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IMPACT OF COVID-19 PANDEMIC ON DAILY ELECTRICITY CONSUMPTION OF CONSUMER HOUSEHOLDS IN A SELECTED CITY IN POLAND

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Abstract: The period of mandatory quarantine referred to as lockdown, which was introduced in Poland in 2020, contributed to changes in the electricity consumption patterns of residential consumers under the new circumstances. In addition to the direct negative impact on people's health, the occurring crisis pointed to serious economic consequences, mainly in terms of ensuring energy security associated with state sovereignty. It clearly highlighted the role of energy system structures as the basis for prosperity and stability in the safe development of societies. The aim of this article is to present and analyse the impact of the COVID-19 pandemic on the structure of household electricity consumption on the basis of experiences during the lockdown as well as in the periods before and after the pandemic. Statistical analysis of the measurement data generated parameters characterising a group of values during the analysed periods. The results of the analyses refer to a specific and numerous group of users, i.e. domestic users, and are based on actual measurements.

Keywords: energy sector, energy demand forecasting, COVID-19 pandemic, restrictions, lockdown

JEL Classification: Q40, Q42

Introduction

The COVID-19 pandemic represents the biggest shock to the global economy since World War II. The IMF (International Monetary Fund) estimates that the global economy contracted by 3.5% in 2020, far worse than the recession following the

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global financial crisis in 2009. The COVID-19 pandemic disrupted daily life and social practices (Zollet et al., 2022). The energy sector determines the functioning of the economy. The development of the energy sector is determined by the availability of energy sources and their price, as well as the political and social acceptability of certain technological solutions, e.g. biogas plants or nuclear power plants (Ritchie, 2020). It is a good time to look back over the past few years, to analyse the impact of the pandemic, and to see possible changes in global electricity trends. In this paper, we will discuss important challenges for the energy sector. The research questions are as follows:

1. How did the COVID-19 pandemic affect the structure of electricity consumption based on experiences during the lockdown and in the periods before and after the pandemic?
2. How has the experience of lockdown affected the electricity sector?
3. How do national quarantine conditions, including lockdown stages, change the average electricity demand of domestic users?
4. Is the level of the average active electricity consumption in a 1-hour interval of the average consumer of electricity stable even under conditions of continuously remaining at home?

The design of electrical installations and the estimation of power requirements for buildings involves the application of standards and regulations, which should guide and determine the optimal amount of electricity/energy units for both individual households and whole buildings. As the energy industry has progressed, standards and regulations have been replaced by more up-to-date ones, adapted to the realities of the time, to keep up with the developing new technologies and changing trends in electricity use (Lai et al., 2020).

Literature review

The literature highlights that the introduction of lockdown can have both positive and negative effects, which are considered from different points of view. A very broad group consists of studies whose authors attempt to examine the impact of lockdown on the development of the disease – the number of infected people and deaths. Thus, studies can be found on the introduction of specific restrictions, such as the compulsory wearing of masks (Mitze et al., 2020; Zhang et al., 2020) or the closure of schools (Alfano et al., 2021). Numerous studies also address lockdowns in this aspect in a broad sense, associated with many restrictions. One can point to publications concerning the United States (Chernozhukov et al., 2021), China (Lai et al., 2020; Tian et al., 2021), the United Kingdom and Spain (Goodman-Bacon et al., 2020) or Sweden (Born et al., 2021; Chu et al., 2020). A common feature of all these analyses is the conclusion that the introduction of lockdown significantly contributed to a reduction in the number of infected people and deaths in the countries studied. The literature related to the impact of lockdown on various aspects of people's lives is extremely broad. For example, there are studies analysing the impact of the imposed restrictions on people's mental health (Fukase et al., 2022; Wu et al., 2021; Xu et al., 2022), air quality (Filonchyk et al., 2020; Mostafa et al., 2021;

Dang & Trinh 2021; Wethal et al., 2022; Yang et al., 2020), energy and gas consumption (Carvalho et al., 2021; Cihan, 2022), the labour market (Yang et al., 2020; Palomino et al., 2020) or the stock market (Deng et al., 2022; Narayan et al., 2021). National restrictions and limited travel during the lockdown affected many areas of life. The most intuitive and direct effect of pandemics is the adverse shock to the population and the labour market (Callegari & Feder, 2022). The lockdown reduced electricity use by the economies in the countries where it was implemented (Prol & O, 2020; Bulut, 2020; Department for Business…, 2020; Lai et al., 2020). In contrast, the household consumption of electricity and water increased, resulting in higher utility bills (Chshmehzangi, 2020; Eastman et al., 2020; Kalbusch et al., 2020; Nemati, 2020; Ong & Nielsen, 2020). The energy sector was severely affected due to significant reductions in transport, trade, and economic activity worldwide (Reuter et al., 2019; Kaczmarek, 2021; Hongyang et al., 2023). An analysis of daily data covering the period from the outbreak of the pandemic to mid-April 2020, published in the Global Energy Review 2020, shows that countries with a full lockdown experienced an average 25% decrease in energy demand per week, and countries with a partial lockdown experienced an average reduction of 18% (IEA, 2023). Having to stay at home, restricting professional and social activities to the place of residence resulted in changes in load profiles across all groups of energy consumers (Bielecki et al., 2021).

Data and methods

This article analyses the electricity consumption of a specific group of consumers, i.e. households, using the example of flats in a central European city (in Poland), comparing the values obtained from measurements conducted during the lockdown period (called 'the national quarantine' in Poland, i.e. restrictions on mobility or activity throughout the whole population of the country) and the respective period of the year before the pandemic, as well as the respective period of the year after the pandemic.

The first lockdown in 2020 witnessed a reduction in electricity consumption at the national electricity system level due to restrictions on conducting economic activity. The group of consumers representing residential consumers showed a different pattern, where an increase in electricity consumption compared to the pre-pandemic COVID-19 period was natural. The need to move professional, social, and welfare/societal activities as well as education to the home resulted in changes in the profile of electricity usage. Using data from consumer smart meters, the average daily power demand profiles of 1-hour intervals of consumers under the national quarantine conditions were determined and compared with the results obtained in the same study group in the corresponding pre- and post-pandemic periods. The research contained in the article is based on descriptive statistics, which deals with the collection, processing, presentation, and analysis of data, together with their summary. It compiles data on a population or sample without using probability. This article analyses data from users living in flats supplied with energy/electricity from the distribution network in Poland. The measured data of consumed electricity comes from smart meters installed in several residential areas. The studied dataset includes measurements from flats in residential buildings. It is worth mentioning that the modern trend in cooking is the phasing out of gas cookers and their replacement by electric cookers, such as ceramic or induction cookers, which increase the energy demand of those households. The measurement data sets were prepared for three periods. The first set covers the period from 16 March 2020 0:00 hrs to 18 April 2020 23:00 hrs (813 hours). The second set contains the data from the pre-pandemic period, i.e. from 16 March 2019 from 0:00 hrs to 18 April 2019 23:00 hrs, and the third set contains the data from 16 March 2022 from 0:00 hrs to 18 April 2022 23:00 hrs. The data for all the periods included active power measurements averaged at 1-hour intervals on a set of 1,000 households during the pre-pandemic period (2019), 1,000 households during lockdown in 2020, and 1,000 households during the corresponding period after the pandemic was declared to have finished. The residents in the area belonged to similar social groups, hence their behaviour concerning electricity use is similar.

The obtained results include the average daily active power consumption profiles of an average household and the differences in active power consumption of a group of domestic users during the analysed periods. The statistical analysis of the measurement data generated the parameters characterizing the group of measurement values/data during the analysed periods. However, a statistical method was employed to determine the peak loads of the feeders supplying the flats according to their number. This knowledge can be useful for operators of distribution networks, designers and planners of municipal electricity networks and electrical installations in residential buildings. The study used the data from 1,000 smart meters installed at customers' homes in a city in Poland. The third largest city in Poland in terms of population (after Warsaw and Krakow) – 674,132 inhabitants (30.06.2023), the fifth largest in terms of area – 292.81 km². The location of the city at the junction of important transport routes, near the western part of Europe, allowed many investments, which in the following years of Polish transformation, gave the city and the region an impetus for further development and economic growth. The city is a bright spot on the economic map of Poland and certainly noticeable on the map of Europe. A decidedly above-average increase in GDP per capita, a very large fall in unemployment, and relatively attractive wages caused the population of the metropolis to increase.

The metering data came from three time periods:

1. 16 March to 18 April 2020 (national quarantine period)
2. 16 March to 18 April 2019 (pre-pandemic corresponding period)
3. 16 March to 18 April 2022 (post-pandemic corresponding period)

Statistical analysis was performed using the Statistica program. For all statistical calculations, the significance level “p” was adopted, not exceeding 0.05. The Kruskal–Wallis test was used to compare differences between more than two independent groups (2019, 2020, 2022). Since the test showed statistically significant differences between the study groups, a post-hoc test (Dunn’s) was performed to examine which years had statistically significant differences.

Results

By averaging the measurement values for all the days of the week, with equal weight for each household, profiles of the average daily active power consumption profiles in the user's home during the lockdown in 2020 and the same period before and after the pandemic were formed. Analysis of variance or ANOVA was used, which is a linear modelling method to assess the relationship between variables. For key factors and observations related to multiple graphs, ANOVA checks whether the average predicted value differs between categories of one input variable or combinations of categories of two input variables. To check if the means are different, ANOVA compares the explained variance (caused by the input variables) with the unexplained variance (caused by the source of the error). If the ratio of the explained to unexplained variance is high, it means that the means are statistically different.

We assume: zero hypothesis H0 – the variable has a normal distribution, alternative hypothesis H1 – the variable has no normal distribution.

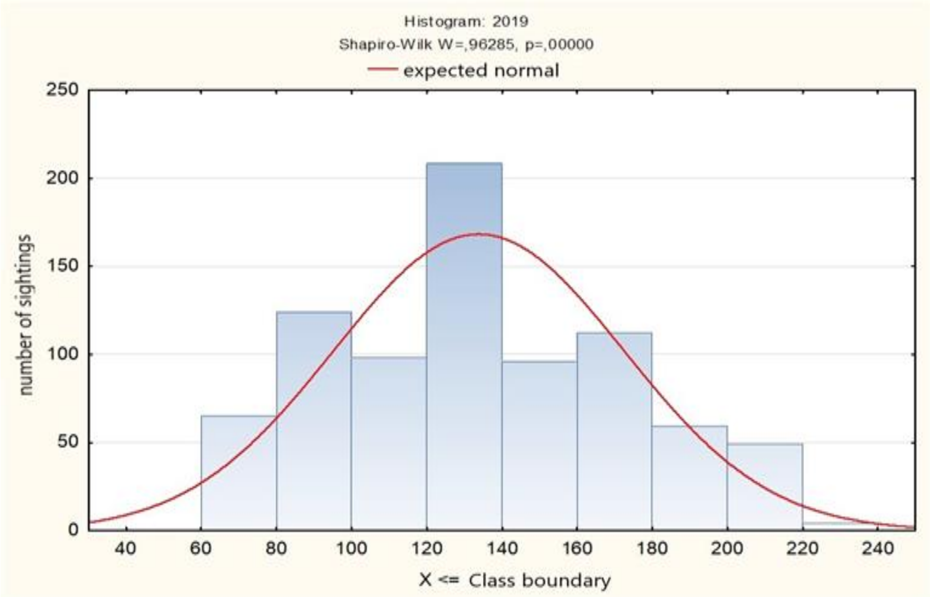


Figure 1. Shapiro–Wilk test for Year 2019 variable

Source: Own research

At the level of significance $p < 0.05$, we reject H0 and accept H1, stating that the variable Year 2019 does not have a normal distribution. The Shapiro–Wilk test is considered to be the best test to check the normality of the distribution of a random variable. The main advantage of this test is its high power, i.e. the probability of rejecting the H0 hypothesis; if it is false, it is higher than for other tests of this type. We assume: zero hypothesis H0 – the variable has a normal distribution, the alternative hypothesis H1 – the variable has no normal distribution.

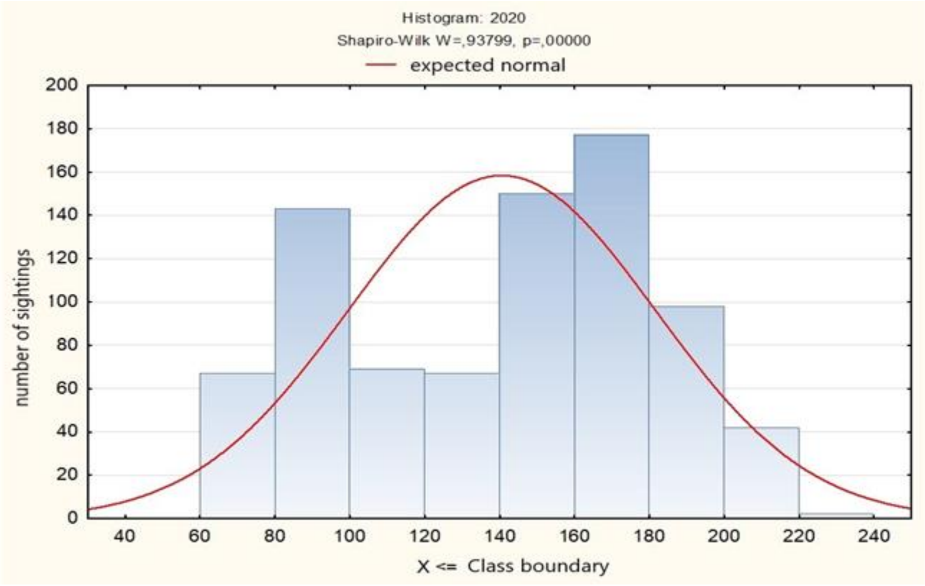


Figure 2. Shapiro–Wilk test for Year 2020 variable

Source: Own research

At the level of significance $p < 0.05$, we reject H0 and accept H1, stating that the variable Year 2020 does not have a normal distribution.

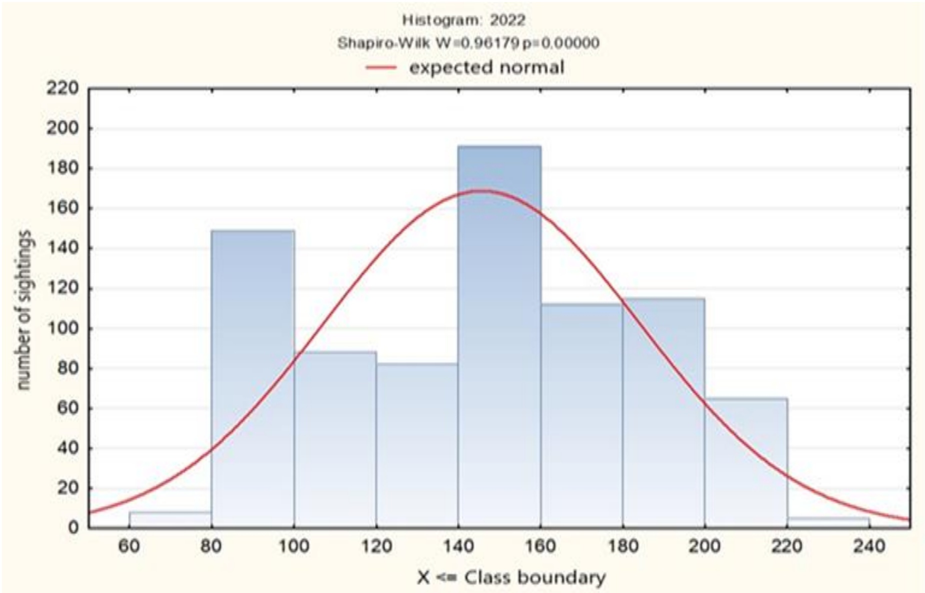


Figure 3. Shapiro–Wilk test for Year 2022 variable

Source: Own research

We assume: zero hypothesis H0 – the variable has a normal distribution, and the alternative hypothesis H1 – the variable has no normal distribution. At the level of significance $p < 0.05$, we reject H0 and assume H1, stating that the variable Year 2022 does not have a normal distribution.

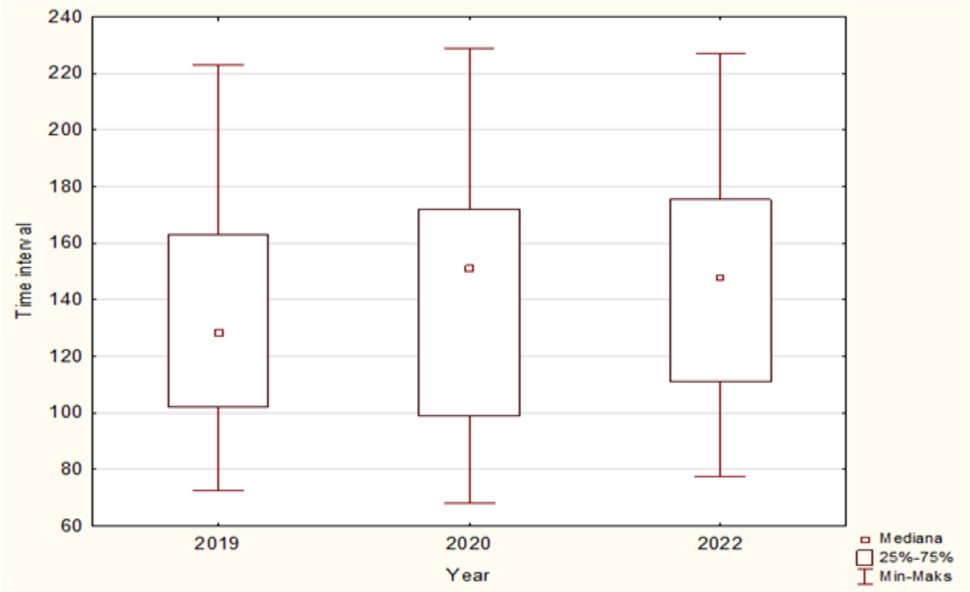


Figure 4. Graphical interpretation of Kruskal–Wallis test of time interval depending on the year

Source: Own research

As with many other tests, ANOVA requires that the data in the individual groups have a normal distribution. Of course, very often this is not the case and then we have to use non-parametric tests. The non-parametric equivalent of ANOVA for the simplest analyses is the Kruskal–Wallis test, which does not require normality. The table below shows the results of the Kruskal–Wallis time interval rank test by year.

Table 1. Test results of Kruskal–Wallis rank test of time interval depending on year

Dependent time interval	**ANOVA Kruskal–Wallis rank of time interval**			
	Independent variables (grouping): Year			
	Kruskal–Wallis test: H (2, N = 2445) = 39.49168 p = 0.0000			
	Code	N important	Sum of ranks	Medium rank
2019	1	815	900108	1104.427
2020	2	815	1013186	1243.172
2022	3	815	1076942	1321.401

Source: Own research

Table 2. Dunn's time interval test results depending on the year

Dependent time interval	**p-value for multiple (bilateral) comparisons: time interval**		
	Independent variables (grouping): Year		
	Kruskal–Wallis test: H (2, N = 2445) = 39.49168 p = 0.0000		
	2019 R: 1104.4	2020 R: 1243.2	2022 R: 1321.4
2019		**0.000218**	**0.000000**
2020	**0.000218**		0.075875
2022	**0.000000**	0.075875	

Source: Own research

We assume: The zero hypothesis H0 is statistically significantly different regarding the time interval depending on the year. There is a statistically significant difference in the time interval depending on the year. Assuming the level of relevance $p < 0.05$, we have grounds to reject the zero hypothesis and accept the alternative hypothesis; therefore, we find that there is a statistically significant difference in the time interval depending on the year. Looking at the chart, we find that the median time interval value was the highest in 2020, and the lowest in 2019. According to Dunn's post-hoc test, we find that there is a statistically significant difference in the time interval between 2019 and 2020 and between 2019 and 2022. However, there is no statistically significant difference in the time interval between 2020 and 2022. The Dunn–Bonferroni post-hoc test is a statistical procedure used to compare multiple pairs of mean (average) in a data group. It is often used after performing a statistical test comparing means, such as ANOVA, which was done in the case of this study. Further considerations concern the average electricity consumption of the population.

In Poland, restrictions on face-to-face contact and a mass shift to working from home began on 16 March 2020 (school closures were implemented earlier). The measures were tightened in the following days, eventually introducing a full lockdown, i.e. stringent restrictions on movement (25 March 2020), including the closure of parks and forests (1 April 2020). The first phase of easing the restrictions took place on 20 April 2020. All the figures above show the average electricity consumption values for the study population over the three study periods mentioned below.

The metering data came from three time periods:

a) 16 March to 18 April 2020 (national quarantine period)
b) 16 March to 18 April 2019 (pre-pandemic corresponding period)
c) 16 March to 18 April 2022 (post-pandemic corresponding period)

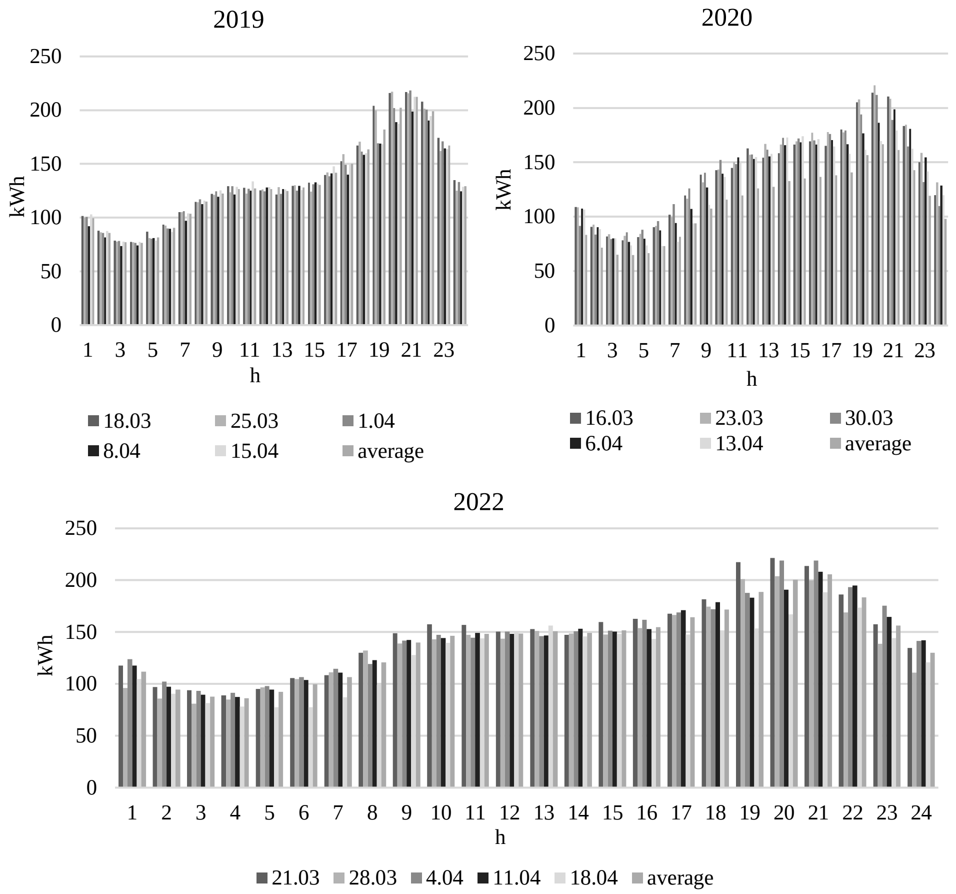
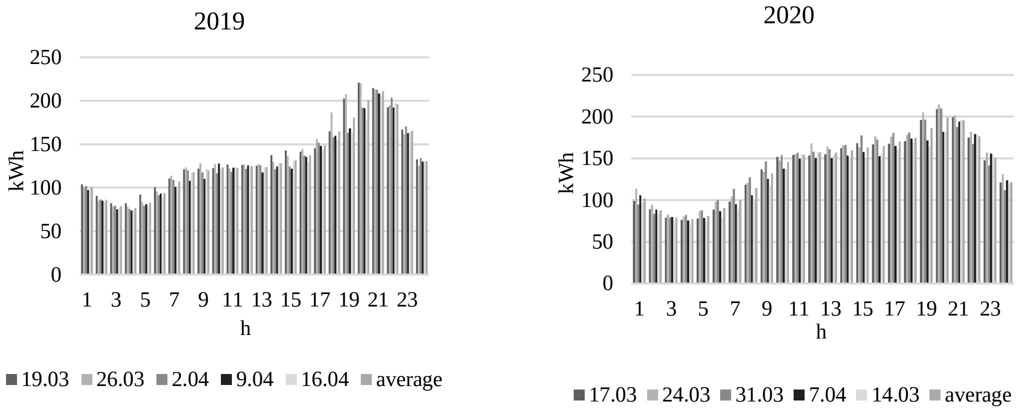


Figure 5. Average value of electricity consumption for study population from five Mondays in 2019, in 2020 and in 2022

Source: Own research



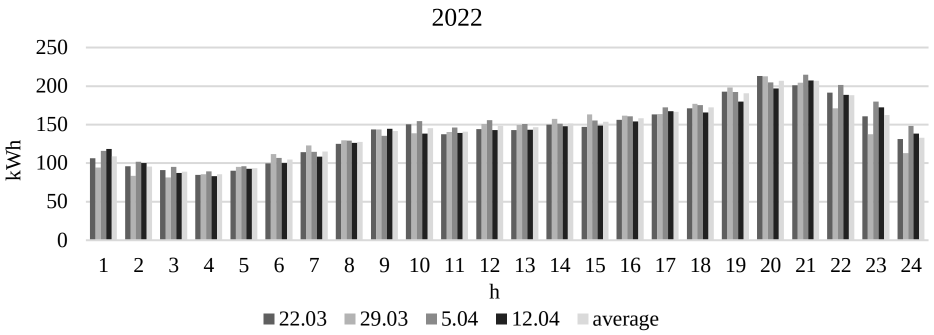


Figure 6. Average value of electricity consumption for study population from five Tuesdays in 2019, in 2020 and from four Tuesdays in 2022

Source: Own research

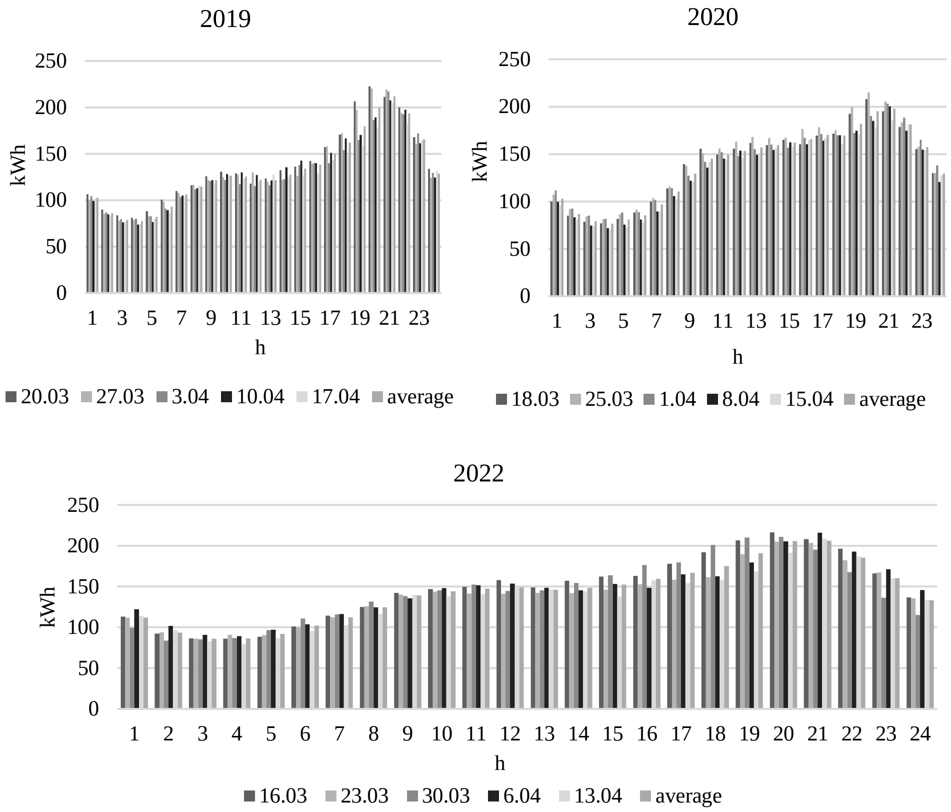


Figure 7. Average value of electricity consumption for study population from five Wednesdays in 2019, in 2020 and in 2022

Source: Own research

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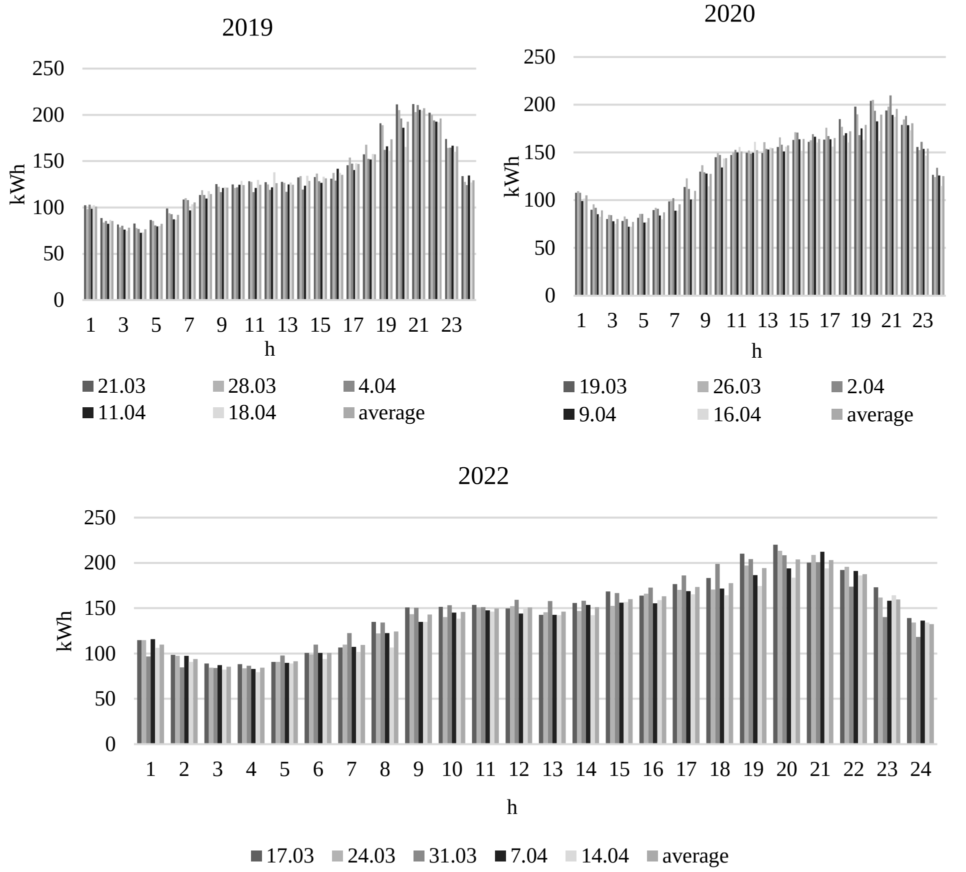
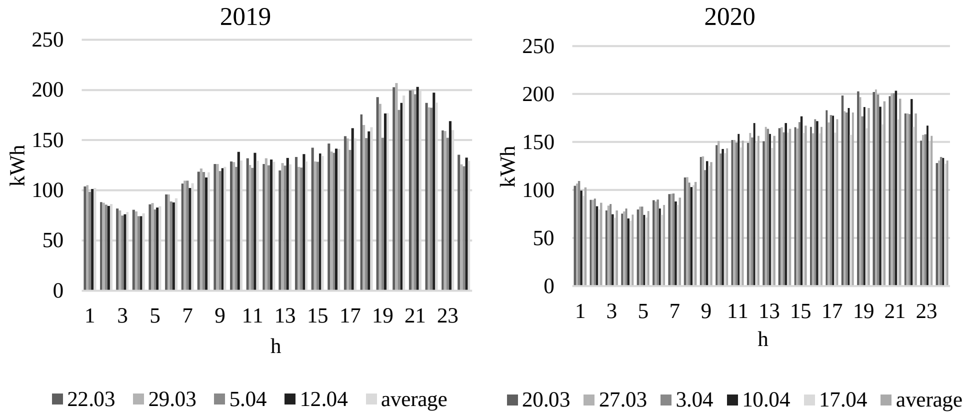


Figure 8. Average value of electricity consumption for study population from five Thursdays in 2019, in 2020 and in 2022

Source: Own research



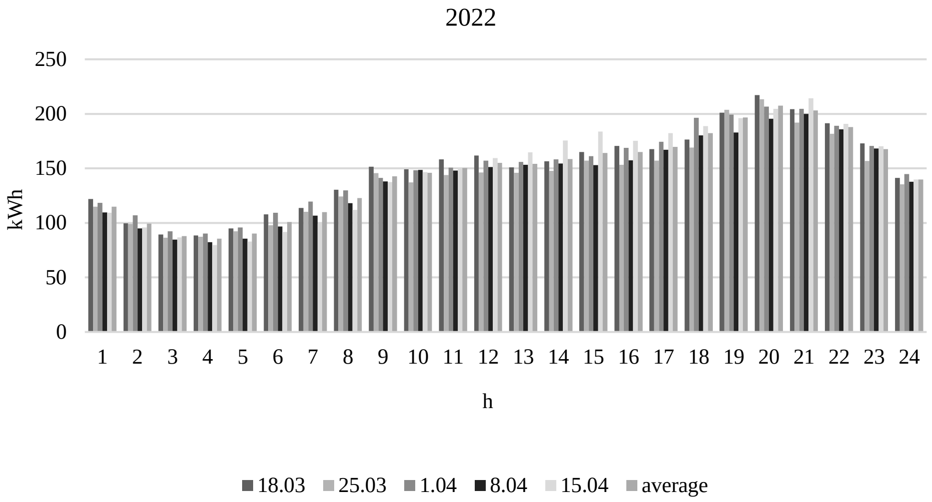
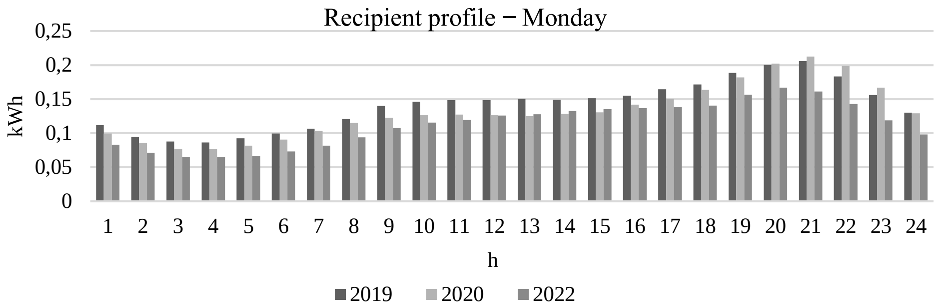


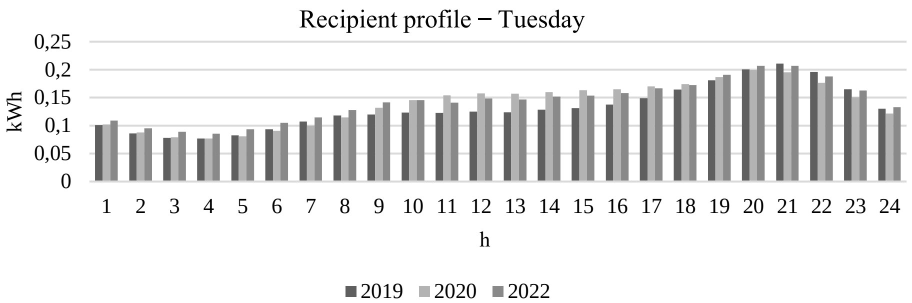
Figure 9. Average electricity consumption value for study population from five Fridays in 2019, in 2020 and in 2022

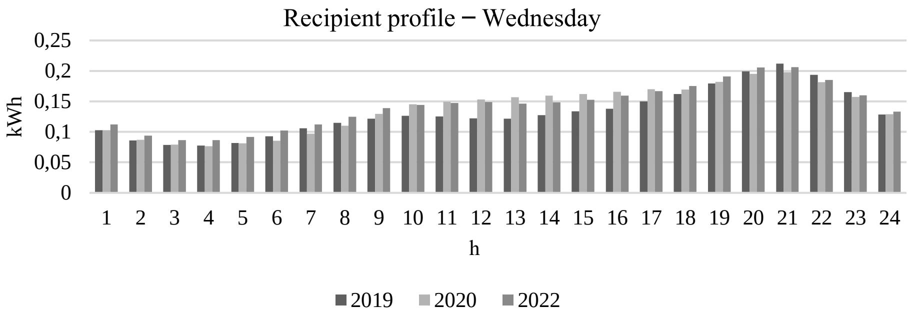
Source: Own research

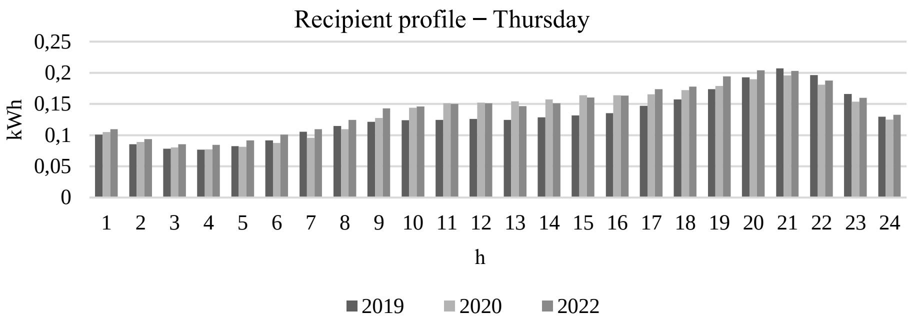
The observed changes in the average profiles of domestic electricity consumers are related to the lockdown period and are not necessarily specific to the post--pandemic period, but they show the range of possible changes that were likely to occur in the post-pandemic period due to users' preferences and experiences during the lockdown. In this context, it is possible to formulate research questions and problems, the solution of which will be important for planning the use of electricity by end users, and consequently, for the design of networks and installations supplying households Regarding forecasting the profiles and volumes of post-pandemic in-household electricity consumption, the following issues deserve to be noted (Bielecki et al., 2021, pp. 980): the development of remote working, education, leisure and entertainment technologies; the range of measures that can be taken in the event of a recurrence of the pandemic; the possibilities of deepening social disparities and the problem of energy poverty; an anticipated economic recession, affecting, among others, a reorganization of work in certain sectors, a reduction in the demand for certain goods and services, and changes in the living standards of various social groups; offers by energy companies to promote presumption, Demand Side Response programs, and new forms of billing; the framework for the functioning of the energy market and energy services; environmental issues and the need to prevent climate disasters, which entails changes in how several consumer goods are used; in addition to current societal needs.

The determined average active power usage of a residential consumer is shown in the figure below.


Recipient profile − Monday
0,25
0,2
0,15
0,1
0,05
0
kWh
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
h
2019 2020 2022


Recipient profile − Tuesday
0,25
0,2
0,15
0,1
0,05
0
kWh
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
h
2019 2020 2022


Recipient profile − Wednesday
0,25
0,2
0,15
0,1
0,05
0
kWh
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
h
2019 2020 2022


Recipient profile − Thursday
0,25
0,2
0,15
0,1
0,05
0
kWh
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
h
2019 2020 2022

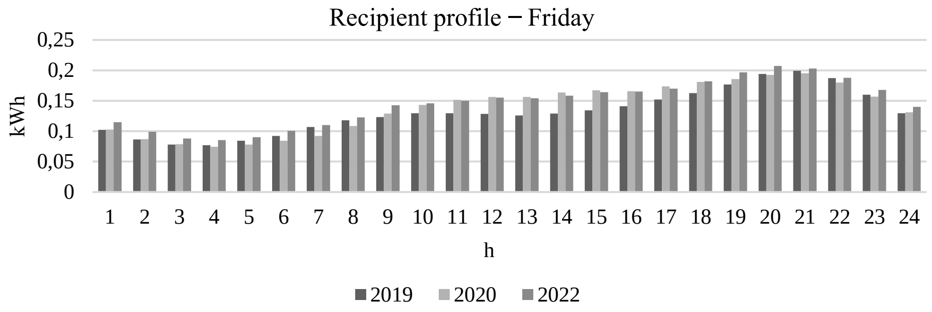


Figure 10. Average active power consumption from Monday to Friday (values averaged at 1-hour intervals for single statistical resident) of consumer households during national quarantine period (lockdown 16.03-18.04.2020), in corresponding periods of 2019 (before pandemic) and 2022 (after pandemic)

Source: Own research

There is a noticeable increase in the active power consumption by households in the daytime hours during the lockdown compared to the corresponding period of 2019 and 2022. After analysing the average daily active power consumption values (Figure 10) of the analysed residential consumers, the following observations can be made:

a) the peak load on weekdays occurred at 9 pm and reached practically the same values (around 225 W) both during the lockdown period and in the corresponding period of 2019; however, at the same time in 2022, the value at 9 pm was slightly lower (around 170 W), although it continued to be a peak demand
b) during the lockdown, the shape of the daytime profile was flattened (levelled out to the peak during the day) and on weekdays the noon dip almost disappeared; the highest peak load time was between 8 and 10 am (from 100 W to about 150 W), another relatively small peak around midnight (from 100 W to about 130 W) and the last daytime peak was between 7 pm and 9 pm (up to 2100 W); a night-time dip appeared around 4-5 am, where the 2019 and 2020 values were a few watts higher compared to 2022.

During the lockdown, compared to the same periods before and after the pandemic, the electricity consumption of the domestic user group in question did increase. This was associated with an increase in consumption during the day between 9 am and 6 pm, as well as an increase in electricity consumption on weekdays. The residential units selected for the analysis represent consumers from the same group in the G11 tariff. The consumers were not covered by any DSR-type (Demand Side Response) program and were billed according to a single tariff rate per kWh unit. As the rate per kWh was identical regardless of the time of day, it can be assumed that the consumers were able to use electricity freely and flexibly in terms of time. The levels of the obtained averaged electricity consumption values are characteristic of the Polish system (Figure 11). A comparison of the shapes of the obtained profiles shows specifically that:

- the peak values during lockdown are almost identical to those recorded in the corresponding period before the pandemic – this is particularly true for weekdays (from Monday to Friday).
- a characteristic feature of the lockdown period is the disappearance of the midday dip on weekdays, while the night dip occurs later (around 4-5 am) than before and after the lockdown (around 3 am).
- during the national quarantine, the Saturday and Sunday profiles became more similar, and for this reason they are not presented in the article.

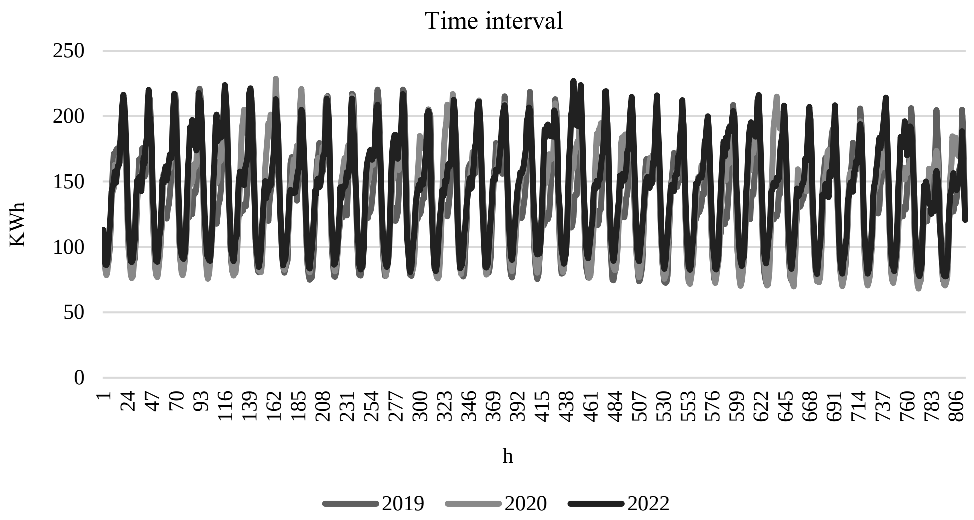


Figure 11. Graphs of average active power usage in group of analysed households for 813 hours during lockdown in 2020, in 2019, and after pandemic in 2022

Source: Own research

The experiment described in the article compares measurement data from three periods of social life and leads to interesting conclusions. For the most part, significant differences in electricity consumption could be expected with an impact on the consumption profiles for the three periods. The analysis, on the other hand, allowed us to confirm the hypothesis of a stable level of average active electricity consumption in a 1-hour interval of the average consumer of electricity even under conditions of continuously staying at home.

Discussion

The study was conducted on data obtained from 1,000 consumer households (all measurement periods). Although the input data was from a specific urban area, it can be assumed that the results are representative of residents of modern middle-class housing estates in large cities. Modern flats are usually equipped with similar household appliances. The author is aware that the presented analysis has its limitations and drawbacks. These limitations should be taken into account when generalizing the conclusions of the study. The study can be regarded as a case study carried out on a large number of households, showing trends and characteristic phenomena in residential-level electricity consumption under lockdown conditions.

The results of the analyses refer to a specific and numerous group of users, i.e. households, and are based on actual measurements. Despite these limitations, the results of the study and analyses serve as a case study to establish how national quarantine conditions, including lockdown stages, change the average energy demand of residential consumers. There are insufficient studies in the literature on household electricity consumption during lockdown from measurement-based analyses. For example, one article (Santiago et al., 2021) shows a case of electricity demand in a four-bedroom flat in a Spanish city during the lockdown in 2020; hence, it can be considered as an example of what happens in many homes during quarantine. Another paper (Snow et al., 2020, pp. 5738) describes the measured changes in electricity consumption in 491 Australian households during the pre-lockdown (1 February – 19 March 2020) and lockdown (21 March – 8 May 2020) periods, reporting on a sample of 17 households with detailed circuit-by-circuit electricity monitoring. Fluctuations in household electricity demand due to the COVID-19 restrictions affected the use of air conditioners in Queensland.

A paper on Germany (Kaneko et al., 2024) pointed out that various factors can influence electricity demand, such as weather, renewable energy capacity, economics, and maintenance habits. This study focuses in particular on the hourly demand for electricity in Germany. The analyses show how electricity demand relates to different factors at certain times of the year. In addition, it was shown how the demand for electricity changes in response to these factors. In particular, the relationships between variables are not consistently linear and can vary depending on seasonal conditions. Therefore, this study focuses on the linear/nonlinear behaviour of the hourly electricity consumption curve. The linear model (LM) employs a limited set of explanatory variables such as weather conditions, the German stock index, and days of data that are commonly used in traditional research as well as assumes a linear relationship between these variables.

From 16-22 March, the largest declines in energy consumption among the analysed countries were recorded in Italy and France, where energy consumption decreased by 12% week-on-week. A slightly smaller drop in energy consumption between 16-22 March compared to 9-15 March was recorded in Spain (−10%), followed by Austria (−8%) and Belgium and Ireland (−7%). In Poland, according to Ember, the decline in energy demand was 4% and was higher than in several countries more affected by the epidemic, such as Germany (−3%) or the United Kingdom (−2%). The conclusions and trends presented in the above-cited articles are qualitatively consistent with the observations obtained from the research presented in this paper.

The coronavirus pandemic caused global havoc and its impact permeated virtually all areas of society (Boström et al., 2022). Restrictions on movement, the introduction of remote learning in schools and universities, major restrictions on trade and the introduction of working remotely resulted in a smaller demand for electricity.

While companies and employees gradually switched to working remotely over time, the sudden shock caused by COVID-19 represented an unexpected and massive test for many employees and companies. Nevertheless, it is important to identify a number of opportunities that have arisen as a result of the COVID-19 pandemic. Lockdown has shown that some occupational activities can be performed from home with similar productivity. The benefits of working remotely are causing companies to increasingly consider remote hiring in the future, which will lead to an acceleration of the already growing trend of remote hiring (Ozimek, 2020). For companies, remote working removes geographical barriers to hiring, allowing them to find the best potential talent regardless of location. For independent professionals, being able to work remotely opens up opportunities to work with companies and clients around the world. As companies shift to a more remote workforce, there will be adjustments, but overall the remote working experiment will have a positive impact on the way in which we work (Ozimek, 2020). There is a trend to transform homes into spaces where home education, office work, leisure activities, and social interactions have become standard; therefore, it should be anticipated that their impact on electricity consumption will increase over time, and energy retrofitting should be taken into account when making decisions (Rana et al., 2020). In contrast, in the longer term, the proliferation of remote working would necessitate addressing new management as well as organizational and psychological issues identified in the context of remote working (Wang et al., 2021), which may indirectly translate into individual energy profiles. Researchers should discuss the results and how they can be interpreted from the perspective of previous studies and the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

Conclusions

The paper, based on metered data from 1,000 households in a selected city in Poland, shows how the average daily energy demand profile of domestic users changed during the COVID-19 pandemic lockdown compared to the corresponding periods of the year before and the year after the pandemic. An increase in daily electricity demand with a virtually unchanged peak load was observed. These are issues that are technically relevant for engineers who design and operate distribution networks and electrical installations in buildings. The electricity consumption analysed and described in the paper refers to the conditions of electricity use by customers not participating in DSR mechanisms. DSR mechanisms allow the operator to manage the network by reducing the demand for electricity at a specific time in a specific area, thereby stabilizing the operation of the network. Rolling out smart metering will allow DSR programs to be implemented, also with households as a target. In order to make rational use of resources and infrastructure, the conditions of supply (the available generation capacity at different grid levels), demand (electricity consumption possibilities) and energy supply possibilities (grid constraints) should be taken into account when designing DSR programs. These conditions may be subject to change over time. The situation forced on people by the lockdown meant for many the need to work and learn remotely, and a side effect of this situation is expected to be an increase in digital competence in society. In the context of the operation of the energy industry, this may contribute to increased interest in new forms of cooperation between end users and their suppliers and distributors. In particular, this could affect the interest in digital billing models between energy consumers and DSOs (Distribution System Operators). A situation that forces people to stay at home and work remotely for longer periods of time increases the pressure on DSOs to meet high-reliability standards. Users concerned about an uninterruptible energy supply may need to take increasing interest in renewable energy sources. This will also apply to residents who could have photovoltaic panels installed on the roofs of the buildings in which they have a flat, e.g. as part of a cooperative.

It will be imperative that a cost-effectiveness analysis of project implementation variants be carried out with regard to the anticipated possibility of installing prosumer sources. The connection of newly distributed sources based on unstable renewable energy generation will complicate the problem of optimal load distribution in the grid and installations. This will necessitate new analyses, taking into account the economic conditions of energy generation and consumption over an appropriate time frame.

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WPŁYW PANDEMII COVID-19 NA CODZIENNE ZUŻYCIE ENERGII ELEKTRYCZNEJ GOSPODARSTW DOMOWYCH W WYBRANYM MIEŚCIE W POLSCE

Streszczenie: Wprowadzony w Polsce okres przymusowej kwarantanny – lockdown – przyczynił się do zmian w strukturze zużycia energii elektrycznej odbiorców domowych w nowych okolicznościach. Obok bezpośredniego negatywnego wpływu na zdrowie występujący kryzys wskazał na poważne konsekwencje ekonomiczne, głównie w zakresie zapewnienia bezpieczeństwa energetycznego utożsamianego z suwerennością państw. W sposób wyraźny uwidocznił rolę struktur systemów energetycznych jako podstawy dobrobytu i stabilności w bezpiecznym rozwoju społeczeństw. Celem artykułu jest przedstawienie i analiza wpływu pandemii COVID-19 na strukturę poboru energii elektrycznej w gospodarstwach domowych na podstawie doświadczeń z czasu lokdownu oraz w okresach przed i po pandemii. Analiza statystyczna danych pomiarowych wygenerowała parametry charakteryzujące grupę wartości w analizowanych okresach. Wyniki analiz dotyczą konkretnej i licznej grupy użytkowników, tj. użytkowników domowych, i opierają się na rzeczywistych pomiarach. Pomimo tych ograniczeń wyniki badania i analizy są studium przypadku mającym na celu ustalenie, w jaki sposób krajowe warunki kwarantanny, w tym etapy lockdownu, zmieniają średnie zapotrzebowanie użytkowników domowych na energię. Ponadto w badaniu wykorzystano test normalności Shapiro–Wilka oraz test rang Kruskala–Wallisa.

Słowa kluczowe: sektor energetyczny, prognozowanie zużycia energii, pandemia COVID-19, ograniczenia, lockdown