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# Managing Electricity Consumption on Campus: The Effect of Online Learning from Home

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**ABSTRACT**

This paper analyzes the effect of Online Learning from Home (OLFH) during the COVID-19 pandemic on electricity consumption and the quality of the learning process quality. This study identifies the reduction of electricity consumption on campus during OLFH, which can be utilized to maintain the quality of the learning process. The electricity consumption data was analyzed from the direct measurement using the electricity consumption real-time monitoring system. Again, the data analyzed of the online learning process quality was obtained from the student survey via Google Forms. The results of monitoring electricity consumption before and during OLFH showed that the most significant decrease in electricity consumption occurred in classroom buildings, with a decrease value of 68.74%. Meanwhile, the lowest reduction of electricity consumption occurred in the rectorate building, with its reduced value of 19.02%. A student survey showed that most respondents were satisfied with the transition from face-to-face learning to OLFH during the COVID-19 pandemic. However, this study also identified negative aspects of OLFH. Reducing electricity consumption during OLFH will cost saving for the university. The cost saving can be used to implement programs to address the deficiencies of OLFH and improve its infrastructure so that the quality of the learning process is maintained.

**Keywords:** Electricity Consumption, COVID-19, Online Learning from Home, Campus Building, Electricity Consumption Monitoring System
**JEL Classifications:** M150, O320, O440

## 1. INTRODUCTION

The COVID-19 outbreak at the end of 2019 in Wuhan, China, the Coronavirus has spread to 230 countries worldwide. More than 600 million people are infected, and 6.5 million are dying because of the virus (Worldometer, 2021). However, the spread of its plague has begun to be controlled today. Thanks to the vigorous vaccination efforts carried out by countries worldwide. However, the heavy burden felt while fighting against the COVID-19 outbreak has still not been erased from people's minds. The COVID-19 pandemic has harmed almost all sectors of human life, especially the productive sector, such as the industrial sector, the tourism sector, the trade sector, the infrastructure sector, the transportation sector, etc. growth in these sectors will result in a decline in economic development. On the other hand, the pandemic has also decreased world energy demand and reduced energy consumption in all productive sectors(Jiang et al., 2021; Tamilselvan et al., 2022).

In general, during the COVID-19 pandemic, businesses will experience a decline in production, leading to a decrease in energy consumption. It also dropped the number of tourist visits in the tourism sector due to travel restriction policies in almost all countries, both domestic and foreign tourism. A decrease in the number of tours will impact a decline in the number of flight routes, land and sea transportation routes, and the number of guest visits to hotels. The condition will lead to a decrease in energy demand in this sector. It also occurred in the industrial sector due to the decline in economic growth during the COVID-19 pandemic, which caused a decrease in market demand for goods from industrial products. A drop will follow the reduction in industrial products in energy demand.

In contrast with the business industry, some countries' educational activities were still running during the COVID-19 pandemic. However, in several countries, learning activities had to be stopped altogether. Most educational institutions control the spread of the COVID-19 pandemic by shifting the face-to-face learning process to Online Learning From Home (OLFH). In other words, the education sector continues its business despite the questionable process quality. However, some institutions do not have internet facilities, especially in developing countries, stopping all learning activities from controlling the spread of COVID-19 (Andrei et al., 2021).

The scope of study in this article is focused on universities switching from face-to-face learning to OLFH to control the spread of COVID-19 on a university campus. In terms of electricity consumption during OLFH, there will be a shift in the need for electrical energy from university buildings to homes, as discussed in the literature (Andrei et al., 2021; Kawka and Cetin, 2021). The amount of consumption in educational institution buildings will decrease, while in homes, there will be an increase in energy consumption.

This article analyzes the effect of OLFH during the COVID-19 pandemic on electricity consumption and the quality of the learning process in the university. The electricity consumption data, before and during OFLH, was obtained from the direct measurements of the electricity consumption real-time monitoring system. At the same time, the data for learning process quality were collected from an online survey of 149 students. In this study, several programs are formulated to stimulate OLFH to maintain the quality of the learning process at the university. As the object of study, Universitas Andalas campus in Padang, Indonesia, was chosen.

## 2. LITERATURE REVIEW

In general, the educational institution's response when the COVID-19 pandemic occurred was to switch from face-to-face lectures to OLFH (APEC, 2021). The change was not too difficult to implement for an institution that has already implemented online learning as e-learning or blended learning. In contrast with the universities that already have information technology (IT) facilities but have not utilized them for online learning processes, it will require a lot of funds and human resources to develop online learning systems quickly. It cannot be carried out for universities that do not provide IT facilities. Some campuses have disrupted all campus academic activities during the COVID-19 pandemic.

In most developing countries, all students cannot reach distance learning due to limitations in Internet access, especially in remote areas (Kawka and Cetin, 2021). In addition, the inability to have electronic equipment/gadgets/digital devices for conducting online lectures and poor internet connections, IT facilities, online teaching materials, and IT skills make it difficult for lecturers and students to implement online learning. Another way to implement the learning process during the COVID-19 pandemic is diverting face-to-face lectures to one-way lectures via radio and television (Tadesse and Muluye, 2020). However, many low-income families still do not have radio, television, and other devices to access learning resources from their homes, so the learning process cannot be carried out effectively. In addition, to help low-income families, governments in several developing countries have made zero-fee policies on internet educational resources, free online learning resources, and broadcast teaching.

### 2.1. The Electricity Consumption Patterns in Campus Buildings

The electricity consumption on campus depends on the electrical equipment used and activities requiring electricity (Pujani et al., 2019). Electrical equipment used in campus buildings can be grouped into cooling and/or heating, lighting, computer equipment, laboratory equipment, and other equipment. Air conditioning (AC) is only needed for campus buildings in the tropics, whereas air cooling and heating are required for areas with four seasons. In general, the buildings on campus, based on user activities, can be distinguished into central library buildings, department/faculty buildings, rectorate buildings, student dormitory buildings, sports buildings, and buildings for other purposes. Electrical equipment and user activities carried out in each campus building will determine the electricity consumption pattern in each building. Each campus building will have different types of electrical equipment installed and electricity consumption patterns. For example, the department building where practicum activities, lecturer academic activities, and administrative activities happen is equipped with the dominant electrical equipment, such as lights, air conditioners, computers, laboratory equipment, and other electrical equipment. Meanwhile, the central library building only has electrical equipment for reading activities and seminars, such as air conditioners, lights, and other electrical equipment.

The impact of the COVID-19 pandemic on electricity consumption patterns in campus buildings is strongly influenced because there is a change in activity patterns that usually occur in that buildings. The consumption pattern in lecture buildings sharply drops when the online learning process is at home. It happened because almost all learning activities moved from campus to home. Meanwhile, the electricity consumption pattern in the rectorate building may not experience a significant decrease because administrative and management activities must continue during the COVID-19 pandemic. Indifferent when a total lockdown is implemented on campus. In general, the electricity consumption pattern in campus buildings during COVID-19 is determined mainly by changes in activity patterns in each building.

According to a study (Kawka and Cetin, 2021), in the United States, during the COVID-19 pandemic, there was a shift in electricity consumption from business buildings, campuses, or offices to residential buildings. It happened because, during the COVID-19 pandemic, the house was used as a temporary office, lecture hall, restaurant, and entertainment center. Thus, the consumption pattern of campus buildings will tend to decrease during a pandemic. In contrast, the electricity consumption pattern in lecturers' and students' homes will tend to increase (Andrei et al., 2021). The percentage decrease in electricity consumption in university buildings and the percentage increase in the homes of lecturers and students is proportional to the decline and growth in the use of computers in the university and households, respectively. On the other hand, online learning from home can reduce energy consumption for round-trip transportation of the academic community from home to campus.

## 2.2. Impact of COVID-19 Pandemic on Education Funding

Regarding education financing, COVID-19 has significantly impacted university finances (Jiang et al., 2021). This business activity relies heavily on tuition fees from domestic and international students to fund learning activities, including research. As more domestic and international students choose to take time off during the pandemic, university revenues have fallen. In contrast, expenses have increased due to the expansion of investments in online education systems to costs associated with disinfecting campus facilities. However, transferring the learning process from face-to-face to online learning at home is an attractive solution for students to continue attending lectures comfortably during the COVID-19 pandemic so that the student's movement can be reduced. In some universities that have started partial online courses or blended learning, investment development in online learning infrastructure is not very significant. Meanwhile, university costs will also decrease due to reduced electricity consumption because of online learning.

From the perspective of students and lecturers, some argue that the online learning system is a cheap learning model in terms of transportation and accommodation costs (Tamilselvan et al., 2022). Students do not need accommodation costs near campus because all learning activities have moved to their homes. Likewise, transportation costs for lecturers and students will decrease drastically because the frequency of trips from home to campus is minimal during the COVID-19 pandemic. However, the financing of electricity and internet bills in the homes of students and lecturers will increase.

## 2.3. The Quality of OLFH Processes at Universities

Radu et al. (2020) from Vasile Alecsandri University of Bacau, Romania, have conducted a study through a survey regarding the impact of the COVID-19 pandemic on the quality of the learning process in the Faculty of Engineering and the Faculty of Physical Education and Sports. The survey results showed that most students were satisfied with switching from face-to-face to online learning during the lockdown period. However, this study also identified negative aspects of online learning during the COVID-19 pandemic. It includes a lack of adequate infrastructure for some students, a lack of effective communication and interaction between students and lecturers, an impossible practical application, and a lack of motivation to learn. It also declared that the opportunity to cheat in exams is relatively high, the tendency to decrease physical and mental health, and sedentary lifestyle patterns.

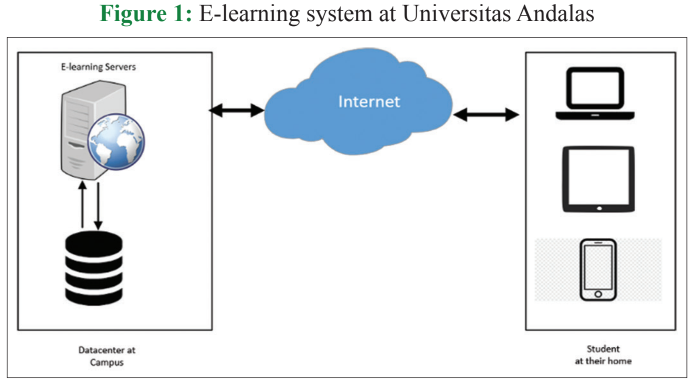
According to (Maatuk et al., 2022), students believe that e-learning can positively contribute to their learning during the COVID-19 pandemic. However, it can reduce the workload on the faculty and increase the course load on students. The main obstacle to e-learning was the low quality of public Internet services during the pandemic. Faculty members agreed that e-learning helped enhance students' computer skills, although it required significant investment development costs. Universities must provide internet services for students and lecturers with sufficient computer hardware to implement e-learning. A modern electronic library and dedicated classrooms with all necessary equipment and tools are also required to implement e-learning instead of coming to the main campus. Holding regular online training and seminars is very important for lecturers to support the implementation of e-learning.

## 2.4. The Online Learning Infrastructure

Universitas Andalas developed the e-learning system before the COVID-19 pandemic as a learning support facility. It was built using Moodle™ with hardware installed and configured in the data center on the Limau Manis campus. The architecture of the existing eLearning system can be seen in Figure 1. The eLearning server is located at Limau Manis main campus with dedicated internet access. Meanwhile, students access eLearning using their internet access.

Server hardware is provided by the campus data center located at Universitas Andalas Campus, Indonesia. With 15 faculties and 1 postgraduate program, they provide four servers with a capacity of 2 CPU cores, 4 GB RAM, and 200 GB storage to serve campus e-learning services. Different things happened during the pandemic. At that time, Universitas Andalas had to upgrade their server hardware to 10 servers with 500 GB storage capacity each, including practicum. It is in line with the OLFH policy implemented by the government for all educational institutions. Figure 2 shows the traffic usage of one of the existing e-learning servers. It showed a significant increase from July, with total traffic of 1 GB to 15 GB in August 2019. It was affected by OLFH policy during that month.

**Figure 1:** E-learning system at Universitas Andalas



# 3. METHODS

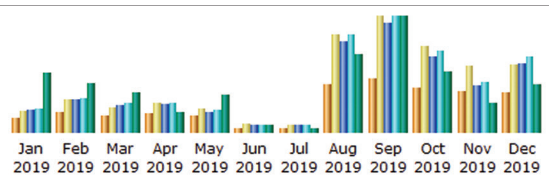
## 3.1. Real-Time Electricity Consumption Monitoring System

A real-time monitoring system for electricity consumption has been investigated and developed since 2019 on several samples of buildings that are the object of study. The system is built with a client/server architecture using web technology as an interaction between application users and the system. Figure 3 shows the energy monitoring system's architecture, consisting of 3 parts: the client, servers, and sensors. With web-based applications connected to the internet, application users can access applications from computers or mobile devices that support web communication. Energy data is taken from sensors in 4 functionally different buildings: lecture, library, faculty, and rectorate.

The server section consists of 3 servers. A web server that serves web service requests from users and processes data stored at the database server. The database server provides the data of sensor readings and data that the web will publish. Meanwhile, the Simple Network Management Protocol (SNMP) server will serve the needs of sending data from each sensor. The communication process between the SNMP Server and the power meter as a sensor device can be seen in Figure 4.

The communication between the SNMP server and the power meter uses one of the SNMP protocols, a protocol in the Application Layer in the OSI model. As a protocol that is widely used for monitoring needs, one of the communication modes used is the SNMP Poll mode. As shown in Figure 4, in SNMP Poll mode, the SNMP manager will send a "Get Request" code to the SNMP Agent located on the Power Meter. It will be replied to with "Get Response" code from the SNMP Agent. Every SNMP Poll is equipped with an Object ID (OID) to ensure that the data sent is as required. All requested OIDs are registered in the same Management Information Base (MIB) in SNMP Manager and SNMP Agent. The SNMP Poll process will be conducted every 5 minutes.

**Figure 2:** E-learning of engineering faculty's server traffic usage during 2019




| Month | Unique visitors | Number of visits | Pages | Hits | Bandwidth |
|---|---|---|---|---|---|
| Jan 2019 | 2,143 | 3,082 | 67,500 | 73,844 | 12.21 GB |
| Feb 2019 | 2,916 | 4,600 | 97,717 | 105,213 | 9.96 GB |
| Mar 2019 | 2,304 | 3,622 | 80,032 | 86,005 | 8.24 GB |
| Apr 2019 | 2,719 | 4,189 | 82,457 | 88,121 | 4.25 GB |
| May 2019 | 2,234 | 3,392 | 62,281 | 67,697 | 7.66 GB |
| Jun 2019 | 632 | 1,204 | 19,908 | 21,555 | 1.42 GB |
| Jul 2019 | 687 | 986 | 22,020 | 23,316 | 1009.87 MB |
| Aug 2019 | 6,756 | 13,622 | 270,749 | 290,747 | 15.86 GB |
| Sep 2019 | 7,557 | 16,474 | 327,500 | 351,686 | 23.98 GB |
| Oct 2019 | 6,333 | 11,908 | 225,037 | 244,137 | 12.51 GB |
| Nov 2019 | 5,756 | 9,269 | 138,959 | 149,742 | 6.13 GB |
| Dec 2019 | 5,671 | 9,439 | 205,668 | 224,583 | 9.71 GB |
| Total | 45,708 | 81,787 | 1,599,828 | 1,726,646 | 112.93 GB |

The web application that is built is the implementation of the PHP language that is integrated with the Laravel® framework. With the support of MySQL® as database management, every data obtained is stored in the database and used for web application (dashboard) needs. For graphic visualization, canvasJS® is used, and AdminLTE® is used to display a more interactive application that is integrated with the Laravel® framework. In addition, the database is also processed to issue information on energy and other variables per day.

## 3.2. Student Survey

The survey's primary purpose is to determine students' perceptions of the effects of online lectures during the COVID-19 pandemic on financing, infrastructure readiness, and the quality of the learning process quality. The survey was conducted using a student sample of 149 students, consisting of 108 students (72.5%) from the Electrical Engineering Department, 21 students (14.1%) from the Management Department, and 20 students (13.4%) from the Information Systems Department. The number of samples was dominated by undergraduate students, as many as 137 students (91.9%), while the Master's program students were only 12 respondents (8.1%). The student survey was carried out in March 2022.

The survey was conducted using the Google Forms platform. The questions in the survey are grouped into three categories. The first category of questions focused on knowing the condition of student financing during online lectures consisted of 6 questions. The second category focused on the condition of the infrastructure supporting online lectures, which included five questions. Meanwhile, the third category contains questions regarding the quality of the learning process during online lectures, which consist of 10 questions. Based on 21 questions in the survey would give an overview of the quality of OLFH and the external factors that impact it. The questions were inspired by the literature of Katić et al. (2021) and Radu et al. (2020).

# 4. RESULTS AND DISCUSSION

## 4.1. The Impact of OLFH and OWFH on Campus Electricity Consumption

The results of electricity consumption data were analyzed by dividing it into four different types of campus buildings with different purposes. It compares the data before and during OLFH. A recording was carried out from August 2019 to February 2020, defined as before the pandemic. It also defines August 2020 to February 2021 as during the pandemic. The duration of recording and analysis is adjusted in odd semesters of academic activities (Andalas, 2019, 2020). Meanwhile, the type of buildings sampled as objects of study is very significant in contributing to the total energy consumption of the campus. In addition, each building provides a different role from one another in carrying out academic activities. A sample of 4 groups of these buildings can represent the fundamental role of

**Figure 3:** The system architecture of electricity consumption monitoring at Universitas Andalas (Pujani et al., 2019)

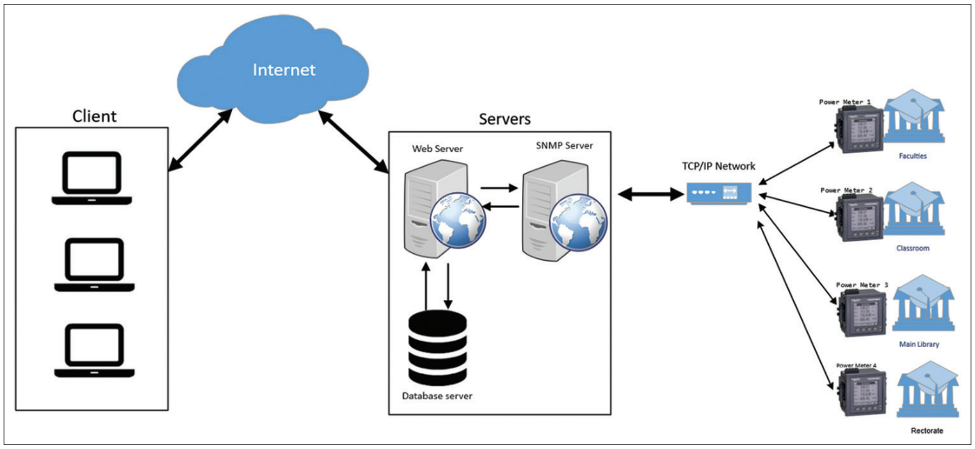



**Figure 4:** The server communication mode with sensor(Huawei, 2007)

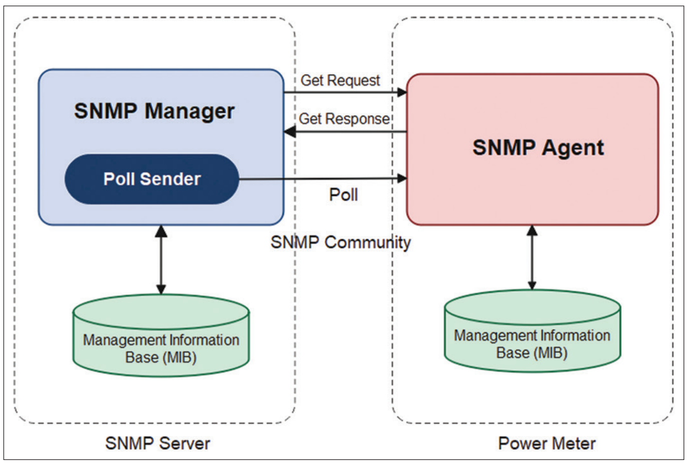
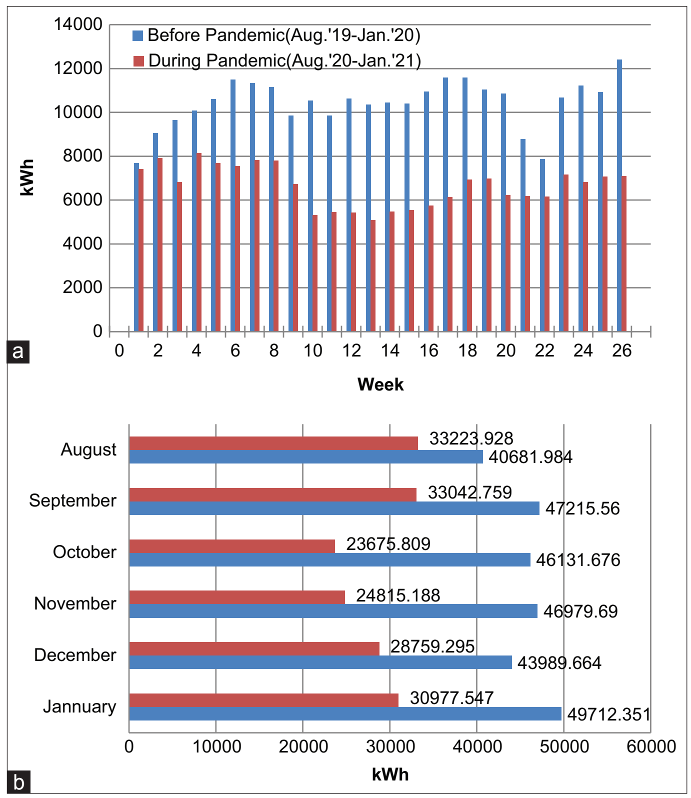



**Figure 5:** The comparison of electricity consumption before and during OLFH in the engineering faculty buildings. (a) Electricity consumption per-week. (b) Electricity consumption per month




the campus in organizing educational activities. The buildings sampled in this study are the dean's office of engineering faculty, the classroom, the central library, and the rectorate building. In the next section, we will try to highlight the impact of each building.

*4.1.1. Impact on faculty engineering buildings*

The faculty engineering buildings consist of department and dean buildings. Activities carried out in department buildings are lab sessions, research, lectures with a limited audience, and other supporting academic activities. Figure 5 shows the results of a comparative analysis of electricity consumption before and during the COVID-19 pandemic on the odd semester. A comparison of weekly electrical energy consumption from faculty buildings is shown in Figure 5a, while Figure 5b compares electricity consumption per month. At the beginning semester, the 1$^{st}$ and 2$^{nd}$ weeks (Figure 5a), the electricity consumption in faculty buildings is almost the same. It could be because, based on the academic calendar in those weeks, lectures and practicum activities had not yet started (Andalas, 2019). As shown by Figure 5b, in October and November, there was the highest decrease in electricity consumption because of the pandemic. It also a policy requires OWFH (Online Work From Home) during the pandemic during these months (Rector, 2020a, 2020b).

*4.1.2. Impact on classroom buildings*

The building group of classrooms consisted of B, C, D, and G buildings. The activities carried out in these buildings were entirely lecture activities. Figure 6 shows electricity consumption before and during OLFH at classroom buildings. As demonstrated in Figure 6a, the weekly electricity usage during the pandemic is almost the same as during a lecture break. This condition occurred because, during OLFH, lecture activities switched to online meetings, so practically no activities were carried out in this building. It is relatively a small consumption of electricity in this building. It is an essential building requirement for night lighting and pumping water. Figure 6b. shows a comparison of monthly electricity usage in lecture buildings before and during

**Figure 6:** The comparison of electricity consumption before and during OLFH in the classroom buildings group. (a) Electricity consumption per-week. (b) Energy consumption per month

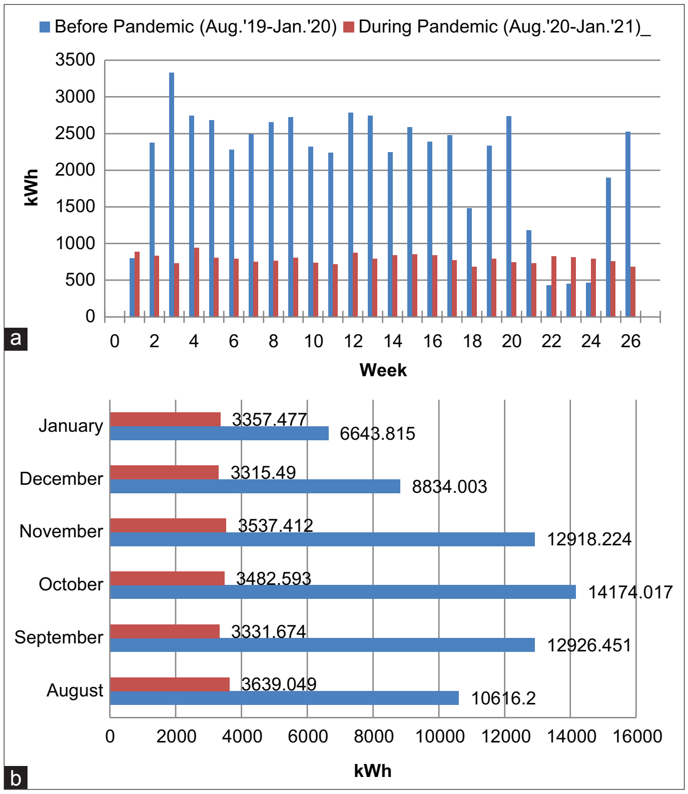
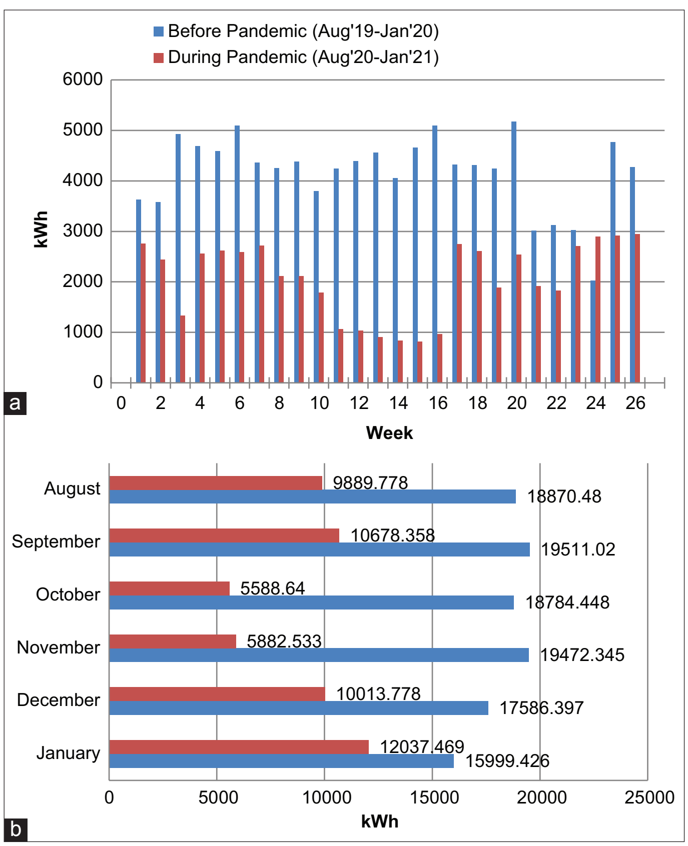



**Figure 7:** The comparison of electricity consumption before and during OLFH in the central library building. (a) Electricity consumption per-week. (b) Electricity consumption per month




OLFH. From October to November, the comparison of electrical energy consumption between during and before the pandemic was lowest in October (Rector, 2020a, 2020b).

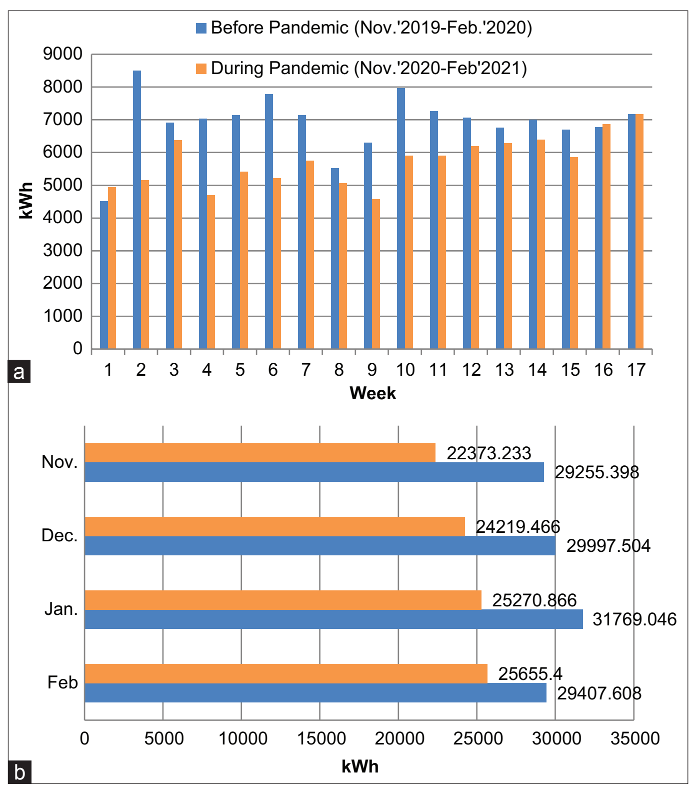
### *4.1.3. Impact on central library building*

Activities in the central library building include lending service, reading service, and library administration. In addition, at the Universitas Andalas library building, seminar room facilities are also provided, usually used every Saturday. Electrical equipment that is very dominant in consuming electrical energy in this building is Air Conditioning (AC) and lights. Figure 7 shows the analysis of electricity consumption in library buildings before and during the OLFH. In general, there has been a significant decrease in electricity consumption in the main library building during the OLFH. The most significant decline occurred in October and November, or weeks 11 to 16, as shown by Figure 7a and b. The decrease in energy consumption from library buildings during COVID-19 was mainly due to reduced student visits to the central library and the university's OWFH policy(Rector, 2020a, 2020b).

### *4.1.4. Impact on rectorate building*

The Rectorate building is the center of administration and management activities of the entire campus. This building includes office work, financial, and student administration activities. In addition, this building is also the center of campus management. Figure 8 compares electricity consumption before and during the OLFH at the Rectorate Building. As shown in Figure 8, there is a decrease in electricity consumption during the COVID-19 pandemic in this building, and it is not too significant if we compare it with the other buildings.

**Figure 8:** The comparison of electricity consumption before and during OLFH at the rectorate building. (a) Electricity consumption per-week. (b) Electricity consumption per month



## 4.2. Effects of OLFH on Quality Learning Process

### *4.2.1. Impact on students' living costs*

The results of the effects of lectures online during OLFH on students' cost of living are shown in Table 1. As shown in Table 1, 69 respondents (46.3%) stated that they had an increment in living costs during online learning, and 34 respondents (22.8%) indicated a decline in living costs. 87 respondents (58.4%) stated that telephone and internet bills were the cause of this problem, followed by component electricity bills, which were declared by 76 respondents (51%). Meanwhile, 70 respondents (47%) said there was a decrease in costs in transportation costs.

### *4.2.2. The supporting factors of OLFH*

Table 2 shows the survey results on the condition of supporting facilities during OLFH. As shown in Table 2, most of the respondents stated that their supporting facilities for implementing online learning were in good condition. Supporting equipment for online learning, such as laptops/mobile phones/tablets/personal computers, are usable. Likewise, supporting media for online lectures, such as Virtual Meetings, Online Classes, and Messenger, are sufficiently available. In addition, the ability to operate supporting equipment and applications from online learning is quite good. However, according to most respondents, internet speed needed to be increased to improve the implementation of quality lectures.

This section discusses the results of a survey on the effects of OLFH on learning process quality. The survey was conducted by asking ten questions about the motivation and quality of the online learning process during OLFH. Questions 1 and 2 relate to student motivation for implementing OLFH during the COVID-19 pandemic. The results are shown in Figures 4 and 9. As can be seen from the answers to questions 1 and 2, students' motivation to participate in OLFH during the COVID-19 pandemic is relatively high.

For questions 3 to 10, each respondent can choose more than one answer. Question 3 regarding the factors that support OLFH, as shown in Figure 10. 50.3% of respondents stated that students agree with online learning because lectures and exams can be carried out more flexibly. In addition, 30.9% of respondents noted that the implementation of OLFH ran smoothly due to the free internet package support from the government and the convenience of attending lectures from home.

Question 4 of the survey asks respondents for their opinion on the advantages of OLFH. 75.8% of respondents stated that the benefit of OLFH is that learning and teaching activities can be carried out flexibly, as shown by Figure 11. At the same time, 47% of respondents agree that online courses can improve digital student abilities.

Question 5 asks the respondent's opinion about the lack of OLFH. 67.8% of respondents stated that OLFH must provide a good internet connection and adequate supporting equipment, as shown by Figure 12. As many as 59.7% of respondents stated that they could not interact face-to-face with lecturers and students during OLFH. Meanwhile, 52.3% of respondents said that learning with the internet causes learning motivation to decrease.

Figure 13 shows the survey results from the answers to question 6. 47% of respondents stated that OLFH resources are interactive and easy to use. 42.3% of respondents noted that the content and sources of OLFH are relevant and qualitative. Meanwhile, 34.9% said that the content and sources of OLFH were suitable for developing student skills related to job opportunities.

The answer to question 7 is shown in Figure 14. As shown in the Figure 14, 85.2% of respondents think that the most effective and quality form of online learning is virtual meeting learning, and 11.4% of respondents choose an online class. Meanwhile, only 3.3% of respondents chose to use messenger.

**Table 1: Results of the survey on the effects of online learning during OLFH on students' living cost**

| Type of student living cost | Greatly increased (%) | Increase (%) | Constant (%) | Decrease (%) | Greatly decreased (%) |
|---|---|---|---|---|---|
| Transportation fee | 4 (2.7) | 15 (10) | 26 (17.4) | 70 (47) | 34 (22.8) |
| Accommodation fee | 6 (4) | 30 (20.1) | 54 (36.2) | 39 (26.2) | 20 (13.4) |
| Meal cost | 8 (5.4) | 50 (33.6) | 45 (30.2) | 31 (20.8) | 15 (10.1) |
| Electric bill | 29 (19.5) | 76 (51) | 33 (22.1) | 7 (4.7) | 4 (2.7) |
| Telephone and internet bill | 87 (58.4) | 43 (28.9) | 15 (10) | 2 (1.3) | 2 (1.3) |
| Total living cost | 13 (8.7) | 69 (46.3) | 23 (15.4) | 34 (22.8) | 10 (6.7) |

**Table 2: The survey results for the supporting factors condition of online learning**

| The item for Online Lecture supporting infrastructure | Very good (%) | Good (%) | Neutral (%) | Bad (%) | Very bad (%) |
|---|---|---|---|---|---|
| The ability of online learning devices to be connected to the internet network | 24 (16.1) | 56 (37.6) | 55 (36.9) | 13 (8.7) | 1 (0.7) |
| Availability of online learning support equipment (HP/Tablet/Laptop/Computer) | 25 (16.8) | 77 (51.7) | 35 (23.5) | 11 (7.4) | 1 (0.7) |
| Ability to operate online learning support equipment (HP/Tablet/Laptop/Computer) | 37 (24.8) | 96 (64.4) | 14 (9.4) | 2 (1.3) | 0 |
| Availability of adequate online Lecture Support Media (Virtual Meeting, Online Class, Messenger): | 31 (20.8) | 68 (45.6) | 45 (30.2) | 5 (3.3) | 0 |
| Information traffic conditions on the campus internet network that support the implementation of online learning | 6 (4) | 36 (24.2) | 86 (57.7) | 17 (11.4) | 4 (2.7) |

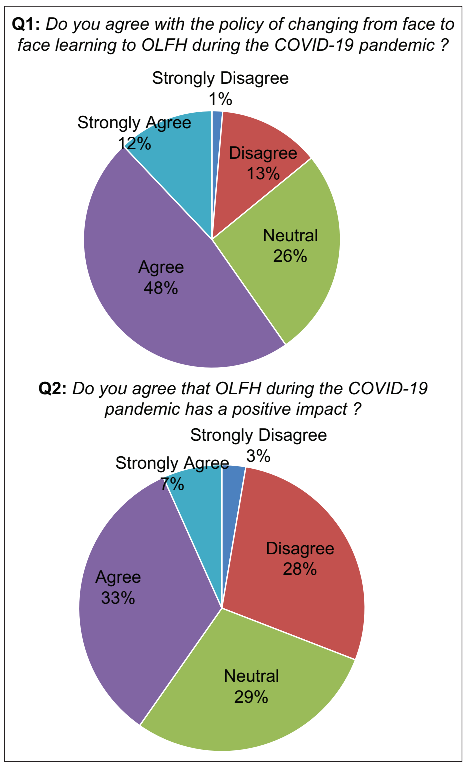
Impact on the quality of the learning process

Question 8 asks the respondent's opinion about the advantages of online exams. As shown by Figure 15, 72.5% of respondents stated that the benefit of online exams is the high flexibility in implementation (it can be taken from anywhere). Meanwhile, 59.1% of respondents noted that the advantage of online exams is that it reduces the high sense of stress while doing it.

Question 9 asks the respondent's perception of the drawbacks of the online exam. As shown by Figure 16, 78.5% of respondents stated that the lack of online exams is very vulnerable to a poor internet connection. Meanwhile, 40.3% of respondents said that the lack of online exams is a higher opportunity for cheating.

Question 10 asks the respondent's opinion about the learning model at regular times. As shown by Figure 17, 30.9% of respondents prefer a balanced learning model between online and face-to-face. 20.8% of respondents want learning to be conducted online only. Meanwhile, 16.1% of respondents want to be mixed online and face-to-face learning with more online learning.

**Figure 9:** Respondents' answers to question 2




## 5. DISCUSSION

As previously explained, all samples of campus buildings experienced a reduction in electricity consumption due to implementing OLFH during the COVID-19 pandemic. The effect of OLFH on electricity consumption varies in each type of building. Its influenced mainly by the activities carried out in each building. This study selected campus buildings with different activities, as shown in Table 3. It has a lot of activities in the engineering faculty buildings. Meanwhile, in the classroom buildings, only lecturing activities have been done in these building.

How significant the effect of OLFH during the COVID-19 pandemic on electricity consumption depends on the function and intensity of activities that occurred in the building. The level of electricity consumption reduction for each activity is shown in Table 4. As shown in Table 4, lecture and practicum activities conducted online causes a decrease in electricity consumption with high levels. It is in line with government policy to organize OLFH during the emergency period of the spread of COVID-19 (Secretary, 2020). Meanwhile, more administrative activities are still carried out offline to maintain service quality so that the level of reducing electricity consumption is the smallest.

Table 5. shows a comparison of total electricity consumption before and during OLFH for each building on the odd semester. As shown in Table 5, the most considerable reduction in energy consumption due to OLFH during the COVID-19 pandemic occurred in classroom buildings, reaching 68.74%. It happened because there was no activity during the OLFH in this building, so the level of reduction of its electricity consumption was the highest. However, the lowest decrease in electricity consumption occurred in the rectorate building, with a decrease value of 19.02%. As an administration and management center, daily activities in the rectorate building continue during OLFH. However, the intensity of activity in this building was limited, and some employees were diverted to work from home (WFH),

**Figure 10:** Respondents' answers to question 3

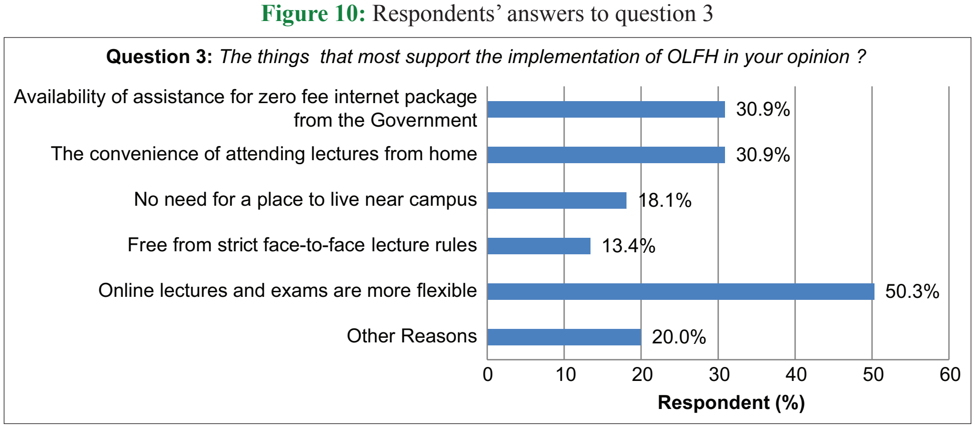


**Table 3: The variety and intensity of activities conducted in the campus buildings**

| Activities variation | Buildings | | | |
|---|---|---|---|---|
| | Eng. faculty | Classroom | Library | Rectorate |
| Lectures | Low | High | NA | NA |
| Seminar/Meeting | Medium | NA | High | Medium |
| Lending service | Low | NA | High | NA |
| Reading service | Low | NA | High | NA |
| Final Project/Research | High | NA | NA | NA |
| Practicum | High | NA | NA | NA |
| Academic activity | High | NA | NA | NA |
| Administration | High | NA | Low | Very high |

NA: Not available

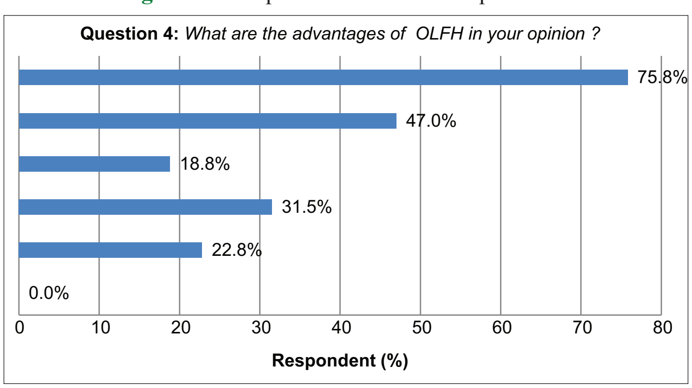
**Table 4: The electricity consumption reduction level for each activity**

| Activities | Electricity consumption reduction level | | |
|---|---|---|---|
| | High | Medium | Low |
| Lecture activities | V | | |
| Seminar/Meeting | | V | |
| Lending service | | V | |
| Reading service | | V | |
| Final project/research | | V | |
| Practicum | V | | |
| Academic activities | | V | |
| Administration | | | V |

**Table 5: The comparison of electricity consumption of buildings before and during OLFH on the odd semester**

| Buildings | Electricity consumption on odd semester (kWh) | | Electricity consumption reduction | |
|---|---|---|---|---|
| | Before Pandemic | During Pandemic | kWh | % |
| Eng. faculty | 274710.925 | 174494.526 | 100216.399 | 36.48 |
| Classroom | 66112.71 | 20663.695 | 45449.015 | 68.74 |
| Central library | 110224.116 | 54090.556 | 56133.560 | 50.93 |
| Rectorate | 120429.556 | 97518.965 | 22910,591 | 19.02 |

**Figure 11:** Respondents' answers to question 4




especially when the campus lockdown policy was enforced (Rector, 2020a, 2020b).

According to most respondents, as shown in Table 1, the results show that OLFH has increased the cost of living. The increase was mainly due to an increase in the components of the living cost, such as electricity bills, internet bills, and meal costs. The increase in electricity and internet bills is understandable due to the rise in electricity, telephone, and internet usage at home due to learning activities at home. The internet cost spike has been anticipated with the government's policy to provide free internet packages to students (Secretary, 2020). The policy was implemented in 2020 and 2021, giving each student a free internet data package of 15 GB monthly. Conversely, according to most respondents, transportation costs decreased during OLFH, as shown in Table 1. Likewise, most respondents said accommodation costs on campus fell during OLFH. Overall, the increase and decrease in the cost of living component during online lectures during OLFH were almost balanced. Even if there were an increase in the total cost of living, it was not significant. Moreover, the government has also assisted with student tuition fees during the COVID-19 pandemic (Ministry, 2020).

Based on the respondent's response, the IT infrastructure supporting the online class was adequate and in good condition. The availability of students' online learning equipment, such as HP/tablet/laptop/computer, is excellent. However, 8.1% of respondents stated that the availability of its supporting tools was not good, as shown in Table 2. Likewise, 9.4% of respondents said that their tools could not be appropriately connected to internet access. Since these two conditions are relatively small in number, they can be resolved case by case. 57.7% of respondents perceived campus internet speed as moderate conditions. Increasing internet bandwidth to the campus data center is necessary to optimize learning process quality during OLFH.

As discussed earlier, the student survey results showed that most respondents were well-received about switching from face-to-face learning to OLFH during the COVID-19 pandemic. Whereas during the post-COVID-19 pandemic, the learning method that was more in demand by respondents was a balanced mix of face-to-face lectures and online lectures. Overall, the majority of respondents have the perception that OLFH during the COVID-19 pandemic has provided benefits for students, including:

a. Learning and teaching activities implemented flexibly
b. Can improve students' digital abilities
c. Online lecture content and resources are more interactive and easy to use
d. Online exams can reduce stress compared to onsite exam.
   On the other side, the perception of the majority of respondents stated that online learning has some drawbacks, among the reasons being:
a. Cannot communicate and interact directly between lecturers and students
b. Implementation of online lectures and their exams must require a qualified internet connection and equipment
c. Cause motivation and enthusiasm to learn to be reduced
d. Opportunities for cheating and plagiarism are higher in online exams.

The significant reduction in electricity consumption in campus buildings due to OLFH during the COVID-19 pandemic is a

**Figure 12:** Respondents' answers to question 5

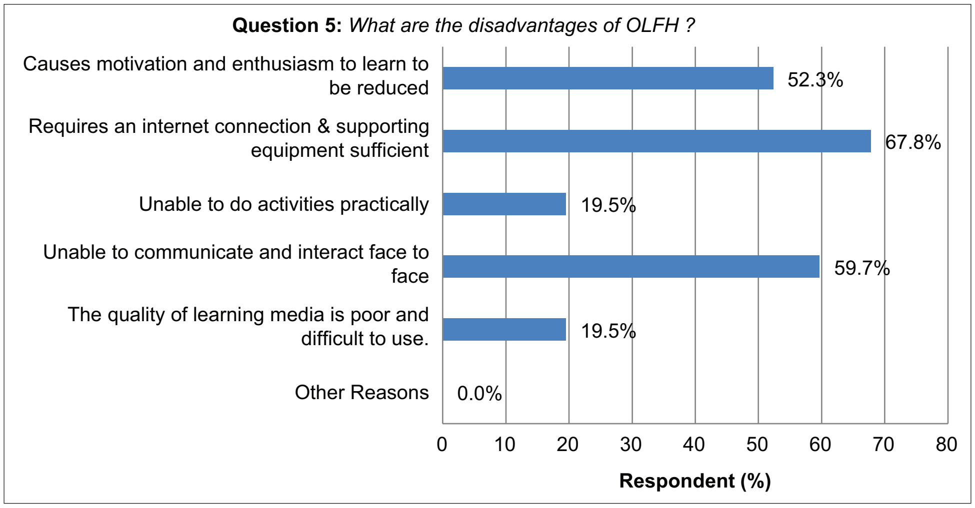



**Figure 13:** Respondents' answers to question 6

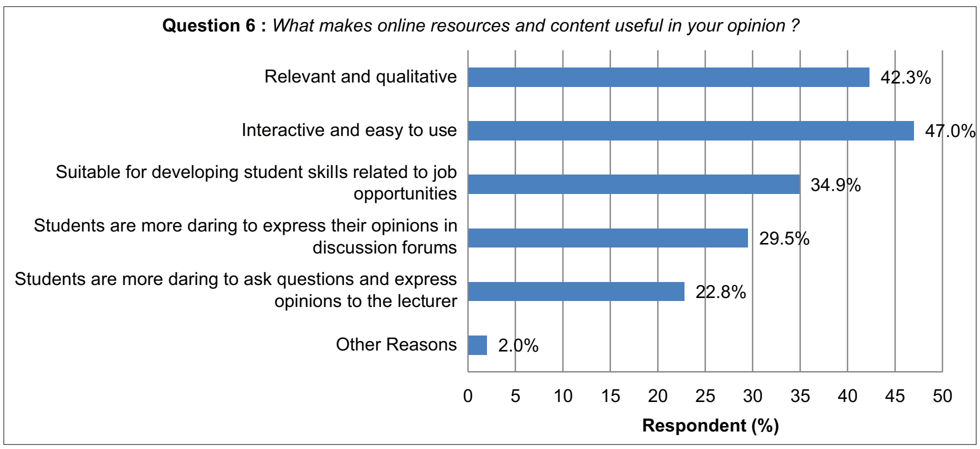
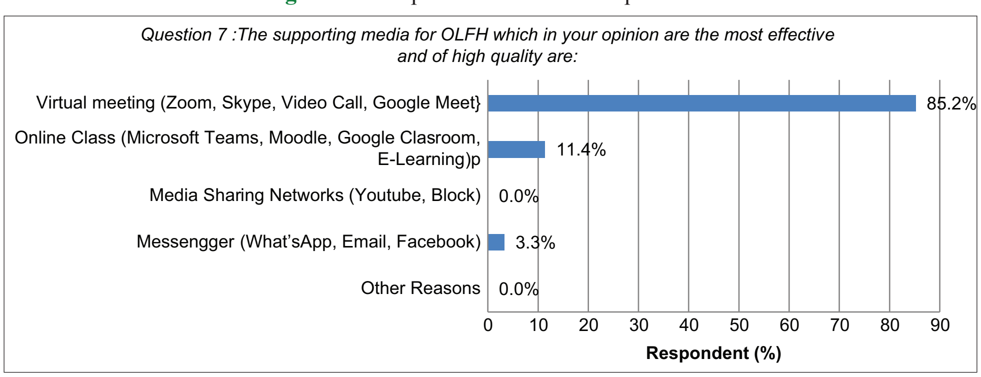



**Figure 14:** Respondents' answers to question 7




source of cost savings for the university. These cost savings can be used to implement programs that can correct deficiencies in the online lecture process, which have been identified from the student survey results. The programs to increase learning in OLFH during the COVID-19 pandemic include:

a. Organizing an international conference regarding how to maintain the quality of the learning process during OLFH
b. Developing an interactive video module as a practicum substitute for OLFH
c. Making a policy in reduction of tuition fees for final-year students.

In addition, OLFH infrastructure improvements have also been made to maintain the quality of the learning process. Their infrastructure improvements are in the form of e-learning server capacity upgrades. This upgrade includes an increase in internal memory from 2GB to 4GB, an increase in the processor from 2 cores to 4 cores, and an increase in the server hard disk from 100 GB to 500 GB.

**Figure 15:** Respondents' answers to question 8

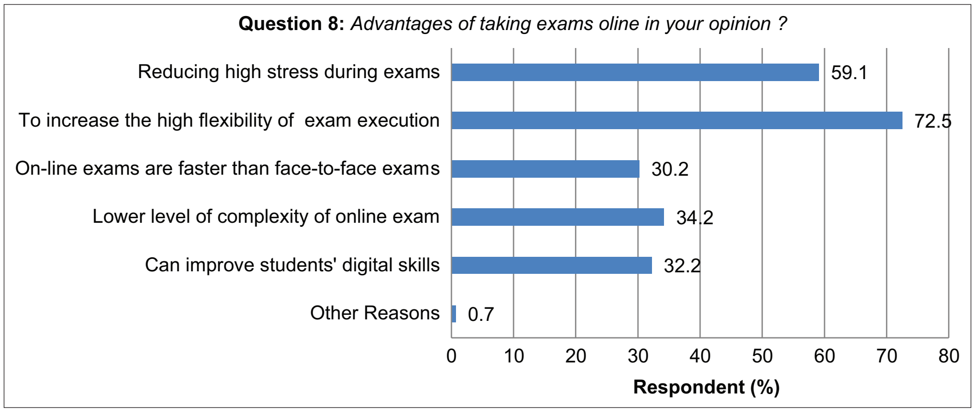



**Figure 16:** Respondents' answers to question 9

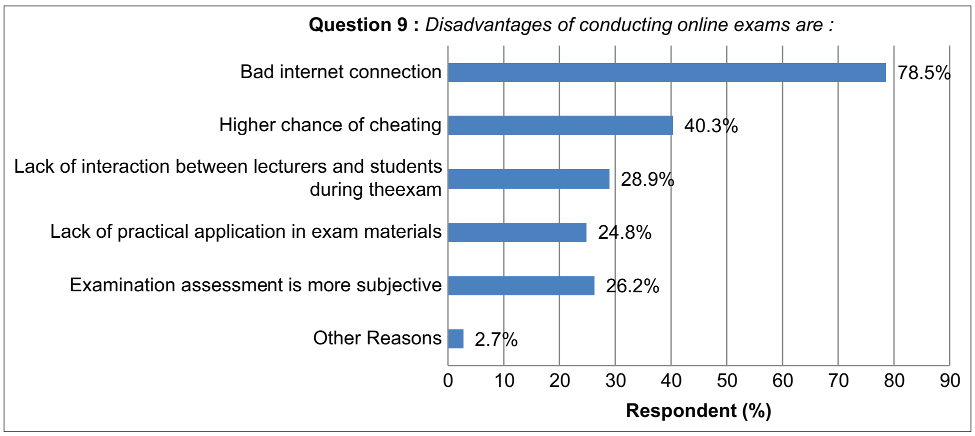
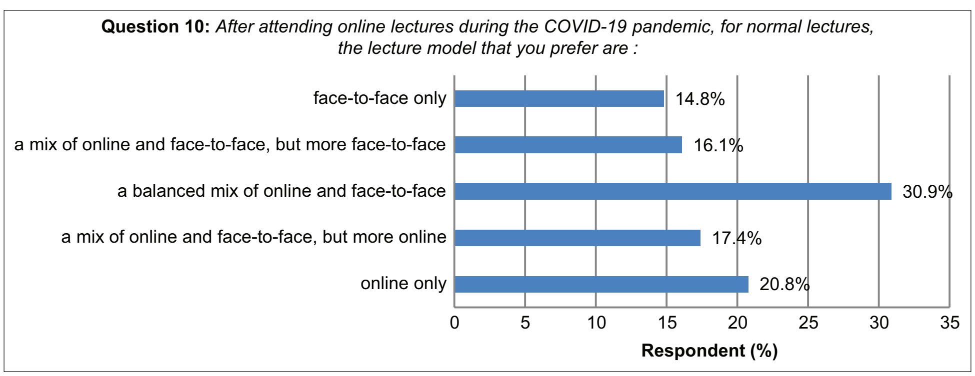



**Figure 17:** Respondents' answers to question 10




## 6. CONCLUSION

This paper has analyzed the effect of switching from face-to-face lectures to OLFH during the COVID-19 pandemic on electricity consumption and the quality of learning in university. The results have shown a significant drop in electricity consumption in all groups of buildings on campus on odd semesters. The most significant percentage decrease in electricity consumption occurred in the classroom buildings, with a reduction of 68.74%. A minor percentage decrease in electricity consumption during OLFH occurred in the rectorate building, with a decline of only 19.02%. The survey results showed that most students were satisfied with switching from face-to-face OLFH during the lockdown period. However, this study also identified negative aspects of OLFH during the COVID-19 pandemic. It stated that online lectures and exams require a good internet connection and adequate equipment. It also cannot communicate interactively between lecturers and students, can decrease motivation and enthusiasm for learning, and opens opportunities for cheating and plagiarism during online exams and independent assignments. It also finds that reducing electricity consumption during the COVID-19 pandemic saves campus operational costs. The saving cost can be used to implement programs to support the deficiencies of online learning and improve IT infrastructure so that the quality of the learning process is maintained.

## 7. ACKNOWLEDGMENTS

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## REFERENCES

Andalas, U. (2019), Academic Calendar 2019/2020. Indonesia: Universitas Andalas. Available from: https://akademik.unand.ac.id/akreditasi/item/209-kalender-akademik-tahun-2018-2019

Andalas, U. (2020), Academic Calender 2020/2021. Indonesia: Universitas Andalas. Available from: https://akademik.unand.ac.id/images/kalender%20akademik%20ta%202020-2021%20-%20ok.pdf

Andrei, H., Diaconu, E., Gheorghe, A., Bizon, N., Mazare, A., Ionescu, L., Stanculescu, M., Porumb, R., Seritan, G., Andrei, P. (2021), Energy consumption, pandemic period and online academic education: Case studies in Romanian universities. In: Conference 2021 7th International Symposium on Electrical and Electronics Engineering. p1–6.

APEC, Human Resources Development Working Group. (2021), Education Response to COVID-19 in the Asia-Pacific Region Challenges and Solutions. Singapore: APEC. Available from: https://www.apec.org/docs/default-source/publications/2021/11/education-response-to-covid-19-in-the-asia-pacific-region/221_hrd_education-response-to-covid-19-in-the-asia-pacific-region.pdf?sfvrsn=16456019_2

Huawei, T. Co., Ltd. (2007), What is SNMP ? Available from: https://support.huawei.com/enterprise/en/doc/edoc1100086963

Jiang, P., Van Fan, Y., Klemeš, J.J. (2021), Impacts of COVID-19 on energy demand and consumption: Challenges, lessons and emerging opportunities. Applied Energy, 285, 116441.

Katić, S., Ferraro, F.V., Ambra, F.I., Iavarone, M.L. (2021), Distance learning during the COVID-19 pandemic. A comparison between European countries. Education Sciences, 11(10), 595.

Kawka, E., Cetin, K. (2021), Impacts of COVID-19 on residential building energy use and performance. Building and Environment, 205, 108200.

Maatuk, A.M., Elberkawi, E.K., Aljawarneh, S., Rashaideh, H., Alharbi, H. (2022), The COVID-19 pandemic and E-learning: Challenges and opportunities from the perspective of students and instructors. Journal of Computing in Higher Education, 34(1), 21-38.

Ministry. (2020), Regulation of the Minister of Education and Culture Concerning Standards for Operational Unit Costs of Higher Education at State Universities within the Ministry of Education and Culture. Kementrian Pendidikan dan Kebudayaan, Repulik Indonesia. Available from: https://peraturan.bpk.go.id/home/details/163756/permendikbud-no-25-tahun-2020

Pujani, V., Akbar, F., Nazir, R. (2019), Management Review of Energy Consumption: The Energy Saving Opportunity in University Buildings. In: Proceedings of the 2019 5th International Conference on Industrial and Business Engineering. p110-116.

Radu, M.C., Schnakovszky, C., Herghelegiu, E., Ciubotariu, V.A., Cristea, I. (2020), The impact of the COVID-19 pandemic on the quality of educational process: A student survey. International Journal of Environmental Research and Public Health, 17(21), 7770.

Rector. (2020a), Circular Letter No. 26 in 2020 Concerning the Implementation of the Work from Home System (WORK FROM HOME) for State Civil Apparatuses in the Universitas Andalas. Indonesia: Universitas Andalas. Available from: https://repo.unand.ac.id/40133/1/edaran%20no%2026%20thn%202020.pdf

Rector. (2020b), Circular Letter No. 29 in 2020 Concerning Implementing the Work System for State Civil Apparatus in the Universitas Andalas Environment. Indonesia: Universitas Andalas. Available from: https://repo.unand.ac.id/40136/1/edaran%20no%2029%20thn%202020.pdf

Secretary, G. (2020), Regulation of the Secretary-General Number 14 in 2020 Concerning Technical Guidelines for Internet Data Quota Assistance in 2020. Kementrian Pendidikan dan Kebudayaan, Repulik Indonesia. Available from: https://lldikti3.kemdikbud.go.id/v6/wp-content/uploads/2020/09/19092020_salinan-persesjen-nomor-14-tahun-2020-merged.pdf

Tadesse, S., Muluye, W. (2020), The impact of COVID-19 pandemic on education system in developing countries: A review. Open Journal of Social Sciences, 8(10), 159-170.

Tamilselvan, M., Srinivasan, P., Kumar, M., Maity, B., Agrawal, N. (2022), Electricity demand and CO Emissions during the COVID-19 Pandemic: The case of India. International Journal of Energy Economics and Policy, 12(3), 161-169.

Worldometer, C.V. (2021), Coronavirus Cases: [Electronic]. Available from: https://www.worldometers.info/coronavirus