiency through replacing conventional lamps with energy-efficient lamps. The research took place in urban areas in the Bantul, Jogjakarta, between December 2021 and April 2022. Sixty-two respondents divide into two groups of households, i.e., observe households (self-selected) and control households (randomly selected). Both observe and control households must have an active electricity account for at least 1 year and have owned a house between 50 and 200 square meters. The model used a t-paired sample through the "Non-Equivalent Groups Design" (NEGD) framework for the two comparisons. The research found that "social norms and curtailment" can reduce household electricity consumption, has cost savings over electricity consumption on average to 16.3049% for 3 months, and no rebound effect on savings happened.

Keywords: Rebound Effect, Households Energy Efficiency, Nudge, Social Norms, Curtailments
JEL Classifications: D14, O18, Q49

1. INTRODUCTION

The most popular reason for energy consumption in the economy is that energy is needed for activity and economic development. This research used experimental methods and case studies to examine household energy consumption factors. What will happen if the current pattern continues? Indonesia's huge energy demand will continue to occur due to increased activity, mainly due to growth in infrastructure development and increasing national income. For this reason, electricity consumption will continue to increase by more than 8.5%/year. Meanwhile, energy investment is still scarce and never meets consumption demand PLN (Persero), (2018). Apart from the increasing demand for energy and limited supply, there are tremendous untapped opportunities for energy efficiency in various sectors in Indonesia, one of which is the household sector. The authors identify that the increase in household energy consumption costs is in line with the increase in the per capita income of Indonesian people in the last 36 years, as depicted in Figure 1. The sharp decline in consumption costs occurred in 1998 when the Asian crisis occurred.

Meanwhile, the percentage of annual growth in household energy consumption expenditures to GDP, as shown in Figure 2 below, has decreased below 60% since 2008, with the highest average occurring during the economic crisis in 1998. The percentage growth in annual energy costs in the average household group

is currently starting to approach the energy costs incurred by the commercial group. Electrical energy in the household is dominated by home equipment. All household appliances make household energy the third-largest energy user. According to connect4climates data, the use of appliances that consume energy in the home is as follows: (1) Cooling and heating: 47% energy use, (2) Water heating: 14% energy use, (3) Washing machines and dryers: 13% energy use, (4) Lighting: 12% of energy use, (5) Refrigerators: 4% of energy use, (6) Electric ovens: 3-4% of energy use, (7) TVs, DVDs, cable boxes: 3% of energy use, (8) Washing machines plates: 2% of energy use, and (9) Computers: 1% of energy use.

However, on the other hand, the increasing use of electricity consumption also increases CO_2 emissions. The high source of large fossil fuels, namely oil and coal in power generation, causes an increase in emissions indirectly. Meanwhile, as stipulated in the National Energy Plan, coal plays a vital role in Indonesia's electricity sector due to its reserves, ease of use, and price. The increase in carbon intensity will increase according to coal sources as fuel in power plants. From 1997-to 2017, coal consumption increased from 258.19 million tons BOE to 407.50 million tons, although the percentage of coal consumption decreased from 19.30% in 2007 to 7.40% in 2017 (MEMR, 2018). This increase in electricity costs has prompted the government to issue government policies to reduce energy subsidies. This subsidy reduction began in 2016 when PLN, at that time, adjusted electricity tariffs and only distributed electricity subsidies only to people who could not afford them. Behind the increase in households, the increasing energy demand grows while energy supply is limited. Therefore, the potential for energy conservation and energy efficiency has excellent opportunities that household groups still do not exploit to carry out energy efficiency (ASEA Brown Boveri, 2013; Oberman et al., 2012).

Figure 1: Trends in the growth of household spending in Indonesia (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2018)

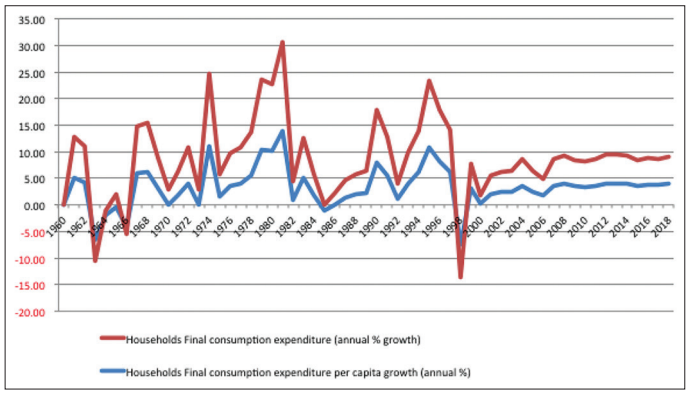
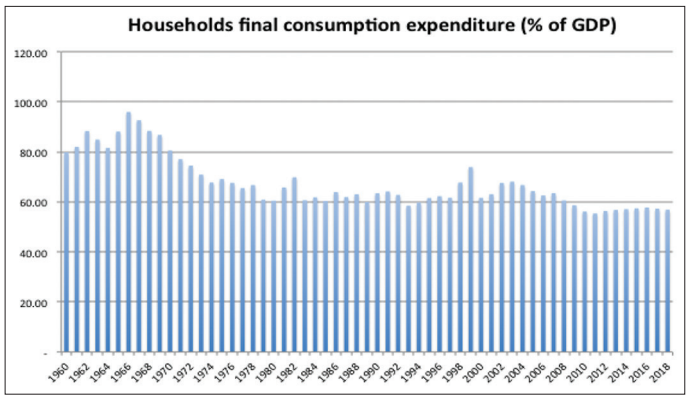


Figure 2: Trends in household consumption to GDP in Indonesia (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2018)



1.1. Indonesian Population and Energy Consumption

The increasing population of Indonesia also increases the number of such households, increasing urbanization. According to data from the Handbook of Energy and Economic Statistics of Indonesia, Indonesia's population in 2017 was 261,891 million, with 67,173 million households, see Figure 3 below. Based on data from the world bank, of the total population of Indonesia, more than most or more than 55.33% of the entire population live in urban areas. Indonesia has become the fastest pace of urbanization.

The trend of urban population growth peaked in 1982 at 5.2% but then declined to only 2.41% in 2017 (Figure 4). The increase in population also increases household income, which dramatically triggers the demand and utilization of electronic home appliances in Indonesia. The increasing demand for electronic devices or Home appliances increases energy consumption. As a result, Indonesia's overall energy consumption has increased, with the housing sector being one of the largest energy consumers in Indonesia (Figure 4). The percentage of household energy consumption will increase to 15.45% in 2107.

Figure 3: Total Indonesian population and households (MEMR, 2018)

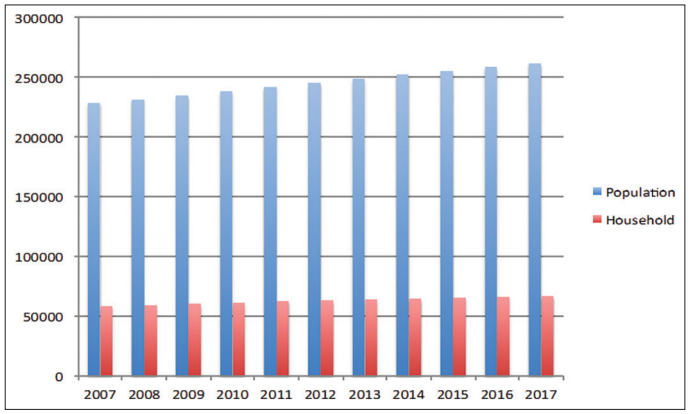
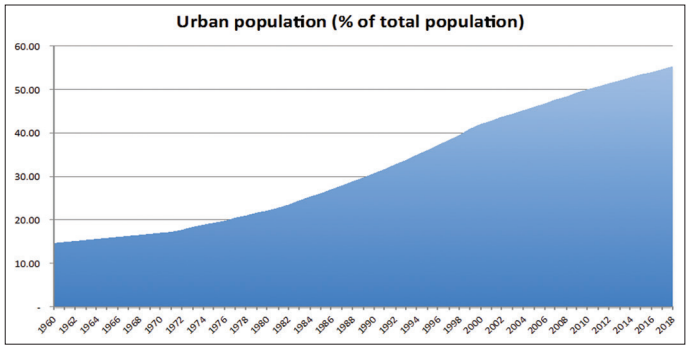


Figure 4: Indonesia's urban population (World Bank)



Reducing the intensity of carbon emissions in electricity has an essential role in reducing overall emissions. To reduce carbon emissions from the supply side, Indonesia should increase its energy mix diversification to cleaner, renewable sources such as geothermal energy. Having a high share of coal-fired power plants is very important for the country to increase efficiency by adopting cutting-edge technology and upgrading coal-fired power plants. However, another program is commonly known as the Electrical Energy Management program on the consumer side or Demand Side Management (DSM). The concept of Demand Side Management (DSM) was first proposed by Clark W. Gellings and John H. Chamberlin. Energy efficiency is one of the DSM programs that reduce energy consumption and emissions. Many countries can limit energy demand growth through DSM, the right policies made in designing and implementing energy efficiency across economies to keep their energy intensity on track. Limiting energy demand growth, utilizing renewable energy, and efficiently maximizing energy reduction policies can reduce emissions. Reducing emissions and achieving a transition to sustainable development requires a shared commitment among all stakeholders, including the public and private sectors, NGOs, and other non-profit organizations.

There are many essential factors in understanding consumer behavior in reducing energy consumption, including behavior in adopting energy efficiency technology in household appliances. This research investigated the most critical factors in motivating energy consumption savings and inhibiting the rebound effect. It is essential to explore the behavior of urban households and the application of the "Nudge" effect to conserve energy and energy efficiency. Meanwhile, the adoption or rejection of energy-efficient technologies is still common at the organizational and individual levels, and individual involvement is often required to recognize the full benefits of these technologies.

The empirical found that obstacles to overcome in applying energy efficiency policy (Sudarmaji et al., 2021; 2022; Dobbs et al., 2013; Gerarden et al., 2015; Schleich, 2012). Gerarden, Newell, and Stavins (2015) said there were two barriers, i.e., "market barriers" and "non-market barriers" in energy efficiency in neoclassical economics (O'Malley et al., 2003). Non-market barriers could hurdle energy efficiency gaps in society (O'Malley et al., 2003 and US Department of energy, 2016). Several other non-market barriers include: (1) Invisible energy efficiency improvements, (2) Lack of standardized documentation, (3) Lack of third-party verified certification, (4) There is a time lag between retrofitting and sales, and (5) Failure to assign qualified examiners/appraisers.

Without savings, Indonesia will experience obstacles in providing energy needs in the future (ASEAN Secretariat (2019). With its rapid economic growth, it needs significant energy investments. The vast demand for energy is caused by increased activity which also increases the number of customers, where an increase in the number of customers is an ongoing problem (Lee and Eang, 2015; PLN (Persero), 2018). A comprehensive energy conservation and energy efficiency program in the housing sector can reduce energy needs, especially at peak loads in 2030. Meanwhile, the "Nudge effect" theory is widely used because of its ability to change people's behavioral adoption (Thaler and Sunstein, 2003). The "Nudge effect" theory provides incentives to change people's behavior on several dimensions, such as a person's propensity to choose to save money or switch to energy-efficient products. The UK, US, and Australia have set up economists working on "nudge units" to test and implement the Nudge initiative. Some "Nudge units" have positive results, which yield benefits outweighing low-cost implementations.

The idea of "Nudging" underlies the thinkers of "libertarian paternalism to increase the influence of policy thinking. One of the strategies of "libertarian" proponents is that choices can be influenced through the "framing" of choices, namely by words or presentation choices (Thaler and Sunstein, 2003). In this Home Energy Efficiency (HEE) research, the authors frame the "framing" option through options at the most cost-effective but able to meet consumer needs in maximizing their energy costs and regarding the desired goals, namely energy conservation and energy consumption reduction. Nudge theory used limited choices (framing) to reduce household energy consumption costs from limited options. The goal is clear, namely the occurrence of energy efficiency, energy conservation, and reduction of carbon emissions. The fundamental question that this research must answer is how likely it is that the Nudge idea can be implemented in the behavior of urban households. Of course, in answer to this question, we must understand the potential barriers that hinder the implementation of the "Nudge effect" initiative itself. Therefore, a qualitative approach is used to explore the usefulness of nudge theory in implementing energy consumption reduction programs in society.

For this reason, the authors use the "Nudge effect" in the chosen architectural program designed to reduce the use of household electricity consumption. Through the "Nudge effect," an experiment to save energy costs by comparing the cost of household consumption with the average consumption cost of other households. As explained in the background of this research, several factors might influence households' common characteristics and socio-economic characteristics in adopting energy conservatism and energy efficiency. This research tried to solve and understand the energy efficiency gap in the household sector through an analysis of the framework, namely the elements that underlie the decisions of household consumer behavior towards new technology equipment that can minimize energy costs. Factors related to typical characteristics and owners' socio-economic characteristics as factors that drive energy conservatism and energy efficiency programs in urban communities in Indonesia are also analyzed. It hopes that a program targeted only at the housing sector could save the potential billions of dollars of energy sector capital (Karali et al., 2015). By establishing a framework, this research aims to find a descriptive, theoretical approach to provide advice to stakeholders and how they can improve decision-making.

2. LITERATURE RESEARCH

The trend of transformation behavior patterns in innovation technology 4.0 will undoubtedly change the behavior of many

households to carry out cost efficiency. When energy costs continue to increase (*uncertainty*) in Indonesia, the main thing is energy cost efficiency. Uncertainty in the decision-making process for energy efficiency includes many things, such as uncertainty related to life cycle costs and perceived benefits of energy efficiency investment, uncertainty related to energy prices, and uncertainty related to *rebound effects* (Jafari et al., 2017).

Most empirical research on energy efficiency is categorized into two parts: based on internal or endogenous factors (based on characteristics) and research-based on external factors. Distinguishing factors consist of (1) economic characteristics, (2) non-economic characteristics, and (3) behavioral and cultural characteristics. Meanwhile, external factors consist of (1) environmental characteristics, (2) *policies*, (3) supply-side energy factors, and (4) energy devices (Dalvi, Bhonsale, and Datar, 2014). The researchers made the initial hypothesis, namely motivation that is economic or based on economics, which predicts that almost all individuals or companies desire to save costs, increase the value of assets or buildings, and have high marketability of their buildings. Other empirical findings prove that predictions based on economic behavior have many obstacles (Priest et al., 2015).

Empirical research based on internal and non-economic factors is widely viewed in terms of age, gender, education, and information about energy efficiency, which is primarily *vague*, causing an information deficit (Dalvi et al., 2014). In addition, several studies are also motivated by several factors such as environmental values and perceptions that are a moral obligation of society in reducing emissions, or in other words, as part of pro-environmental behavior (Chen, 2015). Pro-environmental behavior is fundamentally related to energy consumption, defined as any action that directly or indirectly contributes to the conservation and preservation of the environment (Brody et al., 2008).

Research takes many different directions among researchers worldwide, especially in research based on the behavioral theory of "behavior." Many studies are exploring this matter. The researchers primarily examined it through various types of social influences (normative and informational), moral norms and informational influences (i.e., trust in friends/relatives and neighbors), and attitudes towards target behavior on predictors of intention towards energy efficiency. The theories that supervise and are usually used are the theory of "Theory Plan Behavior (TPB)" (Ajzen, 1991; Lynch and Martin, 2013; Chen et al., 2021; Prete et al., 2017; and Wang et al., 2017). These researchers found that the TPB is a plausible model for explaining energy use intentions and behaviors.

Besides, some researchers use the "Value-Belief-Norm (VBN) theory, where VBN is used to predict energy-saving behavior and technology adoption and discipline such as marketing and consumer research (Stern, 2017; Fornara et al., 2016). VBN theory presupposes altruistic values (welfare) and other values which underlie personal norms (sense of duty). This theory suggests that a person's sense of duty depends on the attribution of responsibility or the environment. Research concerning behavioral patterns concerning the acceptance of energy efficiency technology is based on Rogers' theory (1995). In this theory of "diffusion innovation," Rogers initially divided adopters into five groups: innovators, early adopters, early majority, late majority, and "laggards."

In Rogers' theory, innovators can act as leaders of community groups or those who adopt the innovation in the future. Meanwhile, members of the group may make different decisions to adopt the technology and act differently. They may adopt one technology but not the next. Rogers's theory can be less varied regarding the value or need for the target technology among adopters (Priest et al., 2015). Many previous empirical studies have taken the object of research on residential housing, whether located in rural areas or urban areas (Heesen and Madlener, 2016; Fornara et al., 2016; Priest et al., 2015; Wang et al., 2017; Prete et al., 2017). Meanwhile, the researchers examining residential apartment buildings focus on the problem of the need for efficiency, efficient equipment, technology energy, and incentive problems that arise between the parties (Curtis et al., 2017; Liang et al., 2016; Prete et al., 2017; Khanna et al., 2016). At the same time, objects in the government or municipal are related to the existing hierarchical institutional structure in the government of (Kimita et al., 2016; Polzin et al., 2016).

2.1. Rebound Effect

In developed countries, criticism of energy efficiency programs is related to the rebound effect – where consumers use energy-efficient technologies, but then consumption costs are still high. It makes energy-saving technologies not meet the original goal of saving, and investing in energy-efficient equipment is a lousy investment. Therefore, the impact of energy efficiency interventions must be examined in the broader context of the various social, environmental, and economic benefits. Device efficiency is one of the factors affecting electricity consumption; the higher the efficiency level, the lower the electricity consumption. Therefore, knowledge and awareness of the energy efficiency of the devices used are essential for measuring electricity costs for consumers. Energy efficiency awareness of energy-saving devices occurs when people use knowledge about energy conservation in using electrical devices in their homes (Wijaya and Tezuka 2015). One of the ways to expand the energy-saving model is by cutting or reducing electrical energy during peak loads, commonly called "Peak Clipping." So that Karali et al. (2015) conducted research and chose Indonesia as the case study because they saw the promising potential for increasing energy efficiency that can be achieved in the Indonesian equipment and equipment market.

Improved energy efficiency can also promote economic development, leading to an eventual increase in energy consumption. Empirical data show that an immediate rebound effect happened. There are several methods for calculating the rebound effect or testing the Jevon paradox or the Khazzoome Brookes Postulate, namely, Computable General Equilibrium, LMDI, Cobb-Douglas, and Input-output methods. (Fernández González et al., 2014) They used LMDI to analyze energy consumption in the EU and China. Costa and Kahn (2013) analyzed the rebound effect or Jevon paradox caused by energy efficiency measures in Spain. Wang et al. (2017) also investigated the impact of rebounding energy consumption in China's three industrial sectors.

Energy consumption in the household sector in Indonesia was ranked third at 15.45% of the electricity share percentage after the transportation sector at 46.58% and industry at 29.86% in 2017. In response to the increasing energy demand in the household sector, Appropriate energy policies should be formulated appropriately based on an understanding of electricity consumption in this sector. Tanoto et al. (2013) present research on the factors that decompose the annual electricity consumption of Indonesian households for the period 2000-2010 using the Additive-Logarithmic Mean Divisia Index (Additive - LMDI) method. The total national economic output is 19.5% and 13.7%, respectively. Meanwhile, the efficiency effect also contributed to the positive growth in total electricity consumption with 5.3% below constant prices. In addition to using LMDI, Tanoto and Pasila (2016) also used the Neuro-Fuzzy Takagi-Sugeno (NFTS) network analysis in similar research.

Energy-saving or "energy saving" occurs when technological advances make equipment more energy-efficient. Less energy is required to produce the same amount of product using the same equipment. As equipment has become more energy-efficient, the unit cost of the equipment will be lower. A decrease in the cost of electricity usually leads to a tendency to consume more productive energy, and the extra demand for energy costs from equipment implies consuming more energy. It is denoted as a rebound effect. In developed countries, critics of energy efficiency programs say that the rebound effect occurs when consumers use more energy-efficient technologies than efforts to reduce energy cost savings. The literature distinguishes three rebound effects of energy efficiency improvements: "direct, indirect, and economic" (Greening et al., 2000). The immediate rebound effect is that an increase in energy efficiency will lower the effective price of that energy and should therefore lead to an increase in its energy consumption. Moreover, the rebound effect is indirect for consumers when the lower effective price of energy costs will cause changes in demand for other goods and services. Finally, an overall economic rebound effect occurs where a decrease in the actual price of energy costs will reduce the prices of intermediate and final goods in all areas of the economy, leading to a series of price and quantity adjustments.

In this research, which took 62 respondents in households in urban areas in the Bantul, Jogjakarta area, generally, no rebound effect was found. The researchers researched the rebound effect in the Bantul region because research on energy efficiency and rebound effects is rarely found in Indonesia. This research can be said to have novelty because researching the behavior of regional individuals in urban household areas in Indonesia has never been studied before. These consumers who can be categorized do not have a track record in acceptance of energy efficiency and relatively lower awareness of energy conservation. The local behavior of the people of Bantul, Jogya, has similarities with urban individuals in tropical areas such as those in Indonesia. So, this research in the Bantul area can represent the urban community in the JAVA region in general. Nevertheless, the willingness of the individuals involved to reduce the rebound effect and continue to perform energy efficiency varies significantly depending on their attitudes which are heavily influenced by local behavior.

2.2. "Nudging" Effect

"Nudge effect" fits well with this energy efficiency policy in Indonesia. The "Nudge effect" in this research is used in the electricity cost-saving experiment or randomized control testing (RCT). RCT experiments require a "control group" to compare the performance of the tested subjects, and a pilot project can conduct using a minimal and carefully selected sample size, using a well-thought-out research design. The "Nudge effect" policy is widely used in electricity consumption in US households. US utility companies conducted similar research and policies through the "Home Electricity Report" report. The report compared household electricity consumption to all neighbors with houses of the same size and type. The report compared household electricity usage in the current month to the same month in the previous year. It gave a green star for each month that consumes lower energy costs. The report provided some tips for saving energy while also showing the number of costs saved during the year. Each report contains two pieces of information: the household's absolute consumption level and how that consumption compares with neighbors living in similarly sized houses.

2.3. Roles of Social Norms

Previous studies found that behavior towards acceptance of energy efficiency products was more dominant than general social norms (HY Ha and Janda, 2012). So general social norms do not directly affect and are dominant in determining individual behavior to perform energy efficiency (Lingyun et al., 2011). Cowan and Daim (2013) suggest harmonizing perceptions about a healthy environment by incorporating social factors within community groups, including policies that provide incentives and educational programs made by the government. Government intervention in educational programs or campaigns on awareness of energy efficiency in adopting green technology can increase community efforts to protect the environment and ultimately achieve cost-effectiveness (Malkani, 2012).

The social norms approach to changing behavior in energy efficiency products, especially those directly related to the success of a clean and healthy environmental campaign, is determined mainly by government support (Horne and Kennedy, 2017). However, this is contrary to the situation in China, where, in their research, (Wang et al., 2017) found that government policies did not affect the decision of housing owners in China to make energy efficient. The effectiveness of energy costs also depends on several factors, including energy performance, climate, and, most importantly, electricity prices (Banfi et al., 2008).

This research emphasizes the idea of a "Nudge effect," namely energy cost information through the information that records all energy costs incurred by households and the use of general social norms and curtailment through comparative information. That compares the absolute level of consumption of the household concerned and how consumption compared to neighbors living in the same neighborhood with the same sized house. The idea of the "Nudge effect" falls into the category of restrictive behavior (curtailment) as a pattern of pro-environmental or pro-environmental behavior. For the efficiency behavior category or the second part of the "Nudge effect" idea, this research emphasizes

how the behavior pattern through the replacement of saving equipment, especially conventional lamps, into energy-saving lamps.

3. METHODS

This research found that providing real-time information through displaying energy consumption usage information would reduce the average household electricity consumption. This research supports the hypothesis that the learning effect primarily drives the reduction in energy use. The authors divide the household into the observed household (selected by yourself) and the control household group (chosen randomly). Both observed and controlled households must have an active electricity bill for at least 1 year, between 50 and 200 square meters. The selected target respondents only use electrical energy sources not to produce or carry out business activities, considering that many household units carry out their MSME businesses starting from within their homes. So respondents are selected who use electrical energy as input in producing comfort (e.g., indoor temperature) and family recreational activities.

Total household electricity consumption depends on (1) house attributes, such as size; (2) equipment attributes; and (3) intensity of equipment utilization for recreational and household activities. These choices, in turn, depend on climate, price, and personal attributes, including brand. This research used an experimental method with *Non-Equivalent Groups Design* ("NEGD"), which is often used in social research (Sudarmaji and Munirah, 2019; Enkel et al., 2011; Shadish et al., 2002; Trochim, 2002). NEGD arises when program participants are treated differently. The primary strategy of this research is to provide additional information and training to the *observe* or *intervention* household group, which is used as an "*observe"* variable to other "control" groups. Some information and additional training on restrictive behavior and efficiency taught in the observe group can be described as follows: (1) Turning off the lights when occupants leave the room, (2) Waiting for old light bulbs at home with energy-efficient consumption, (3) Washing clothes during pick-off hours and only when there are enough, (4) Replacing high-consumption electrical appliances (e.g., dishwashers, irons) with more energy-efficient models, (5) Turning off computers and monitors when not in use.

This research explored whether these households can adopt the energy conservation behavior and consumption saving program designed by the authors based on the idea of a "Nudge effect," which frames the available options in reducing the consumption of electricity costs. Therefore, this research provided clear answers and insights into how household consumers spend energy costs and their knowledge of energy conservation. Against this background, two groups are being tested. The observed household group will read the report and respond to it, like wanting to lower their bill and then reduce their consumption. At the same time, the control group will continue to consume as they did so far.

The final questionnaire was distributed to see the real effects or consequences after the consumers know the benefits of energy conservation activities. The pilot experiment took place in an area in the Bantul district. There are two types of "Nudge effect" ideas used in the experiment: (i) providing information about electricity costs and (ii) providing information about social norms. A field experiment compares the relative effects of different "Nudge effects" ideas on household electrical energy consumption behavior. Using this purpose-built field experiment, the authors hope to find that each intervention has a positive effect. In addition, the literature review and Focus Group Discussion (FGD) activities that the authors hold are to find out the choices (defaults) that already exist in each household. It is important to show whether the "default option" has a strong effect on the energy consumption behavior within the household. Analysis of findings from the literature review, Focus Group Discussion (FGD) activities, and the results of pilot experiments are expected to play an essential role in energy conservation policies in the household sector.

This research explores the effect of the average "savings" treatment due to energy-efficient consumer behavior patterns. This research also examined how the effect varies based on typical house attributes and the owner's socio-economic characteristics. The novelty of this research was our emphasis on the urban environment, which has the characteristics of different households. The characteristics and socio-economic characteristics of households can be seen from the total household electricity consumption. These characteristics were analyzed as essential determinants of how households responded to information about the rebound effect.

The research strategy used was several randomly selected respondents in the form of case studies to examine the phenomenon of energy efficiency implementation and research the background and applicable practices, existing programs, and activities carried out. It is followed by collecting more detailed data or information through the following revised questionnaire, a mixture of closed and open. The research population is the family who owns and rents a house in the Bantul district. The research sample was determined based on the following criteria:

1. Have an active electricity bill for at least 1 year,
2. Own a house of between 50 and 200 square meters.
3. The selected target respondents only use electrical energy sources not to produce or carry out business activities, considering that many household units carry out their MSME business starting from within their homes. So respondents are selected who use electrical energy as input in producing comfort (e.g., indoor temperature) and family recreational activities. Building owners and managers, business and operational managers who are responsible and can represent building owners.

Data were collected using survey methods, interviews, and questionnaires. The collected data were processed using descriptive and quantitative analysis tools. The analytical technique used to analyze the data is the statistical application of "SPSS." The validity test is used to determine the respondent's interpretation of each statement item contained in the research instrument and whether the interpretation of each respondent is the same or completely different. If the respondent's interpretation is the same, then the research instrument can be valid, but if it is not

the same, it can be said to be invalid, so it needs to be replaced/updated. Meanwhile, the reliability test was carried out to test the respondent's interpretation of the statement items contained in the research instrument, as indicated by the consistency of the answers given. Reliability is a measure of the construct indicators' internal consistency that shows the degree to which each of these indicators indicates a common construct/latent factor. Based on Stephenson et al. (2010) energy framework, the authors can formulate a temporary framework or conjecture that can be taken as the following hypothesis:

H_1: The effect of the rebound effect occurs when energy saving occurs in the *observed* or *intervention* household group, and

H_2: There is a significant difference in the *observed* or *intervention* household group.

4. FINDINGS AND DISCUSSION

4.1. Information Can Reduce Electricity Consumption

The RCT experiment required 62 household respondents to be taken from urban housing in Bantul district, Jogyakarta, where some were included in one control group and the other in the "observe or intervention" group. Both groups had energy usage information installed in their homes, and both groups were observed for a 3-month trial from late December 2021 to early April 2022. The control group did not receive any information about energy conservation through the "boost effect," which allowed them to make efforts to reduce electricity costs. The information displayed through information can provide households with real-time information about their electricity consumption.

This research found that providing real-time information through a token usage display reduced household electricity consumption by 16.3049% (Table 1). The effect diminishes over time. This research supports the hypothesis that the reduction in energy use is primarily driven by the learning effect and, to a lesser extent, the effect of having a constant reminder of energy use – the so-called saliency effect. It has some importance given that the dominance of the learning effect will advocate for policy initiatives targeting the importance of information and learning to households. It could take the form of, for example, information campaigns or the labeling of energy-consuming goods and services. Evidence from this experiment can reduce the energy use of urban housing. Households receive feedback reports of their electricity consumption with the use of tokens. Households receiving reports made significant reductions in energy consumption over 3 months from January 2022 to March 2022.

Table 1: Paired samples statistics – electricity cost savings

	Mean (%)	N	SD	SEM (%)
Pair 1				
ObsJanFeb	4.9325	31	4.12157	0.7403
ContJanFeb	–0.6294	31	4.21178	0.7565
Pair 2				
ObsFebMar	11.3723	31	6.65489	1.1953
ContFebMar	5,9755	31	6,36170	1.1426
Pair 3				
ObsJanMar	16.3049	31	10.07178	1.8089
ContJanMar	5,3460	31	8,02195	1,4408

4.2. Energy Conservation Experiment in Bantul

Two types of encouragement used in this experiment were: (i) providing information about the consequences of donations and (ii) providing information about social norms. Field experiments compare the relative effects of two different types of drives on urban household behavior. In our pilot field experiment, we compared the relative effects of two different types of encouragement on household behavior. We found that each intervention positively affected using this tailor-made field experiment. The results show that subtle interventions such as appealing to social norms or providing information influence environmentally friendly behavior in energy conservation.

Within the household production framework, households value electricity as an input in producing comfort (e.g., indoor temperature) and leisure and household production activities. The amount of household electricity consumption in a certain period is the electricity consumption for each activity. These choices, in turn, depend on climate, prices, and personal attributes, including

Table 2: Descriptive analyst – household saving

	Minimum	Maximum	Mean		SD
	Statistics	Statistics	Statistics	SE	Statistics
Respondent status	1.00	2.00	1.06	0.04	0.25
House area	36.00	147.00	107.77	5.87	32.69
Number of family members	1.00	2.00	1.94	0.04	0.25
Home status	1.00	2.00	1.65	0.09	0.49
HOME directions	1.00	4.00	1.61	0.13	0.72
Electric capacity	1.00	4.00	1.77	0.14	0.76
Electricity payment	1.00	2.00	1.29	0.08	0.46
Bulb/(hours × amount)	-	216.00	82.71	10,20	56.82
LEDs/(hours × amount)	-	48.00	9.68	2.94	16.36
Neon/(hours × amount)	-	28.00	7.74	1.84	10.23
AC/(hours × amount)	-	16.00	0.52	0.52	2.87
Refrigerator/(hours × amount)	-	48.00	19.35	2.34	13.03
TV/(hours × amount)	-	72.00	15,10	2.60	14.49
Fan/(hours × amount)	-	96.00	22.84	3.65	20,30
Iron/(hours × amount)	2.00	4.00	2.06	0.06	0.36
Machine/(hours × amount)	-	2.00	1.55	0.15	0.85
Savings (Jan-Mar)	-	0.34	0.16	0.02	0.10

ideology. With this background, two main hypotheses can be tested. Many households will read the report and respond with a desire to lower their bill. Regardless of ethnicity, religion, race, and class, these households can reduce their consumption. Such households find that information about the cost of their energy consumption is more reliable in reducing energy costs according to their strong beliefs (Miller and Buys, 2008). Furthermore, they are influenced primarily by the people in their environment (Roberts et al., 2019).

This research in Bantul is expected to explore the effect of "home energy reporting – HER" and examine how social norms, curtailment, and energy efficiency practices vary based on typical characteristics such as house attributes and socio-economic characteristics of the owner. A distinguishing feature of this research is the emphasis on the urban household environment as an essential determinant of how urban communities, especially in Indonesia, respond to new information. Experiments with the "curtailment" concept include using the washing machine when it is off-peak, turning off lights or electrical equipment when not in use, and washing clothes when clothes are dirty together. Moreover, the laundry is complete and turning off the lights when going out of the room. Replacement installations were carried out on 31 households in the Bantul area, Jogyakarta, in December 2021.

4.3. Characteristics of Respondents Based on Electrical Usage

The characteristics of the respondents based on monthly electricity consumption are dominated by monthly consumption of 30 thousand -120 thousand rupiahs, followed by the use of 120 thousand - 210 thousand rupiah and 210 thousand - 300 thousand. It is related to household income which is dominated by small households. Meanwhile, the respondent's land and house area is dominated by an area between 96sqm and 126sqm, followed by 126sqm-156sqm. From Figures 5-8, it can be seen that the use of conventional incandescent lamps dominates the use of lighting lamps for respondents for as much as 10-15 h/day. The average use of conventional incandescent lamps is 13.45 h/day, and 7.47 h/day for fluorescent lamps. Meanwhile, the use of conventional fluorescent lamps is 0-5 h/day and 10-15 h/day. Fluorescent lamps are widely used in the outdoor yard environment.

Meanwhile, TV equipment is used by almost all of the respondent's households. In Figures 5-8 above, the average respondent watches TV for 10.30 h/day, which indicates that TV is one of the entertainment that the respondent's family often watches. Meanwhile, the authors did not find the use of air conditioning in this respondent. The use of fans is almost found in all households in Bantul to cool the respondent's room. The average fan usage per family is 13.93 h/day. For irons and washing machines, it can be said that the average usage is minimal.

4.4. Descriptive Statistical Analysis

A descriptive statistical approach to describing the characteristics of the independent variables. Table 2 shows descriptive statistical info from the object of the sample data studied (N), namely the sample data of 62 respondents. The table shows each variable's minimum, maximum, average, and standard deviation values. In descriptive statistics, the individual characteristic variables consisting of the house area have a minimum value of 36 sqm and a maximum value of 147 sqm, an average value of 107.7 sqm, and a standard deviation of 32.69. Other individual characteristics

Figure 5: The trend of growth in Indonesia's urban population (World Bank) & Presentation of energy use by sector (MEMR, 2017)

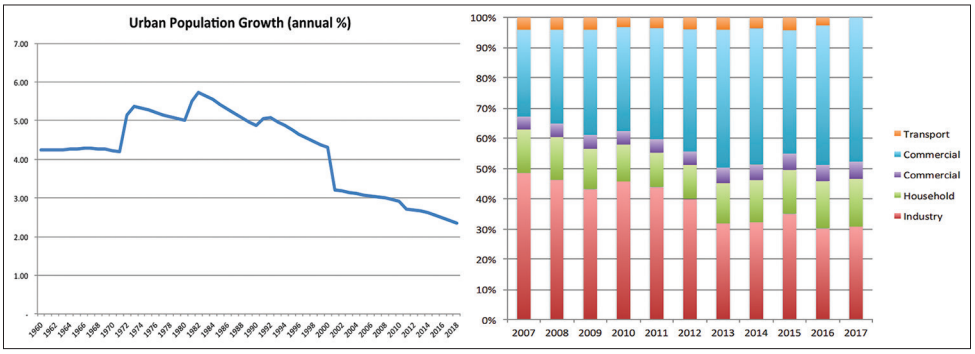
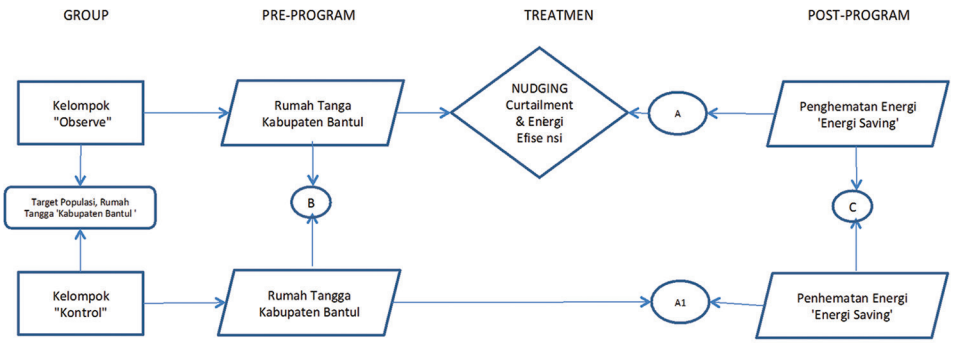


Figure 6: Research framework

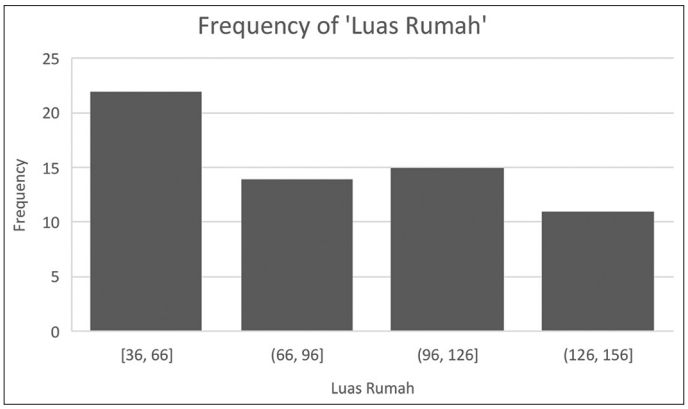


number of respondent members marked with dummy = 1 for household members living in the house and less than five people.

In comparison, dummy = 2 was marked for household members with more than five people living in the house. For electrical capacity, dummy = 1 is marked for 450watts of electricity, while dummy = 2, dummy = 3, and dummy = 4 are marked for 900 watts, 1300 watts, and above 1300watts. The value of electrical capacity has an average value of 1.7 7 and a standard deviation value of 0.76, which means that the average installed electrical capacity in urban communities is 450 watts or 900 watts. In the variable type of electricity payment, the number dummy = 1 is indicated by monthly payments, and dummy = 2 indicates payments through tokens.

For variable use of electrical devices installed inside and outside the house, it is marked by the average use of conventional lamps or commonly called bulbs, as much as 82.71 h for several light bulbs installed and turned on for 1 day. Next, the second and third most

Figure 7: House area



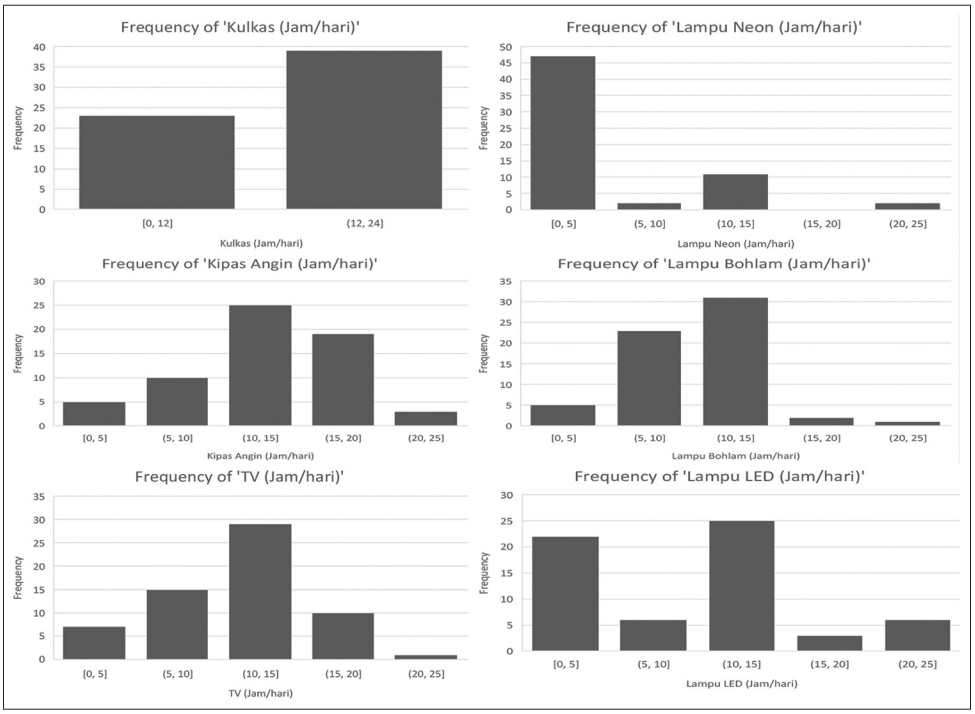
are fans and refrigerators. The hot weather in the Bantul area causes the use of fans to dominate the room temperature adjusters used. At the same time, the refrigerator is indeed marked with continuously installed for 24 h. The average amount of refrigerator use is less than a fan, and almost a light bulb, the urban community in Bantul does not have it. Meanwhile, TV is the fourth device often turned on by urban communities, with an average usage of 15.10 h/day.

4.5. Differential analysis: T-paired Sample – NEGD Model

The authors try to analyze how big there is a significant difference between the observed and the control groups by using statistical analysis. In order to analyze the effect of the nudge-choice architect's effect on the cost of electricity (energy) in the two groups, t-paired sample analysis was also used where the NEGD model was tested to predict the outcome of the nudge-choice architecture in an urban environment. The mean and standard deviation indicators of the variables "social norms, curtailment, and energy efficiency" that affect the motivation for saving electricity costs show very significant results between the two groups.

Table 3 below shows the differences in the mean and standard deviation indicators between the two groups of respondents. Savings variable in January in the group given the "encouraging effect" had an average savings of 4.9325%, in February 11.3723%, and the month 16.3049% with a standard deviation of 0.7403%, 1.1953%, and 1.8089% in January, February, and March. Meanwhile, in the control group, the average mean on the savings variable in January was minus 0.6294%, with a standard deviation of 0.7565%. This minus average indicates an increase in electricity consumption costs in January. However, in February and March, the average value of savings to be positive was at 5.9755% and 5.3460% indicating improvement and savings had occurred.

Figure 8: Respondent's use of electrical equipment



The standard deviation was between 1.1426% and 1.4406% in February and March. Based on the mean value in the experimental group, it can be seen that there was a very significant increase starting in the 1st, second and third months. From this situation, the savings in the cost of electricity consumption in the urban community respondents. They were encouraged to carry out energy conservation and energy efficiency. Moreover, Table 3 below also proves no rebound effect on the savings.

Before doing the test, the authors conducted a correlation test on the three variables saving January, saving February, and Saving March. Table 4 below shows the output of Paired Sample Statistics. The results of the Paired Sample Correlation Table show that the scores for January saving, February saving and March saving are not significantly positively correlated, or the two variables are shown to be r = –0.022, r = 0.194, and r = 0.156, and a significance value of 0.907, 0.296 and 0.402. significance value is > 0.05.

The hypothesis test in this research uses a different T-test. It is done to find out whether there is a difference between the energy consumption levels of urban communities. This test is carried out using the paired sample test because the data on the variables tested are typically distributed. This paired sample test aims to determine whether different treatments or conditions will give different results on the statistical average. If the test criteria are significant > 0.05, it is no different, and if < 0.05, the data is different. This paired sample test uses variable data saving for the months of January-Feb, saving January-March, and saving January-March. The results of the paired sample test are shown in the table as follows:

The mean and standard deviation indicators of the variables "obsJan-ContJan", "obsFeb-ContFeb," and "obsMar-ContMar" affect the motivation for saving electricity costs with significant results between the two groups. Table 3 above shows the differences between the two groups' mean and standard deviation indicators. Based on Table 3 of the paired sample test with a 95% confidence interval, the following data are generated:

Table 4: Paired samples correlations - electricity cost savings

	N	Correlation	Sig.
Pair 1			
ObsJanFeb and ContJanFeb	31	–0.022	0.907
Pair 2			
ObsFebMar and ContFebMar	31	0.194	0.296
Pair 3			
ObsJanMar and ContJanMar	31	0.156	0.402

a. Savings variable data in January were taken from two sample respondents who were given different treatments. One sample respondent was encouraged social norms, curtailment, and energy efficiency or observed variables compared to people who were not given encouragement or control variables. The table above shows that the t count for both variables is 5.199, df is 30, the significance value is 0.000, and the significance value is 0.000 <0.05. So it can be concluded that there is a difference between the cost of energy consumption in urban communities given the "boost effect" on their energy consumption behavior in January.
b. Data saving variable for February, it is known that the t count on both variables is 3.635, df is 30, and the significance value is 0.001; the significance value is 0.001 < 0.05. So, there is a difference between the cost of energy consumption in urban communities given the "boost effect" on their energy consumption behavior in February.
c. Data for saving variables in March shows that the t count for both variables is 5.146, df is 30, and the significance value is 0.001. The significance value is 0.000 <0.05. So it can be concluded that there is a difference between the cost of energy consumption in urban communities given the "boost effect" on their energy consumption behavior in March.

Based on the third test of electricity cost savings from January to March using the paired sample test, the significance value of 0.000, 0.001, and 0.0000 is smaller than 5% or 0.05. So the H_2 test in this research was accepted, meaning that there were differences in electricity cost savings in the two groups. The results of this research are in line with research conducted by (Nasip and Sudarmaji, 2018). From these results, it can be concluded that many "urban" households will read the report and respond by reducing their consumption (Kotchen and Moore, 2008; Costa and Kahn, 2013). Through information, they spend more time monitoring their electricity bills and are actively involved in reducing their electricity costs voluntarily (e.g., turning off unnecessary lights. The results of this research are in line with the results of research by (Graffeo et al., 2015); Gerarden et al., 2015; Karali et al., 2015). They concluded that nudging architecture significantly reduces the cost of electrical energy or generates energy savings in the observed group (experimental group).

This research supports the hypothesis that reducing energy use can reduce electricity costs, especially during peak times. The learning effect drives the curtailment saving effect. The results of this research are in line with the research results of Tanoto, Santoso, and

Table 3: Paired 4 samples test – energy saving

	Paired differences					t	df	Sig. (2-tailed)
	Mean	SD	SEM (%)	95% Confidence interval of the difference				
				Lower (%)	Upper (%)			
Pair 1								
ObsJan–ContJan	5.562%	5.957%	1.069	3.377	7.747	5,199	30	0.000
Pair 2								
ObsFeb–ContFeb	5.397%	8.267%	1.485	2,365	8.429	3,635	30	0.001
Pair 3								
ContMar	10.959%	11.857%	2.129	6.609	15.308	5.146	30	0.000

Hosea (2013). The concept of curtailment is indirectly in line with Demand Side Management (DSM) expressed by Gellings (1985). Turn off the lights when leaving the room. Experiments with the "curtailment" concept include using the washing machine when it is off-peak, turning off lights or electrical equipment when not in use, and washing clothes when clothes are dirty together, and the laundry capacity is full. From the results of the t-paired sample test analysis, where all of these values can be stated that the observed group or the people who are encouraged by the architecture of choice (Nudging) can be said to have a desire to reduce electricity costs from the control group who are not encouraged (Table 3).

5. CONCLUSION

The background of this research is based on the current and future needs of Indonesia's electricity consumption. Without savings, Indonesia will experience obstacles in supplying its energy needs. The great demand for energy is caused by increased activity. Comprehensive energy efficiency and energy conservation programs in the housing sector can reduce energy demands. There are many essential factors in understanding consumer behavior in reducing energy consumption, including behavior in adopting energy efficiency technology in household appliances. Several factors might influence households' typical socio-economic characteristics in adopting energy conservation and energy efficiency.

This research will investigate the most critical factors in motivating electricity cost savings through the application of "social norms, curtailment, and energy efficiency. For this reason, the authors use the "Nudge effect" in the chosen architectural program designed to reduce the use of household electricity consumption. On the basic idea of "Nudging," the authors motivate to increase the influence of policy thinking on urban households. One of the authors' strategies is that choices can be influenced through the "framing" of choices, i.e., by words or presentation choices. In this research on energy efficiency behavioral models, the authors frame the "framing" options through choices at the most cost-effective but able to meet consumer needs in maximizing electricity costs and regarding the desired goals, namely energy conservation and reduction of carbon gas emissions. The "Nudge effect" experiment found energy cost savings and no rebound effect in urban communities in Bantul, Jogyakarta. These savings also occur by comparing household consumption costs through the information that the household can easily access.

This research also aims to find a descriptive, theoretical approach to provide advice to stakeholders and how they can improve their decision-making. The findings of this research are expected to increase knowledge about the idea of a "Nudge effect" and the choice of architectural programs that can be used for energy efficiency and energy conservation policies in the household sector in Indonesia. Perspectives concerning regulatory, behavioral, knowledge, and cultural aspects will be of value to policymakers in understanding the idea of a "drive effect" and program architecture of choice on the household sector and energy efficiency in Indonesia.

The research subjects taken were urban households in an area of Bantul Regency. The authors use a pilot experimental research. There are two types of "Nudge effect" ideas used in the experiment: (i) providing information about the cost of energy consumption and (ii) providing information about social norms. A field experiment compares the relative effects of two different types of "Nudge effect" ideas on household electrical energy consumption behavior. The authors divide the household into the observed household (selected by yourself) and the control household group (chosen randomly). Both observed and controlled households must have an active electricity bill for at least 1 year, between 50 and 200 square meters. The selected target respondents only use electrical energy sources not to produce or carry out business activities, considering that many household units carry out their MSME businesses starting from within their homes. So respondents are selected who use electrical energy as input in producing comfort (e.g., indoor temperature) and family recreational activities. Using this purpose-built field experiment, the authors hope to find that each intervention has a positive effect.

Previous studies have explored the effect of treatment and examined how the effect varies based on typical household attributes and the owner's socio-economic characteristics on households in the Bantul area. The distinguishing feature of this research is the emphasis on the urban household environment as an essential determinant of how Bantul's urban society responds to a well-meaning "Nudge effect." The authors' initial hypothesis is that urban people as energy consumers tend to agree with public opinion and see what they say. A group in a rural environment (rural) in the Bantul region may have the same similarities in the Java island region so that the Indonesian government or relevant authorities can draw the same conclusion. The authors also have an initial hypothesis that the behavior of accepting energy efficiency and energy conservation products, public opinion, or general social norms will undoubtedly be more dominant in urban communities.

This research found that providing information could reduce household electricity consumption, saving on average household electricity consumption costs up to 16.3049% for more than 3 months. The effect diminishes over time. This research supports the hypothesis that the reduction in energy use is primarily driven by the learning effect and, to a lesser extent, the effect of having a constant reminder of energy use – the so-called saliency effect. No rebound effect was generally found in this research, which took 62 respondents in households in urban areas in the Bantul, Jogjakarta area. The researchers researched the rebound effect in the Bantul region because research on energy efficiency and rebound effects is rarely found in Indonesia.

REFERENCES

Ajzen, I. (1991), Theory of Planned Behaviour. Massachusetts: The University of Massachusetts.

ASEA Brown Boveri. (2013), Indonesia Energy Efficiency Report. Available from: https://library.e.abb.com/public/215e27d2819ee70bc1257be800547219/Indonesia.pdf

ASEAN Secretariat. (2019), Integration Report. ASEAN Secretariat.

Banfi, S., Farsi, M., Filippini, M., Jakob, M. (2008), Willingness to

pay for energy-saving measures in residential buildings. Energy Economics, 30, 503-516.
Brody, S.D., Zahran, S., Vedlitz, A., Grover, H. (2008), Vulnerability and public perceptions of global United States. Environment and Behaviour, 40(1), 72-95.
Chen, H., Yan, H., Gong, K., Yuan, X.C. (2021), How will climate change affect the peak electricity load? Evidence from China. Journal of Cleaner Production, 322, 129080.
Chen, M.F. (2015), Extending the theory of planned behavior model to explain people's energy savings and carbon reduction behavioral intentions to mitigate climate change in Taiwan-moral obligation matters. Journal of Cleaner Production, 112, 1746-1753.
Costa, D.L., Kahn, M.E. (2013), Energy conservation "nudges" and environmentalist ideology: Evidence from a randomized residential electricity field experiment. Journal of the European Economic Association, 11(3), 680-702.
Cowan, K., Daim, T. (2013), Adoption of energy efficiency technologies: A review of behavioral theories for the case of led lighting. Green Energy and Technology, 60, 229-48.
Curtis, J., Walton, A., Dodd, M. (2017), Understanding the potential of facilities managers to be advocates for energy efficiency retrofits in mid-tier commercial office buildings. Energy Policy, 103, 98-104.
Dalvi, S.D., Bhonsale, A.V., Datar, R.M. (2014), Acute assessment of dynamics, barriers and resolutions governing household energy efficiency: Global review. Journal of Automation and Control Engineering, 2(2), 129-133.
Dobbs, R., Pohl, H., Lin, D.Y., Mischke, J., Garemo, N., Hexter, J., Matzinger, S., Palter, R., Nanavatty, R. (2013), McKinsey Global Institute Infrastructure Productivity: How to Save $1 Trillion a Year. McKinsey Global Institute.
Enkel, E., Bell, J., Hogenkamp, H. (2011), Open innovation maturity framework. International Journal of Innovation Management, 15(6), 1161.
Fernández, G.P., Landajo, M., Presno, M.J. (2014), Multilevel LMDI decomposition of changes in aggregate energy consumption. A cross country analysis in the EU-27. Energy Policy, 68(1), 576-684.
Fornara, F., Pattitoni, P., Mura, M., Strazzera, E. (2016), Predicting intention to improve household energy efficiency: The role of value-belief-norm theory, normative and informational influence, and specific attitude. Journal of Environmental Psychology, 45, 1-10.
Gellings, C.W. (1985), The concept of demand-side management for electric utilities. Proceedings of the IEEE, 73(10), 1468-1470.
Gerarden, T., Newell, R.G., Stavins, R.N. (2015), Deconstructing the energy efficiency gap: Conceptual frameworks and evidence. American Economic Review, 105, 183-186.
Graffeo, M., Ritov, I., Bonini, N., Hadjichristidis, C. (2015), To make people save energy tell them what others do but also who they are: A preliminary study. Frontiers in Psychology, 6, 1-19.
Greening, L.A., Greene, D.L., Difiglio, C. (2000), Energy efficiency and consumption the rebound effect a survey. Energy Policy, 28, 389-401.
Ha, H.Y., Janda, S. (2012), Predicting consumer intentions to purchase energy-efficient products. The Journal of Consumer Marketing, 29(7), 461-469.
Heesen, F., Madlener, R. (2016), Technology Acceptance as Part of the Energy Performance Gap in Energy Efficient Retrofitted Dwellings Florian Heesen and Reinhard Madlener December 2014 Revised February 2016 Institute for Future Energy Consumer Needs and Behavior (FCN). 52074, Aachen, Germany.
Horne, C., Kennedy, E.H. (2017), The power of social norms for reducing and shifting electricity use. Energy Policy, 107, 43-52.
Karali, N., McNeil, M.A., Letschert, V., de la Rue du Chan, S. (2015), Potential Impact of Lighting and Appliance Efficiency Standards on Peak Demand: The Case of Indonesia Nihan Karali. Ernest Orlando Lawrence Berkeley National Laboratory.
Khanna, N.Z., Guo, J., Zheng, X. (2016), Effects of demand side management on Chinese household electricity consumption: Empirical findings from Chinese household survey. Energy Policy, 95, 113-125.
Kimita, K., Sugino, R., Rossi, M., Shimomura, Y. (2016), Framework for analyzing customer involvement in product-service systems. Procedia CIRP, 47, 54-59.
Kitchen, M.J., Moore, M.R. (2008), Conservation: From voluntary restraint to a voluntary price premium. Environmental and Resource Economics, 40(2), 195-215.
Lee, B., Eang, S. (2015), A Review of Building Energy Efficiency Development in Indonesia. (WBCSD Publications Library, 2015).
Liang, X., Peng, Y., Shen, G.Q. (2016), A game theory based analysis of decision making for green retrofit under different occupancy types. Journal of Cleaner Production, 137, 1300-1312.
Lingyun, M., Rui, N., Hualong, L., Xiaohua, L. (2011), Empirical research of social norms affecting urban residents low carbon energy consumption behavior. Energy Procedia, 5, 229-234.
Lynch, D., Martin, P. (2013), How Energy Efficiency Programs Influence Energy Use: An Application of the Theory of Planned Behaviour. European Council for an Energy Efficient Economy Summer Study. p2037-2048.
Malkani, A.P. (2012), Building Green: The Adoption Process of LEED and Energy Star-Rated Office Buildings. Theses Doctoral Dissertations.
Miller, E., Buys, L. (2008), Retrofitting commercial office buildings for sustainability: Tenants' perspectives. Journal of Property Investment and Finance, 26(6), 552-561.
Mills, B., Schleich, J. (2012), Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries. Energy Policy, 49, 616-628.
Ministry of Energy and Mineral Resources of the Republic of Indonesia. (2018), Handbook of Energy and Economic Statistics of Indonesia 2018. Indonesia: Ministry of Energy and Mineral Resources of the Republic of Indonesia. p1-129. Available from: https://www.esdm.go.id/assets/media/content/content-handbook-of-energy-and-economic-statistics-of-indonesia.pdf.
Nasip, I., Sudarmaji, E. (2018), Managing tax dispute due to IFRS-16 on the retrofits implementation in Indonesia. International Journal of Engineering and Technology, 7(3), 200-208.
O'Malley, E., Scott, S., Sorrell, S. (2003), The Economics of Energy Efficiency: Barriers to Cost-effective Investment. In: Policy Research Series, EIB Papers.
Oberman, R., Dobbs, R., Budiman, A., Thompson, F., Rosse, M. (2012), The Archipelago Economy: Unleashing Indonesia's Potential. McKinsey Global Institute. p7-65.
PLN (Persero). (2018), Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) PT PLN (PERSERO).
Polzin, F., von Flotow, P., Nolden, C. (2016), Modes of governance for municipal energy efficiency services the case of LED street lighting in Germany. Journal of Cleaner Production, 139, 133-145.
Prete, M.I., Piper, L., Rizzo, C., Pino, G., Capestro, M., Mileti, A., Pichierri, M., Amatulli, C., Peluso, A.M., Guido, G. (2017), Determinants of Southern Italian households' intention to adopt energy efficiency measures in residential buildings. Journal of Cleaner Production, 153(13), 83-91.
Priest, S.H., Greenhalgh, T., Neill, H.R., Young, G.R. (2015), Rethinking diffusion theory in an applied context: Role of environmental values in adoption of home energy conservation. Applied Environmental Education and Communication, 14(4), 213-222.
Richard, H.T., Sunstein, C.R. (2003), Libertarian Paternalism. Harvard Business Review.
Roberts, M., Sander, F.G., Tiwari, S., editors. (2019), Time to ACT:

Realizing Indonesia's Urban Potential. Jakarta: World Bank Indonesia.

Rogers, E.M. (1962), Diffusion of Innovation. 3rd Editio. London: The Free Press: A Division of Macmillan Publishing Co., Inc.

Shadish, W.R., Cook, T.D., Campbell, D.T. (2002), Experimental and Quasi-Experimental Designs for Generalized Causal Inference. Boston, Massachusetts: Houghton Mifflin.

Stephenson, J., Barton, B., Carrington, G., Gnoth, D., Lawson, R., Thorsnes, P. (2010), Energy cultures: A framework for understanding energy behaviours. Energy Policy, 38(10), 6120-6129.

Stern, D.I. (2017), How accurate are energy intensity projections? Climatic Change, 143(3-4), 537-545.

Sudarmaji, E., Achsani, N.A., Arkeman, Y., Fahmi, I. (2021), Can energy intensity impede the CO_2 emissions in Indonesia? Lmdi-Decomposition Index and Ardl: Comparison between Indonesia and ASEAN Countries. International Journal of Energy Economics and Policy, 11(3), 308-318.

Sudarmaji, E., Achsani, N.A., Arkeman, Y., Fahmi, I. (2022), Decomposition factors household energy subsidy consumption in Indonesia: Kaya identity and logarithmic mean divisia index approach. International Journal of Energy Economics and Policy, 12(1), 355-364.

Sudarmaji, E., Munirah, M. (2019), Alternative model for putting indonesian young digital talent in business. Review of Management and Entrepreneurship, 3(1), 1-24.

Tanoto, Y., Pasila, F. (2016), Energy Decomposition Model Using Takagi-Sugeno Neuro-Fuzzy. In: Second International Conference o Electrical Systems, Technology, and Information (ICESTI 2015). p149-154.

Tanoto, Y., Santoso, M., Hosea, E. (2013), Demand side management of household's lighting considering energy use and customer preference: A preliminary study. International Journal of Engineering and Technology, 5(3), 3134-3141.

Trochim, W.M. (2002), What is the Research Methods Knowledge Base? Available from: http://trochim.human.cornell.edu/kb/index.htm

US Department of Energy. (2016), Electronic Publishing 2016 Solid-State Lighting R&D Plan. Available from: https://www.energy.gov/sites/prod/files/2016/06/f32/ssl_rd-plan_ jun2016_0.pdf

Wang, Z., Wang, X., Guo, D. (2017), Policy implications of the purchasing intentions towards energy-efficient appliances among China's urban residents: Do subsidies work? Energy Policy, 102, 430-439.

Wijaya, M.E., Tezuka, T. (2015), Analysis of Decision-Making in Electrical Devices Use in Indonesian Households, Report. p1-10.