

Electrical energy consumption and the energy market in Poland during the COVID-19 pandemic

Michał Czosnyka
Wrocław University of Science
and Technology
Department of Power Engineering
Wrocław, Poland
michal.czosnyka@pwr.edu.pl

Bogumila Wnukowska
The Witelon State University
of Applied Sciences
Department of Technical
and Economic Sciences
Poland
bogumila.wnukowska@wp.pl

Katarzyna Karbowa
Wrocław University of Science
and Technology
Department of Power Engineering
Wrocław, Poland
katarzyna.karbowa@pwr.edu.pl

Abstract—The paper presents how the COVID-19 pandemic influenced on the energy market in Poland. It contained analyzes of power demand and electricity consumption in the period of the economic downturn. The data were compared with characteristic periods from the past. The article also contains an analysis of price changes on the Polish Power Exchange.

Keywords—electrical energy, COVID-19, power demand, power grid, Polish Power Exchange

I. INTRODUCTION

Certainly, we will all remember the turn of winter and spring 2020. Almost all over the world, at one time, governments of all countries, at all costs, wanted to stop the disease associated with the SARS-Cov-2 virus. The strategy to fight the virus was simple and drastic at the same time. Hold everything that is not of strategic importance and isolate people from each other.

The COVID-19 pandemic was unexpected and difficult to predict and include in any electrical energy forecasts. The response of the economy and financial markets in this case was also sharp and pessimistic. In a relatively short time, the economies of many countries reached the level of the global financial crisis.

Restrictions introduced successively, aimed at stopping the development of the epidemic, unfortunately also had a negative impact on the condition of the economy. Many companies were forced to limit production, reorganize production processes, change the business profile or also to completely cease production of products. It was influenced by various factors, not only those directly aimed at economic activity. Closing borders hindered the flow of goods and services. Closing schools and kindergartens meant that many employees had to look after their children. There was also fear in society of infection in the workplace. Limiting industrial production is significant for the demand for electricity. Households use only 19% of energy. Industrial plants, the construction industry, small and medium enterprises and agriculture consume on average 62% of energy [1].

The effects of the epidemic can be seen not only in economic indicators but also in electricity demand. This article is an attempt to answer the question how the coronavirus pandemic affected the Polish electricity market, energy demand and prices.

II. METHODOLOGY OF ANALYSIS

In the article it was decided to analyze whether the COVID-19 epidemic had an impact on the electricity market in Poland. On the basis of statistical data obtained from the Polish Power System and Polish Power Exchange, analyzed electricity consumption, the demand for power in peak hours, power balance and electrical energy prices. The focus was mainly on the period from March 1 to May 15, 2020. It was the time of introduction and application of the restrictions [2].

In order to follow the trend of changes in this period, reference was made in relation to the preceding months. We also compared the energy consumption of the corresponding periods of 2018 and 2019 years. Detailed hourly power demand data allowed to accurately determine the demand for electricity and analyze the trend of changes. For this purpose, we used the dynamics indicators most often used on financial and stock markets. Among other things, an individual dynamics index with a variable basis by which energy consumption in the epidemic period was compared to the preceding periods [3].

$$i_{t/0} = \frac{y_t}{y_{t-1}} \cdot 100, \quad (1)$$

where:

$i_{t/0}$ – individual dynamics index with a variable basis,
 y_t – value level over the period considered,
 y_{t-1} – value level in the period immediately preceding the period considered.

We checked the correlation between the macroeconomic indicators informing about the condition of the economy and consumption of electricity. The analysis was performed in Microsoft Excel, and also uses built-in functions to operate on data sets, such as trend lines and moving averages.

III. ANALYSIS OF PEAK HOURS POWER DEMAND

The graphs in figure 1 show the maximum power demand, determined for each day of the month in the period from March 1 to May 15. In each of them, the maximum demand for power from the examined period in 2020 was compared to 2019 and 2018.

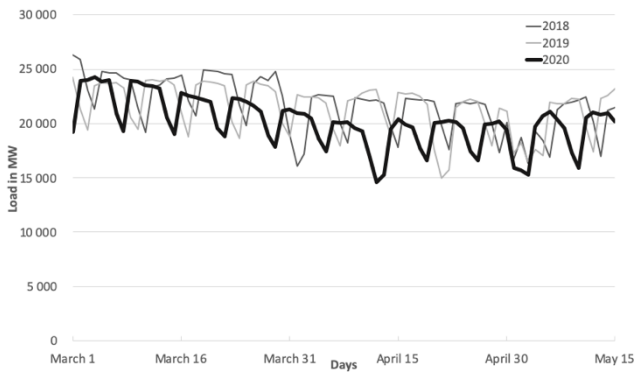


Fig. 1. The course of power demand in peak hours between March 1 and May 15, compared to 2019 and 2018, own elaborated based on [4]

As can be seen, the maximum power demand in peak is lower compared to the same period in the last two years. The change trend is downwards every year. However, in 2020 it deviates in absolute value compared to previous years.

TABLE I. THE POWER DEMAND IN PEAK BETWEEN MARCH 1 AND MAY 15, OWN ELABORATED BASED ON [4]

Year	Average peak power demand	Minimum peak power demand	Maximum peak power demand
	MW	MW	MW
2018	21 037	16 048	24 838
2019	21 045	14 958	23 877
2020	19 403	14 581	22 345

The above analysis shows that the average power demand in peak during the pandemic period was 1 642 MW lower compared to 2019 and 1 634 MW lower compared to 2018. The maximum peak power demand in this period was 22 345 MW. It was 1 532 MW less compared to 2019 and 2 493 MW less compared to 2018.

IV. ANALYSIS OF ELECTRICAL ENERGY CONSUMPTION

Electrical energy is a specific commodity. The consumption of electricity must be closely linked to production. There is no way to produce energy for storage. A shortage of energy can lead to a blackout, while its excess negatively affects the stability of the network.

The figure 2 presents the course of electricity consumption in the period from January 1 to May 15, 2020. The bold line in the chart indicates the characteristic period from March 1.

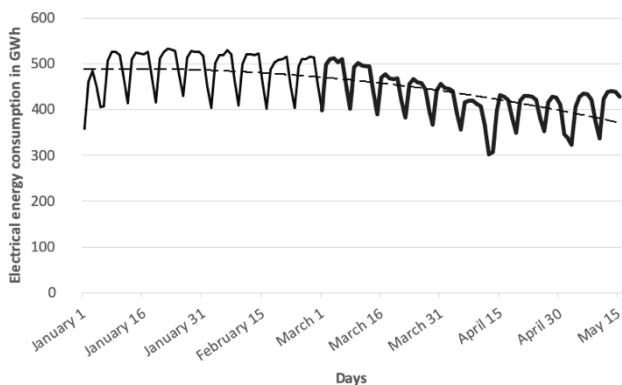


Fig. 2. Electrical energy consumption in Poland between January 1 and May 15, own elaborated based on [4]

The graph in fig. 2 shows that in January and February electricity consumption remained at a similar level. From the beginning of March, electricity consumption began to fall week by week. The decrease in electricity consumption was probably caused by the unstable economic situation and restrictions. The figure 3 and 4 compare electricity consumption between March 1 and May 15, 2020 compared to the same period in 2019 and 2018.

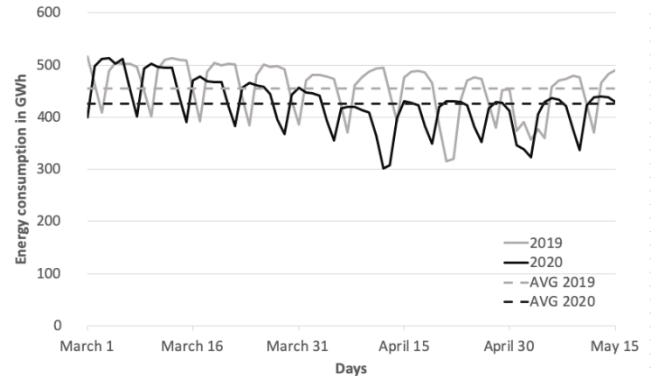


Fig. 3. Electrical energy consumption in Poland between March 1 and May 15 compared to the same period in 2019, own elaborated based on [4]

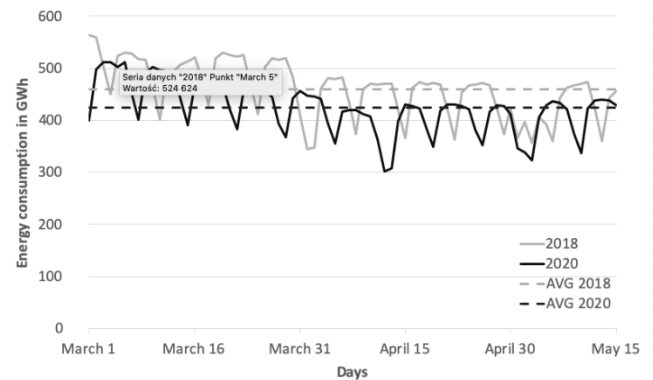


Fig. 4. Electrical energy consumption in Poland between March 1 and May 15 compared to the same period in 2018, own elaborated based on [4]

The dashed line marks the average value of electricity consumption for a given period. This is the arithmetic average determined on the basis of the data of daily energy consumption. After March 15, there was a visible drop in electricity consumption. From April 4, energy consumption was below the daily average over the period considered. Both in 2018 and 2019, there is a visible reduction in energy consumption in April, probably due to Easter. From May 5, electricity consumption during the working week began to rise above average due to the gradual lifting of restrictions.

Based on Fig. 3, Fig. 4 and Table II, the average daily electricity consumption in the analyzed period in Poland amounted to 425 249 MWh and decreased by 6.9% compared to 2019 and by 8.1% compared to the same period in 2018.

TABLE II. AVERAGE DAILY ENERGY CONSUMPTION AND TOTAL ENERGY CONSUMPTION BETWEEN MARCH 1 AND MAY 15, OWN ELABORATED BASED ON [4]

Year	Average daily energy consumption	Total energy consumption
	MWh	TWh
2018	459 537	34.925
2019	454 855	34.569
2020	425 149	32.311

As part of this analysis, attempts were made to correlate electricity consumption with macroeconomic indicators. The most characteristic indicator about the condition of the economy is GDP (gross domestic product). However, GDP is a quarterly indicator and fluctuations in the energy market are characterized by much greater dynamics of changes. Therefore, another indicator was chosen - sold production of industry (SPoI), which is updated every month and describes the condition of the economy as well [5].

TABLE III. CORRELATION OF ENERGY CONSUMPTION WITH THE ECONOMIC INDICATOR, OWN ELABORATED BASED ON [4], [6]

Month	Index of sold production of industry	Index of average electricity consumption	Index of summary electricity consumption
	100=last month	100=last month	100=last month
January	104.5	100.0	100.0
February	102.2	99.7	93.2
March	102.2	93.9	100.4
April	74.5	88.0	85.1

The chart in figure 5 presents the relationships described in the Table III.

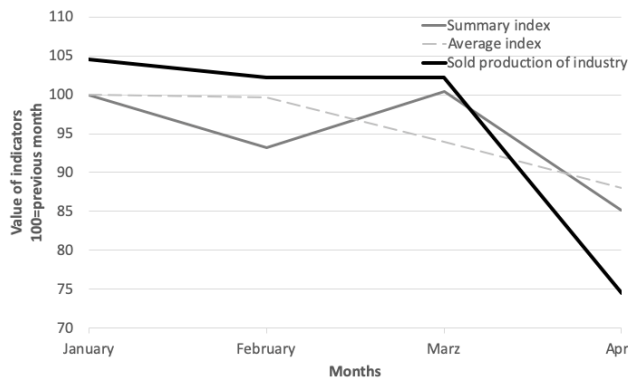


Fig. 5. Comparison of energy consumption with economic indicators, own elaborated based on Table III

Chart analysis leads to the conclusion that there is a clear correlation between the condition of the economy and electricity consumption. But it can be seen that the index of summary electricity consumption for electricity better reflects the trend of the sold production of industry index. The steep decline of SPoI in April is much greater than the steep decline in index of summary electricity consumption. The reason for this is that many companies seconding their employees to work remotely from home. Probably, the rate of decline in energy consumption would be higher if employees were sent to forced leave or dismissed on a national scale. The high rate of decline in SPoI may be caused by the pan-European economic slowdown and restrictions introduced in conducting various types of economic activities. Until the end of March, the economy was accelerating by orders and commitments from before the epidemic. The announcement of the pandemic resulted in increased market uncertainty and also the demand for manufactured goods decreased.

V. ANALYSIS OF POWER BALANCE

The Polish power system does not work alone. It is connected as part of cross-border exchange with synchronous zone with the Czech (CEPS), Slovak (SEPS) and German

(50Hertz) power systems and as part of cross-border exchange with non synchronous zone with Ukraine (NEK Ukrenergo), Lithuania (Litgrid) and a DC connection with Sweden (SvK). The combination of power systems allows to import energy and balance electricity shortages caused by high demand and insufficient own generation. Similarly, in the case of surplus energy production, it can be successfully exported to meet the demand of another country.

For several years, Poland has been struggling with the problem of increasing power demand, which could not be met by domestic generating units. Therefore, electricity had to be imported to ensure continuity of supply. Import of electricity is not quite wring and the volume of imports should not be treated as the indicator of the condition of electrical energy sector. The connection of power systems increases the diversification of energy supplies, which improves energy security.

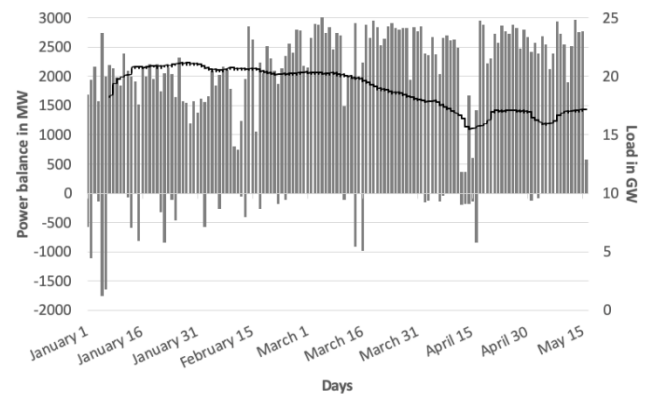


Fig. 6. Power balance from January 1 to May 15, 2020 in Poland, own elaborated based on [4]

The chart on Fig. 6 presents the balance of cross-border exchange in the period from January 1 to May 15, 2020. It shows that the COVID-19 pandemic, the reduction in electricity demand that was evident from March 1 to May 15, did not reduce electricity imports. For comparison, in the period characteristic for the present analysis in 2019, international exchange covered on average 6.0% and maximum 12.0% of power demand.

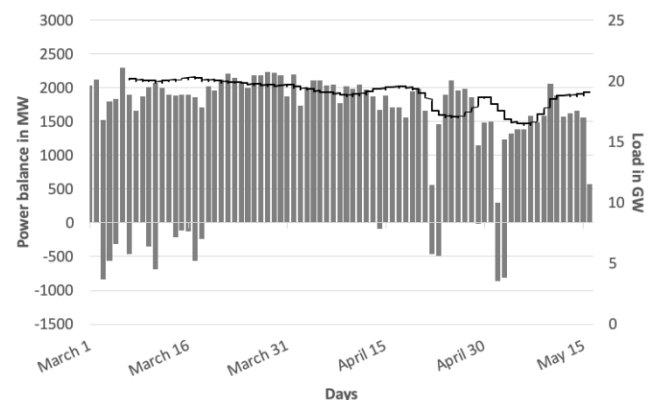


Fig. 7. Power balance from March 1 to May 15, 2019 in Poland, own elaborated based on [4]

In the same period of the current year, the average balance was 8.3%, and the maximum share of imports was 17.5%.

VI. ANALYSIS OF ELECTRICAL ENERGY PRICES

Much attention has been paid in the media to the impact of coronavirus on oil prices. As a result, a decrease in fuel prices was visible in Poland. However, not much attention was paid to the impact of a pandemic on electricity prices. This impact should also be observable because the price is determined by market mechanisms and depends on the demand. As shown in previous chapters, electricity demand has decreased. Supply has not changed because no one has included a pandemic and economic slowdown in energy forecasts. Given the relationship between supply and demand, the price should decrease in such a situation.

On the Polish Power Exchange, electricity is traded on two main markets: spot and forward. The spot market is divided into: *Intraday Market*, which mainly aims to adjust position and balancing electricity, and the *Day-Ahead Market*, whose main purpose is also balancing. On the other hand, the *Commodity Forward Instruments Market* allows to plan and buy electricity in advance, e.g. yearly, quarterly, monthly or weekly. It gives the entities that trade energy the opportunity to offer a fixed price with a guarantee of delivery. The course and the price change over time in all markets for the Polish Power Exchange presents multiple indexes. They provide information on the price of electricity and the general situation on the energy market. Appropriate index interpretation is a reference point for investment and analytical activities.

For the purposes of this publication, the focus was on the impact of the epidemic on two of them: *TGeBase* from the Day-Ahead Market and *BASE_Y-21* representing the volatility of energy prices in 2021 futures contracts.

The chart in figure 8 shows the change in electricity price over the Day-Ahead Market. In this case, the range of data on the chart covers the period from November 2019 to May 15, 2020. A broad perspective will allow a better reference to the situation on the energy prices market during the epidemic.

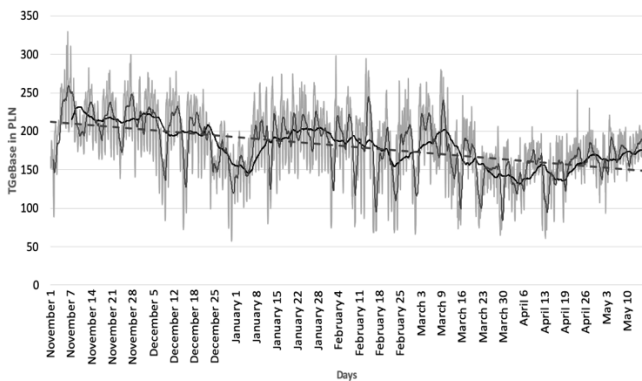


Fig. 8. The course of electricity prices on Day-Ahead Market in Polish Exchange Market between November 2019 and May 15, 2020, *own elaborated based on [7]*

As you can see around March 20 there was a visible drop in electricity prices on the next day's market. Probably caused by the economic slowdown and reduced demand for electricity. The following table set monthly average price per 1 MWh of electricity on the spot market, and the rates of dynamics of price changes in relation to the previous period and the base (in November 2019).

The price of electricity was falling even before the epidemic. However, at the turn of March and April the price drop was significant and stable. In April, the price of

electricity was on average 30% lower than in November. It is noted that electricity prices increased in the first half of May.

TABLE IV. INDICATORS OF DYNAMICS CHANGES OF ELECTRICITY PRICES, *OWN ELABORATED BASED ON [7]*

Month	Average electrical Energy price	Index of dynamic changes	Index of dynamic changes
	PLN/MWh	100=previous period	100=November 2019
November 2019	216	100.0	100.0
December 2019	190	87.9	87.9
January 2020	190	100.0	87.9
February 2020	176	92.8	81.6
March 2020	165	93.6	76.4
April 2020	151	91.7	70.1
May 2020	171	113.2	79.3

The epidemic also had an impact on the price of electricity on the Commodity Forward Instruments Market (Fig. 9). Base_Y-21 index quotations in the period from November 2019 to the first half of March 2020 were basically at the same level on average around 250 PLN per one MWh of energy.

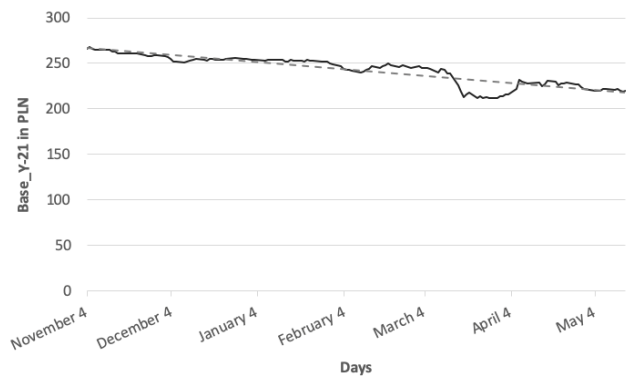


Fig. 9. The course of electricity prices on forward market between November 2019 and May 2020 in Poland, *own elaborated based on [7]*

The COVID-19 outbreak has slightly reduced energy prices in future contracts from March 16 to April 8. On average, the energy price was PLN 36 lower than in previous periods. However, it should be suspected that this reduction will not have a significant impact on electricity prices in 2021.

VII. CONCLUSIONS

The COVID-19 pandemic and the economic slowdown had an impact on electricity consumption in Poland.

In the period from 01/03 to 15/05 in 2020, electricity consumption was 6.9% lower than in the same period in 2019 and 8.1% lower compared to the same period in 2018. The average daily energy consumption was 6.5% lower.

The maximum power demand in peak was by 6.4% smaller than in 2019 and by 10% lower than in 2020. The average power demand in peak was 7.8% lower compared to 2019 and 2018.

The shape of the sold production of industry index is similar to the shape of summary electricity consumption index related to the previous period.

The reduction in electrical energy consumption has not resulted in import reduction. On the contrary, the average share of imports in meeting demand increased to 8.3% from 6.0% in 2019.

The average price of electricity on the spot market (index TGeBase) decreased in April by 30% compared to November 2019.

The price of electricity in long-term contracts for 2021 (Index Base_Y-21) in the period from 14/03/2020 to 08/04/2020 decreased by 14.5%.

The reduction in electricity demand could be due to other factors, such as relatively warm winter and the beginning of spring. However, when analyzing energy consumption, a noticeable drop in demand can be seen, especially in the second half of March, when most restrictions came into force. In addition, a 25% reduction in SPoI should be taken into account, which resulted directly from the economic slowdown

caused by COVID-19. Given that industry is the main recipient of electricity, this is reflected in the consumption of electricity.

Notes a slight increase in demand for electricity in the period from May 10, probably due to the lifting of restrictions.

REFERENCES

- [1] 'Technologies help to reduce high electricity bills', <http://forsal.pl/artykuly/1391268,technologie-pomagaja-zbic-wysokie-rachunki-za-prad.html> (accessed May 29, 2020).
- [2] 'Coronavirus: information and recommendations', <https://www.gov.pl/web/koronawirus> (accessed May 29, 2020).
- [3] A. Zimny, *Descriptive statistics: exercise materials*. Konin: Wydawnictwo Panstwowej Wyzszej Szkoły Zawodowej, 2010.
- [4] Polish Power System -PSE - Reports. <https://www.pse.pl/web/pse-eng/data> (accessed May 31, 2020).
- [5] Statistics Poland, Dictionary of terms. <https://stat.gov.pl/metainformacje/sloownik-pojec/pojecia-stosowane-w-statystyce-publicznej/362.pojecie.html> (accessed May 31, 2020).
- [6] Macroeconomic Data Bank. <https://bdm.stat.gov.pl/> (accessed May 30, 2020).
- [7] Polish Power Exchange - Statistical data. <https://tge.pl/statistic-data> (accessed May 31, 2020).