

## DEVELOPMENT OF ELECTRICITY AND GAS PRICES

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**Abstract:** Energy prices are a widely discussed topic and their development influences everyday life of every person. This paper deals with the development of electricity and natural gas prices in the years 2017 – 2022 with the aim to evaluate this development and determine the impact of extreme events on this development. For the purposes of describing the development, the descriptive analysis of electricity and natural gas time series was used. The impact of extreme events represented by the COVID-19 pandemic was determined using the correlation analysis. The results show that in the monitored period, the development of electricity prices was more stable than the prices of natural gas. However, the correlation between the average increment in the number of patients with COVID-19 and the prices of energy commodities could not be confirmed. To prove the influence of the above extreme events, a more complex analysis would be necessary, which would include other factors that could have an impact on energy prices.

**Keywords:** Electricity, natural gas, price development, extreme events, correlation.

### 1 Introduction

Most households and businesses are dependent on energy supplies, which also account for a major part of their expenditure. A large increase in energy prices can thus have a negative impact on their activities, which makes energy commodities some of the most monitored ones on the market. Martins, Felgueiras and Caetano (2022) consider energy availability and affordability to be essential requirements in eradicating poverty or ensuring access to goods or water. At the same time, they consider modern life to be dependent on electrical appliances and devices, which makes energy prices a key factor for people. Energy is also essential for industries and can affect industrial productivity; energy price fluctuations can have an impact on the level of final energy consumption (Xu et al., 2022).

It has been confirmed in the past that there are interactions between energy markets and other raw materials markets. Price rises and fluctuations in commodity markets can thus have considerable political and economic consequences. Although these fluctuations can be observed in all types of commodities, it is energy which is currently being paid much attention to (Spärgberg, 2020). A causal relationship has been found to exist between the prices of energy and food. In the context of agricultural development, there has been an increase in energy consumption as well as in the dependence on energy in agricultural production. Therefore, it is advisable to reduce the consumption and dependence by replacing the energy sources used with alternative “free” sources (Kirikkaleli and Darbaz, 2021).

Like other commodities, energy prices can also be influenced by extreme events. The link between these natural or human-related extreme events and energy prices is very significant, since such events have considerable impact on the financial risk in the energy sector (Wen, Zhao and Chang, 2021). A recent example is the COVID-19 pandemic, which has caused a significant drop in energy prices, thus affecting negatively the global economy. In the short run, energy prices turned out to be very sensitive to the uncertainty caused by the pandemic. Compared to the development of natural gas and fuel oil prices, the impact on oil prices was determined to be larger. However, it was found that the degree of impact would grow with the change of the relationship from short-term to long-term (Khan, Su and Zhu, 2022). Another event that has shaken the global economy and significantly affected energy prices was Russia’s invasion of Ukraine. The main effect of this war may be a rapid increase in the already high inflation in Europe, which will naturally lead to a slowdown in the economic growth and a reduction in the standards of living of the population. Some of the European

countries have been dependent on Russia for energy, especially in terms of oil and natural gas, which accounted for up to 75 %. It can be expected that as a result of the Russian invasion of Ukraine, there will be several permanent changes in Europe, including strengthening of defence and acceleration of the so-called green transformation, or the transition from fossil fuels to renewables (Astrov et al., 2022).

The objective is to evaluate the development of electricity and natural gas in the last 6 years. To achieve this objective, the following research questions are formulated:

RQ1: How did electricity prices evolve in 2017 – 2022?

RQ2: How did natural gas prices evolve in 2017 – 2022?

RQ3: What was the influence of extreme events on energy prices in the monitored period?

### 2 Literary research

There is no doubt that extreme events have an impact on the global economy. The effects of these events on energy markets are subject to many studies. For example, Wen, Zhao and Chang (2021) focused their study on the relationship between extreme events and price risk in the energy sector. Using the SVAR model, the analysis of long time span data identified that epidemics have the greatest impact on oil price risk. Also, natural disasters increase the risk of natural gas prices, but on the contrary, the effect of terrorism is not significant. The impact of terrorist attacks on energy prices is also contradicted by another study that focuses on the relationship between geopolitics and energy trade. It uses a regression discontinuity method to simulate a natural experiment and analyses 17 emerging economies based on monthly data and a geopolitical risk index. The results show that wars and conflicts lead to an increase in energy trade (Liu et al. 2022).

Gong, Chen and Lin (2020) focused on oil price fluctuations. Using a time-varying vector autoregression model based on oil prices, they show that shocks caused by major events have a huge impact on oil price volatility and they adversely affect the world economy to a large extent. While periods of elevated oil prices attract a great attention, there is little research into the price of energy in the context of transportation. This research focuses on transport equity issues, including the impacts of fuel prices. Content analysis was used to review publications on the impacts of fuel prices, transport and urban contexts. The paper highlights the need for further studies looking at the interaction between energy, transport and land use and suggests a greater focus on transport equity (Leung et al. 2018)

In the last few years, a high attention has been paid in particular to investigating the impact of the COVID-19 pandemic on commodity market raw material prices trying to estimate their future development. De De Blasis and Petroni (2021) point out the impact of this particular pandemic on all areas of society, with energy markets being no exception. One implication is a reduced predictability of energy price volatility. The method of minute time series analysis is used to study changes in the effects between standard and renewable energies. The model has failed to predict fluctuations during periods of higher volatility during a pandemic while price guidance has been strongly influenced by the phases of virus spread. One of the studies conducted in China also endeavours to estimate price volatility of energy efficiency products during the COVID-19 pandemic, but unit root tests are used to derive the results there. Among energy products, volatility was significant for crude oil, natural oil, and gasoline and diesel oil, for example, due to the interventionist role of green fiscal policies (Yin et al. 2022). Dmytrow, Landmesser, and Bieszk-Stolorz (2021) conclude that commodities such as fuel oil, gasoline, or crude oil are only slightly associated with the COVID-19 pandemic whereas natural gas is strongly affected by the spreading of the pandemic. In this study, a dynamic time warping technique was used to

compare the time series of energy commodity prices with the time series of daily COVID-19 cases to assess the relationship between these positive cases and the energy commodity sector.

The conflict between Ukraine and Russia is causing great concerns and raises many questions about the future of the global economy. Both countries are large exporters of commodities and have a significant impact on food and energy security. Thus, sudden supply disruptions are causing global uncertainty in commodity markets (Ihle et al. 2022). In terms of commodity prices, strong dynamics can be observed recently due to this very ongoing conflict. Using a time-varying parameter vector autoregression method, the effects of this conflict on several markets and commodities such as oil and natural gas are investigated. Not only is high interconnectedness between all markets and commodities found, but changes in commodity markets can be considered the largest since the 2008 financial crisis (Alam et al. 2022).

There is no dispute that the COVID-19 pandemic and the conflict between Russia and Ukraine have affected the energy sector of economies around the world. It was identified from the impact analysis of these events across the energy system that they have caused not only fluctuations in energy demand, but also crude oil price shocks, energy price increases or energy security problems. The impacts of these crises on low-carbon transitions are also gradually observed. These efforts have resulted in political recommendations to implement robust and sustainable energy systems (Zakeri et al. 2022)

Jääskeläinen, Huhta and Syri (2022) studied the trend of electricity prices in Europe, which have climbed to high levels. Concerns about the affordability of energy prices deepened in 2022 when European countries sought to reduce their dependence on Russian fossil fuels due to the Russian invasion of Ukraine. This study based on a combination of legal and qualitative data analysis seeks to show the reasons for the rapid rise in electricity prices by using Finland as an example. The above analysis concludes that high energy prices are generally the result of multiple factors such as weather, economics or politics. The research also shows that the European market design essentially requires price variability to ensure market investment and energy security in the long term. Romania has produced an overview of the electricity sector illustrating the monthly trend in electricity consumption and instantaneous electricity production over the last few years. A quantitative analysis and a linear correlation analysis of market prices in the Eastern European region were used to show the monthly trend of average prices. The results show that electricity markets have experienced significant changes both in terms of prices and behavioural factors. Prices were shown to have fairly similar trends in several countries in the region over the examined period, with price correlations being stronger with higher levels of electricity grid interconnection (Busu, Călin and Mureşan, 2019).

Berrisch and Ziel (2022) studied the natural gas price modeling. This study used daily price data from 2011 to 2020 and an extensive descriptive analysis to develop time series models that capture all the stylized facts of the data. They include the effect of autocorrelation, seasonality, risk premium, temperature, storage levels, European emission allowance prices and the associated oil, coal and electricity prices. The results provide a thorough diagnosis of the model and all its components are interpreted in detail. In addition, future price trends were identified from a probabilistic forecasting study.

In order to reach the goal, content analysis was used to collect data. Subsequently, the descriptive time series analysis method was chosen for data processing to answer research questions 1 and 2 which allows to track the changes of prices over time and understand the trends and fluctuations in the time series. Finally, the method of relational analysis, specifically correlation, was used to answer the third research question.

### 3 Data and methods

#### Data

Data on electricity and natural gas prices are taken from the website kurzy.cz (Kurzy.cz, 2023). The average monthly prices of both energy commodities available for the period January 2017 – December 2022 will be used. Furthermore, there will be used data for the period when the Czech economy was influenced by a specific extreme event, an increment in the number of patients with COVID-19, in the period March 2020 – December 2022. The data will be taken from the website Onemocnění aktuálně, an official website of the Ministry of Health of the CR (MZČR, 2020).

All collected secondary data are presented in Appendix 1 and 2.

#### Methods

Data are processed using Microsoft Excel 2013. Time series of electricity and natural gas price data are processed using descriptive analysis. First, time series are expressed in the form of a graph. The mean value, spread and size of the dataset are described using statistical characteristics, such as the average, median (mean value), variance, and standard deviation, which is calculated by taking the square root of variance.

Next, the trend in the time series is graphically represented using a line (linear trend line) in the graph.

The existence of a statistically significant relationship between the development of energy commodity prices and the COVID-19 pandemic is determined using the correlation analysis. Correlation coefficient calculated using CORREL takes on values between -1 and 1. The value of 1 indicates a direct functional linear dependence between the variables; -1 indicates an indirect functional linear dependence between variables; if the correlation coefficient equals 0, there is no dependence between variables (Stuchlý 2012, p. 29). The next step is to compare the test statistic, which considers the calculated correlation coefficient and the data volume, with the so-called critical value. The critical value is taken from the tables of Student's distribution. The selected significance level is 5 %.

In order to answer RQ3, the following hypothesis is formulated:

H0: Extreme events have impact on electricity and natural gas prices.

H1: Extreme events do not have impact on electricity and natural gas prices.

The application of the selected methods brings the following results:

Graphical representation of electricity price development

Statistical characteristic of electricity price time series

Graphical representation of natural gas prices development

Statistical characteristic of natural gas time series

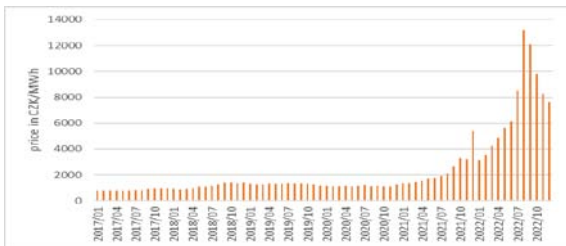
Level of correlation between energy commodity prices and the incidence of cases of COVID-19.

The authors assume that until 2020, electricity and natural gas prices were more or less stable but grew due to the COVID-19 pandemic. It is assumed that a positive correlation will be found between the prices of the above energy commodities and the increments in the number of patients with COVID-19. In the example of this pandemic, it will be demonstrated that extreme events can affect electricity and natural gas prices.

### 4 Results

Figure 1 shows the development of electricity prices in the monitored period using a bar chart.

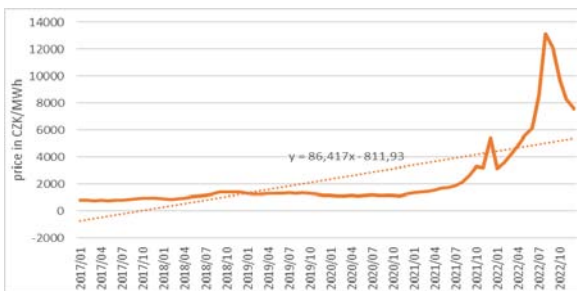
Figure 1 Electricity prices in the years 2017 – 2022



Source: Author.

The minimum values were recorded in May 2017, with the price being CZK 793.77 / 1 MWh, while the maximum values could be seen in August 2022, when the price of 1 MWh was 13 169 CZK. It can be seen from the graph that the values did not differ significantly until 2021, but approximately from the mid-2021, there was an increasingly sharp increase in prices.

Figure 2 Trend of the electricity prices time series

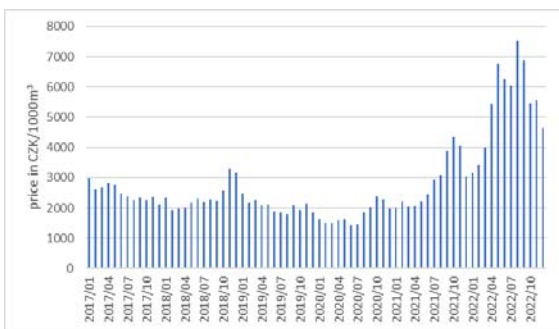


Source: Authors.

The line representing the trend can be expressed with the equation  $y = 86.417x - 811.93$ . Given the positive slope of the line, it is evident that prices grow over time; however, due to the dispersion of the values from the line, this trend cannot be considered statistically significant.

Figure 3 shows the development of natural gas prices in the monitored period.

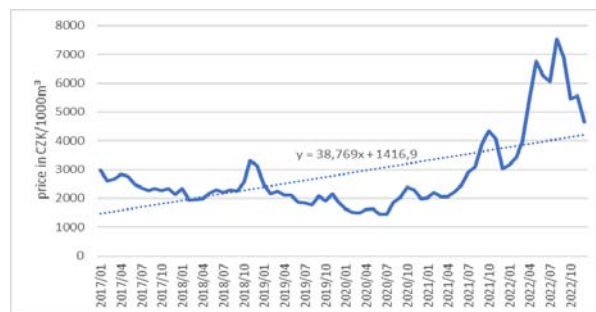
Figure 3 Natural gas



Source: Authors.

The minimum price was recorded in June 2020, specifically 1 436,9 CZK / 1 000 m<sup>3</sup>. The maximum price was achieved in August 2022 (7 530,5 CZK / 1 000 m<sup>3</sup>). Compared to electricity prices, natural gas prices show larger fluctuations even before the year 2021 but significant increases did not occur until mid-2021.

Figure 3 Trend in natural gas prices time series in 2017 – 2022



Source: Authors.

The line representing the trend in natural gas prices is expressed in the form of the equation  $y = 38.769x + 1416.9$ . As in the case of electricity prices, the slope of the line is positive, but the values are rather far from the trend line.

To determine whether there is a relationship between electricity and natural gas prices and the increments in the number of patients with COVID-19, it is necessary to calculate the correlation coefficient, test statistics, and find critical value. The results are presented in Table 3.

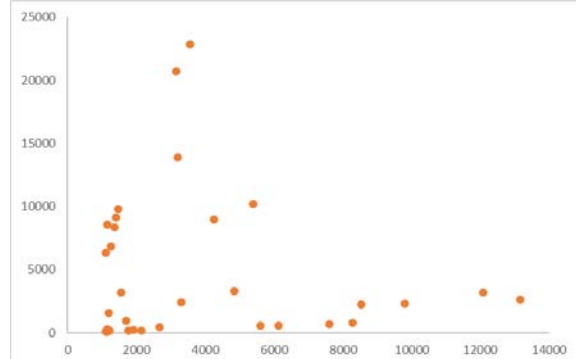
Table 1 Correlation between electricity and natural gas prices

	Electricity, COVID- 19	Natural gas, COVID-19
Correlation coefficient	-0.07435	-0.07362
Test statistics	-0.422	-0.418
Critical value	2.042	2.042

with the increments in the number of patients with COVID-19

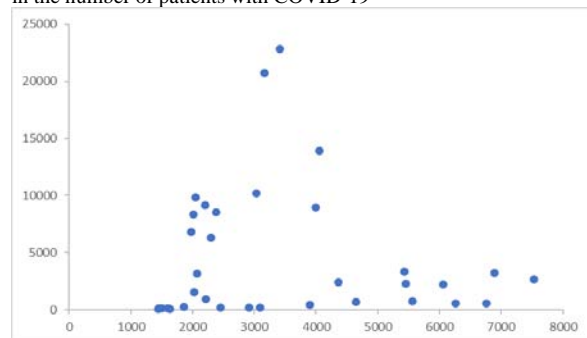
No correlation was confirmed for electricity or natural gas prices and the increments in the number of patients with COVID-19. The negative values of the correlation coefficients were very close to zero, which indicates there is no linear dependence between the monitored variables. The absolute value of the calculated test statistics is significantly lower for both commodities than the critical value at the 5% significance level; statistical significance thus has not been proved. For better clarity, Figures 5 and 6 below show the variance of the monitored values.

Figure 4 Correlation between electricity prices and increment in the number of patients with COVID-19



Source: Authors.

Figure 5 Correlation between natural gas prices and increments in the number of patients with COVID-19



Source: Authors.

The graphical representation of the level of correlation between the energy commodity prices and the positive increments of the number of patients with COVID-19 in the monitored period shows that no dependence between these values can be proven. Therefore, the null hypothesis stating that extreme values have impact on electricity and natural gas prices was thus rejected and the alternative hypothesis was accepted.

## 5 Discussion

Based on the results obtained, it is possible to answer the research questions:

### *How did electricity prices evolve in 2017 – 2022?*

Between 2017 and 2020, electricity prices in the Czech Republic were more or less stable, ranging on average between approx. 861 CZK/MWh and 1293 CZK/MWh. A more significant growth was recorded in the last two years, especially in 2022, with the average price reaching 7 250 CZK/MWh. The instability of prices in this year is also demonstrated by the value of the standard deviation, which has increased several times compared to the previous year, reaching 3,261 CZK/MWh and thus shows a relatively large dispersion of monthly prices from the average price for this year.

### *How did natural gas prices evolve in 2017 – 2022?*

As for the prices of natural gas, an upward trend can be seen in the monitored period. However, there were larger fluctuations compared to electricity prices. Average prices tended to decrease until 2021 when the average price of 1 000 m<sup>3</sup> was 2 686 CZK, which is only a slightly more than in 2017. The highest average price was recorded again in 2022 when it reached 5 508 CZK/1000 m<sup>3</sup>.

### *What was the influence of extreme events on energy prices in the monitored period?*

The influence of extreme events on electricity and natural gas prices was examined in the example of the COVID-19 pandemic. According to Dmytrow, Landmesser and Bieszk-Stolorz (2021), there is a correlation between the spread of the pandemic and the prices of natural gas, but this does not apply to other energy commodities. In the presented study, no correlation was found between the increments in the number of patients with COVID-19 and electricity or natural gas prices, which means that it was not possible to prove that the price increase was related to the COVID-19 pandemic. To determine the influence of this extreme event, it would probably be necessary to carry out a deeper analysis and include more factors that might have influenced the prices of energy commodities in relation to the pandemic.

## 6 Conclusion

The objective of the paper was to evaluate the development of electricity and natural gas prices in the Czech Republic in the last 6 years and to determine whether extreme events have an impact on the prices of these energy commodities. The objective of the paper was achieved. It was found that electricity prices

were more stable in the monitored period compared to natural gas prices. The comparison of the graphical illustration of the prices' development showed that the natural gas prices show larger fluctuations. However, the prices of both commodities recorded a significant growth approximately in mid-2021; the maximum values were achieved in August 2022.

For the purposes of demonstrating the dependence of these energy commodity prices on a specific extreme event, represented by the COVID-19 pandemic, the correlation method was used. However, the values of the correlation coefficients were negative and very close to zero, which means that the assumption that the average increments in the number of patients with COVID-19 is related to the development of energy commodity prices could not be confirmed. If we wanted to prove this, a more complex analysis, such as a regression model, would be necessary, which would include other factors – measures introduced by the state (closures of schools or businesses, restrictions on mobility) in connection with energy consumption during this period, or economic factors, such as the development of GDP during the pandemic.

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