Rethinking sustainability during WFH: A survey on living environment quality and energy use

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Abstract. This study is trying to investigate the occupant’s lifestyle change during the ‘Work from Home’ (WFH) in face of the COVID-19 pandemic in Indonesia. It is predicted that energy use, especially electricity use in the housing sector is increasing due to longer in-home period during activities restriction. In addition, the household’s way of using their thermal appliances such as air conditioner (AC), electric fan, and the ventilation ways by windows are also predicted to increase in hot and humid climate cities. For that reason, the survey was conducted during the mid of April to the end of April 2021 through the web-based questionnaires which are targeting the individual and families. First, the data collected are summarized includes the building characteristics, family structures, home appliances, lifestyle, and the ownership of thermal air conditioning system appliances. Secondly, to grasp the change in electricity use, we summarized the results about the lifestyle change related to home energy use during the period of WFH. Finally, from the results of this survey, people's concerns and awareness regarding the health and quality of the surrounding environment are increasing. This could be good momentum for authority to establish a modern society with awareness and a good quality environment. A strategy for energy distribution and increasing the use of renewable energy in household buildings is needed to meet demand and build a sustainable society.

1. Introduction

It is predicted that the first case came from a source of pathogen propagation originating from the Huanan seafood market and then transmitted from person to person [1]. Later the Wuhan Municipal Health Commission informed the city about the early signs of a pneumonia outbreak that pushed the local government of Hubei of Wuhan, to lock down the city. However, a few weeks later, the virus spread faster and WHO declared that Covid-19 became a global pandemic. The emergence of the first new cases around the world resulted in the participation of European and American countries to carry out a lockdown, the same as what was done in the city of Wuhan [2].

In March 2020, the first case in Indonesia was recorded as coming from a Japanese citizen who traveled to Indonesia, which continued to increase after that [3]. Recently, the number of infections has decreased during the vaccination program to counter the pandemic. But, during the writing of this paper,
The number of infections tends to rise after serial of holidays in Indonesia. In response to this situation, the Large-Scale Social Restrictions (LSSR) is currently extended in place in some biggest cities of Indonesia, includes measures such as closing public spaces, restricting public transport, and limiting travel to and from the restricted regions. Since then, the pandemic continues to affect many sectors, especially affect to how people work. Some metropolitan cities had already closed their offices and schools. This government program named as Work from Home (WFH) or Stay at Home. People start to adapt to the new way of living and make the home as comfortable as possible to do almost all daily activities than before. Since the local government and experts suggest to opening the windows to flows the indoor air, it is predicted that people are opening their windows while keeping the air conditioner on due to the hot climate of Indonesia. Thus, the in-home period of residents is predicted to increase in line with the use of home electronic appliances. Therefore, the increase in in-home energy demand is inevitable.

Even before Covid-19, energy use demand in the household sector is high so often the power supply is inadequate. According to Indonesia National Energy Council (ESDM), in 2018, the total primary energy production consisting of oil, gas, coal, and renewable energy was 411.6 MTOE. Besides that, Indonesia also imported energy especially crude oil and petroleum products of 43.2 MTOE and a small volume of high-rank coal to meet the industrial sector’s need [4]. The total final energy consumption (without traditional biomass) in 2018 was around 114 MTOE derived from 40% transportation, 36% industry, 16% household, 6% commercial sector, and 2% other sectors [4]. With its fourth most populous country in the world, during the Covid-19 pandemic, the energy use, especially electricity demand in the household is predicted to increase several times in Indonesia. This phenomenon of sudden lifestyle changes needs to be measured and analyzed carefully as a guideline for local government, planners, and building experts in response to an uncertain situation. For that reason, this study is conducted to grasp the existing situation during a pandemic due to the lifestyle changes especially in the residential building through an online-based questionnaire survey.

2. Methods
Questionnaire distribution and collection were done through internet-based form. Questionnaire surveys are conducted to investigate and grasp the information of family and house characteristics, behavior changes, and people’s view about the local policy regarding virus spread prevention. The questionnaire categories are divided into some main categories as shown in below. The survey was carried out to Indonesian households from April 2020 to April 2021 among total 550 respondents from several cities and provinces in Indonesia.

| Table 1. Survey contents. |
|---------------------------|
| Categories | Contents |
| 1 | Personal information | Age, job, family structure, income |
| 2 | Building information | House type, size, year, direction |
| 3 | About WFH | Lifestyle change, activities |
| 4 | Consumption | Electricity, gas, other consumption |

3. Results and discussion
3.1. Basic information
Table 2 summarises the questionnaire results on household characteristics. It shows almost half of the total respondents (40.5%) are aged between 31-35 years old which also represents the productive working-age group in Indonesia. This result also means the internet users in this survey are mostly dominated by a group of age between 20 to 40 years old. On the other hand, the family size involved in
this survey is mostly young families with a member of 2 to 4 people in the household. The compositions are dominated by 4 members (25.2%), followed by 2 members (23%) and 3 members (18%). It also shows the stay period of households in the current house. About 23% of households have stayed between 1-3 years in their current building. This table also shows that there are no significant differences between groups of households that stay for less than 1 year (14%), 4-6 years (14.9%), and 7-10 years (14.9%).

Refer to employment status, working as an employer of a company is the biggest percentage of householders involved in this survey, count for more than 31%. Followed by public/government servants (19.8%) and educational work (15.3%). Concerning the total household income, it shows that 9.9% of households still under the local minimum salary standard.

### Table 2. Results on household characteristic.

| No | Categories          | Unit       | Result             |
|----|---------------------|------------|--------------------|
|    | Basic information   |            |                    |
| 1  | User age            | years old | %                  |
| 2  | Family size         | person     |                    |
| 3  | Occupants stay period | years |                    |
| 4  | Employment status   | %          |                    |
| 5  | Household income    | %          |                    |
|    | Building information|            |                    |
| 1  | Building type       | -          | Multi-dwelling     |
|    |                     |            | Detached house     |
| 2  | Construction year   | %          |                    |
| 3  | Building direction  | %          |                    |
| 4  | Floor size          | sqm        |                    |
|    | Work style          | %          |                    |
| 2  | Working from home before Covid-19 | % | Yes | No |
| 3  | Work from Home since Covid-19 | % | Yes | No |
| 4  | WFH period          | Month      | %                  |

### 3.2. Building condition

In terms of building basic information, Table 2 shows the composition of building type. Almost 80% of the households involved in this survey are living in a detached house, and only 20.3% are living in multi-dwelling. This also represents that people still prefer to live in a detached house than multi-dwelling types such as apartment or public communal dwellings [5]. It shows the results of the current building construction years. Most are dominated by the building constructed between the year of 1990-2000 and 2000-2010, which is 32.9% and 35.1% respectively. The building direction varied from west, south, east, and north counted almost in the same percentage between 22% to 24%. Building direction becomes an important factor related to the thermal comfort of the occupant [6]. Since the detached house still becomes the preference of most households involved in this survey, 33.5% of the house have a total floor area of more than 90 sqm. Although there is also a significant number of buildings with floor areas between 21-30 sqm (12.6%) and 51-60 sqm (10.7%). House floor area is also an influential factor affecting the household consumption in terms of electricity use [7].

### 3.3. Working style

The questionnaire also collected the information of occupant’s behaviours related to the working style. The situation before and during the pandemic also become a concern in this research to grasp the shift or change of the lifestyle. Almost 75% of the household are working parents (both husband and wife). While 25% of households are single-income families. Before the pandemic, 73% of respondents had to
go to their workplace and 17.6% are not required, while 9.5% answered that sometimes they can do the work from home. Even before the pandemic, there are groups of households that have already practiced WFH. Then, the situation is changing. Nearly 90% of respondents are pushed to WFH during the outbreak of Covid-19, some are their initiative some others are the companies or local government rules. The result left only 10.8% of respondents that are not doing WFH.

About 10.2% of respondents are doing WFH for at least 2 months and 33% of households have stayed at home between 3-4 months. Although most of the respondents, 44.7%, are doing WFH for 5-6 months. While 9.1% of households have stayed more than 6 months. In addition, the survey also asked about the change of occupant’s activity during the local lockdown in their home and some outdoor activities. Some questions are related to activities that probably change if WFH was implemented over a longer period. It also shows the results of home activity change during the pandemic. There are 93.2% respondents answered that outdoor activities have decreased sharply compared to before WFH. Therefore, according to more than one third respondents there are many indoor activities that increased during WFH, such as workout, spent time with hobbies, sleep hour, sun bathing, eat, house cleaning and cooking. In accordance with the increasing of Internet, TV and AC usage.

3.4. Consumption

With the household consumption that affected due to sudden change of household lifestyle, specifically, the survey asked about the change in home appliances use intensity during the WFH. Figure 3 shows that the use of personal computers in the home largely increase, compared to the other electronic appliances this device has the biggest intensity use. In line with the increase of cooking activity in Figure
1. Figure 3 also confirms that most of the respondents use more frequent cooking stove compared to before WFH. The results also found that the use of electric fans has shown a significant increase in more than half of the total respondents.

3.5. Concern and awareness
The survey also asked about the people’s concern and awareness about the pandemic issues, health, and some financial impact that may affect the households. The previous study shows that people are becoming more concerned on the issues such as physical distancing for 87% of respondents during the virus outbreak, followed by direct contact, the use of facemask, knowledge, and information about the virus, hand washing dan clothes cleanliness issues, rather than concern about the energy use and electricity expenses [8]-[9]-[10]-[11]-[12]. People also become more concerned and aware about the cleanliness of public transportation and facilities that may have been used by other people. Some groups of families are also worried about the expenses that they may spend for the internet to keep up with their work/school and expenses for medicine/medical facilities just if they get infected by the virus or avoiding become sick and going to the hospital during the uncertain situation of the pandemic.

3.6. Energy use profile
Change of the lifestyle during at home is highly affecting the consumption of energy use, includes of electricity and gas use. Refer to Figure 4, the survey also asked about the household’s electricity bills before the Covid-19. The results vary but are dominated by the household group with monthly electricity bills between 100,000 – 200,000 IDR (18.9%), then the percentage is gradually decreasing to 800,000 – 900,000 IDR a month. On the other hand, in Figure 5, since the pandemic, more than 30% of respondents found that their home energy consumption expenses have increased between 10% to more than 100%. While 64.6% of respondents stated that the electricity and gas bills increase by not more than 10% compared to before WFH.
3.7. Living environment quality

WFH is a good opportunity to get to know and evaluate the comfort level of residents who usually work outside the home during working hours. Regarding the living environment, in the survey, we also asked about the comfort level of residents during the pandemic. In Figure 6, although most respondents feel that the comfort level is still tolerable (67.2% for the comfort level of air temperature and 66% for the humidity level) related to air temperature and humidity in the room, there are still quite large numbers at temperatures that are too high (heat) and high humidity of 16.6% and 14.6%. The comfort rate of air temperature and temperature is quite high, it is necessary to investigate the cause if it is directly proportional to the increasing use of air conditioning.

![Figure 1. Indoor thermal comfort level.](image)

In Figure 7, we also evaluate the quality of the living environment. It is found a fairly high level of discomfort in noise and insect disturbance. The noise level of the environment where they live is also a concern compared to before the pandemic period where online meetings were rarely held. In addition, the tropical climate of Indonesia is also meant many insects every year, so this is often an obstacle for residents to open their windows. Figure 8 shows the level of ownership of AC from the respondents. It is shown that more than 44% of the user only use one AC unit in their house. However, there is a significant number and it is expected to continue to grow, which is the AC ownership of more than 5 units per household.

In terms of the method of indoor air circulation, Figure 9 shows the types of methods used by residents, both with AC, opening and closing windows, or a combination of both. It is found that 36.4% of residents choose to open and close windows as a method of air ventilation. Meanwhile, 35.1% used a combination of AC and opening windows. This is because the indoor air temperature is high if they don't use appliances such as AC and electric fans. In addition, although there are still in small number, residents who use full AC also show a fairly significant number. Before the pandemic, tightly closing doors and windows due to the AC can keep the room temperature comfortable so that the performance of the air conditioner is also maximized. But during the pandemic, opening the doors and windows are highly promoted as a ventilation option to move the indoor air to avoid viruses infection.

Regarding the performance of the AC unit, Figure 10 and Figure 11 show the results of a questionnaire regarding the period of cleaning the air conditioner regularly and the year it was purchased. The more often cleaning the AC unit, the maximum performance and the safer the air conditioner to use, but a significant number of users don't care about the cleanliness of the air conditioner. Figure 11, shows that 40.7% of the AC units are still relatively new, between 0 to 5 years old. But, many users who use air conditioners that are more than 10 years.
Figure 3. AC ownership per household.

Figure 4. Ventilation method.

Figure 5. AC cleaning period.

Figure 6. AC unit built up year.

In addition, Figure 12 shows that there is an increasing trend in the use of AC in the future. Although currently 60% are still dominated by the number who choose not to use AC, with the improving economic and family’s financial conditions and the need for a higher level of comfort and quality of life in their homes, it is estimated that there will be an increase in AC ownership in the future.

Figure 7. Future plan on buying AC unit.
When people are trying to maximize the performance of thermal appliances such as AC by tightly closing doors and windows, a pandemic has come that again recommends opening doors and windows as a way of ventilation. In other words, researchers, and planners should rethink sustainability. Tropical architecture and buildings are supposed to be buildings that breathe through the method of ventilating and flow the air in every element of the building. In contrast to colder countries that use an insulation approach as a way to maximize ventilation performance. However, the quality of outdoor spaces is a big challenge, such as the heat island phenomenon in urban environments, air quality (pollution), noise levels, and insect disturbances are challenges that must be faced so that the value of sustainability can be achieved. The sudden emergence of a pandemic has also made people less concerned with sustainability issues than before [13]. If the building that ventilates air and using natural resources becomes the principle of sustainability, besides being able to reduce the risk of virus transmission, it is also able to reduce the use of energy (electricity) in buildings, especially residential housing.

4. Conclusions
From the results of this survey, it can be concluded that:
1. For the productive family age group, the availability of internet services at home is very much needed to support WFH and education activity that has been implemented since the pandemic in Indonesia. Internet, in any case, reduces the mobility of employers when their work does not require them to go to the workplace.
2. This survey found that activities outside the home have been drastically reduced followed by the decrease of household consumption related to transportation and mobilization. This becomes a crucial aspect in developing a future city, that distance is no longer an obstacle as long as work productivity can be fulfilled.
3. From the results of this survey, people’s concerns and awareness regarding the health and quality of the surrounding environment are increasing. This could be good momentum for authority to establish a modern society with awareness and a good quality environment.
4. The increase in electricity and gas consumption due to the longer time spent at home during WFH needs to be underlined. A strategy for energy distribution and increasing the use of renewable energy in household buildings is needed to meet demand and build a sustainable society.
5. Massive efforts are needed to achieve high thermal comfort but by still using the sustainability principle of breathing buildings, namely by solving external environmental problems such as urban air quality, and environmental cleanliness.

In the future, research will be developed to relate the factors that cause energy consumption in residential homes with the pandemic that has changed the lifestyle of residents during WFH.

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