THE PRICE DEVELOPMENT OF SELECTED ENERGETIC COMMODITIES

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Abstract: The aim of the paper was to evaluate the price development of electrical energy and inflation as a commodity in the course of the past 10 years. The production of electrical energy decreased from 83.7 TWh in 2010 to 70.6 TWh in 2020 in the Czech Republic in accordance with the results achieved by using the methods of descriptive statistics, time series, correlation analysis and regression analysis. The consumption of energy slightly increased. The proportion of production to consumption declined and consumption was higher than production in 2020. The prices of electricity reveal oscillations influenced by the conflict in the Ukraine. The use of the sources of energy changed, however, without specific trends. The dependence of prices on inflation is considerable and direct. Energy policy ought to deal with the dependence on import and support the domestic production of energy.

Keywords: Electrical energy, prices, inflation, development, consumption, production, import.

1 Introduction

Global macroeconomic conditions, inflation, economic policy uncertainty and monetary policy are important factors influencing the length of different phases of the commodity price cycle. In addition, a greater number of wars around the world are subsequently associated with shorter periods of booms and busts in commodity prices (Agnello et al., 2020). The ongoing geopolitical crisis that has emerged due to the war in Ukraine has created economic winners and losers. We adopt DS-ARDL and Cross-Quantilogram approaches to examine the impact of higher energy prices on commodity currencies during this war. (Sokhanvar et al., 2023) In analysing the risks associated with commodity investing, the authors were able to uncover interesting relationships between oil commodity prices and the prices of agricultural commodities such as wheat, corn, soybeans, and rice (Shahzad et al., 2018). Over the past 20 years, the evolution of electricity prices has been strongly influenced by the deregulation of electricity markets, the transition to a low-carbon energy system, and the growth of renewable energy sources. Electricity prices are important for electricity market coordination and long-term market analysis (Wyrwoll et al., 2021). Electricity prices in the Czech Republic have changed significantly over the last decade. Significant deregulation of the electricity market and the growth of renewable energy sources have led to greater price volatility (Dobeš et al., 2019).

The aim of the work is to evaluate the development of electrical energy prices and inflation as a commodity in the course of the past 10 years.
The following research questions were defined to achieve this aim:

RQ1: What was the proportion of generated, exported and imported electrical energy within the Czech Republic in the past 10 years?

RQ2: What was the development of the prices of electrical energy as a commodity in the past 10 years?

2 Literary research

Nguyen and Prokopczuka (2019) find that energy, metal, and grain commodities exhibit high jump correlations, while jumps in meat and soft commodities are barely correlated. Commodities may offer a lower correlation with traditional investments, meaning they may perform well in a market environment where traditional investments may weaken. In recent years, new models and techniques have been developed to predict electricity prices. One of the most recent innovations is the use of machine learning and artificial intelligence to develop forecasting models (González Romero et al., 2019). These models have been shown to be able to capture complex patterns in electricity price time series and provide more accurate forecasts than traditional statistical methods (Bessa et al., 2017).

Effective modelling and forecasting of electricity prices has become an important need for all electricity market participants in recent years. It enables them to develop effective supply strategies and make investment decisions. However, accurate price prediction is difficult due to specific electricity price issues such as periods of high volatility, seasonal patterns, calendar effects and non-linearity (Jan, Shah and Ali, 2022). Uncertainty about future electricity supply, demand, and prices has increased with the advent of smart grids and the increasing integration of renewables. As a result, it has become increasingly important to correctly forecast electricity prices (and load) using probabilistic models, which is essential for efficient planning and operation of power systems (Nowotarski and Weron, 2018). Deregulation has taken place in many countries to create a more efficient market. This change makes it easier to purchase electricity across regions and countries. Electricity market participants have an advantage in predicting future prices to optimize risks and profits, as well as planning for the future (Beigaite, Krilavioius and Man, 2018).

Another new feature is the integration of probabilistic models. These provide uncertainty ranges and allow market participants to better manage the risks associated with electricity prices (Nowotarski and Weron, 2018). These models also enable more efficient planning and operation of power systems. Electricity prices in the Czech Republic have changed significantly over the last decade, with significant deregulation of the electricity market and the growth of renewable energy sources leading to greater price volatility (Dobeš et al., 2019). As a result of these changes, electricity prices have become more sensitive to factors such as changes in demand, supply and fuel prices (Stávková et al., 2017). Electricity prices in the Czech Republic are influenced by many factors, including global macroeconomic conditions, inflation, economic and monetary policies, and war conflicts (Agnello et al., 2020). In addition, the growing reliance on renewable energy sources such as solar and wind power has increased uncertainty about future electricity supply, demand, and prices (Wyrwoll et al., 2021). Factors such as changes in electricity consumption, policy decisions, regulation, infrastructure investment, and climatic conditions also play an important role in determining electricity prices in the country (Jan, Shah, and Ali, 2022).

Content analysis will be used as the data collection method for all research questions. Data processing methods will include descriptive statistics, time series, correlation analysis and regression analysis. Each scientific question will list the specific methods that were used to calculate the results.

3 Data and methods

The data on electrical energy prices in the Czech Republic obtained from the official sources, such as Czech Statistical Office (ČSÚ, 2023) or the operator of electricity market (OTE, 2023), will be used for the analysis. The data include the average annual prices for households and industrial consumers in korunas for megawatt-hour (CZK/MWh). Apart from the prices of electrical energy, there will also be collected data on macroeconomic variables, such as inflation (ČSÚ, 2022), political events and the development of renewable resources in the Czech Republic. All the needed data are included in the attachment No.1. It is necessary to determine the following hypotheses in relation to the determined research questions:

Does inflation bear principal influence on the prices of electrical energy in the Czech Republic in the monitored period?

H0: Inflation bears influence on the prices of electrical energy in the Czech Republic in the monitored period.

H1: Inflation bears no influence on the prices of electrical energy in the Czech Republic in the monitored period.

The determined hypotheses will be examined on the 0.05 significance level.

Descriptive statistics

This method includes the calculation of fundamental statistical indicators, such as average, median, standard deviation, minimal and maximal values providing an overview on the division of electrical energy prices in the course of the past 10 years comparing the main operators in the electricity market. Furthermore, there will be determined a statistic of production, export and import of electrical energy within the Czech Republic in the past 10 years. On the basis of these data the ratio of export vs import will be determined.

Time series

The analysis of time series will be performed with the aim of identifying seasonal patterns, trends and cycles in the prices of electrical energy. There will be employed methods, such as moving average, exponential smoothing and decomposition of time series.

Correlation analysis

This method will be used to identify the relations between the prices of electrical energy and various macroeconomic variables, such as inflation, political events and a development of the sources of renewable energy. Pearson correlation coefficients between the prices of electrical energy and these variables will be calculated. The parameters of individual linear dependencies are given in the table below.

Table 1 the parameters of linear dependency

lin.dependency	**weak**	**medium**	**strong**
correl. coef.	r < 0.3	0.3 < r < 0.8	r > 0.8

Regression analysis

Regression analysis will be made with the aim of better understanding the influence of individual factors on the prices of electrical energy. Multipath regression model involving the price of electrical energy as a dependent variable and macroeconomic variables (inflation) as independent variables will be used. We may presume the concurrence of prices of individual operators, where prices will be dependent on the size of inflation, within the results. The individual analyses mentioned above will help us prove this assumption.

4 Results

Descriptive statistics

The table shows the annual statistics of generation, consumption, export and import of electrical energy in the Czech Republic from 2010 to 2020. The energy generation dropped from 83.7 TWh in 2010 to 70.6 TWh in 2020, while the consumption slightly rose. Energy export dropped while import rose which resulted in decreasing the export – import ratio from 5.88:1 in 2010 to 2.62:1 in 2020.

In the tables below there are averages, maxims minimums or standard deviations in accordance with individual operators and OTE in the past 10 years.

Table 2 The comparison of annual averages of individual operators

Year	**E.ON**	**PRE**	**ČEZ**	**OTE**
2010	4.6	4.5	4.4	1.1
2011	4.7	4.3	4.6	1.2
2012	4.6	4.5	4.8	1.1
2013	4.8	4.4	4.9	1.0
2014	4.3	4.1	4.3	0.9
2015	4.2	4.1	4.2	0.9
2016	4.2	4.0	4.1	0.8
2017	4.3	4.1	4.2	1.0
2018	4.5	4.3	4.3	1.2
2019	4.9	4.6	4.7	1.0
2020	5.0	4.5	4.9	0.9
2021	5.2	4.7	5.2	2.6
2022	6.3	5.7	6.5	6.1
2023	8.2	7.8	8.2	2.8

Source: ČSÚ, OTE-ČR, Authors.

Table 3 The standard deviations of individual operators

Year	**E.ON**	**PRE**	**ČEZ**	**OTE**
2010	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0
2013	0.0	0.3	0.0	0.0
2014	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0
2017	0.0	0.0	0.1	0.0
2018	0.0	0.2	0.0	0.0
2019	0.1	0.0	0.0	0.0
2020	0.0	0.0	0.2	0.0
2021	0.1	0.2	0.7	0.0
2022	1.1	0.8	0.0	0.0
2023	0.2	0.0	0.0	0.0

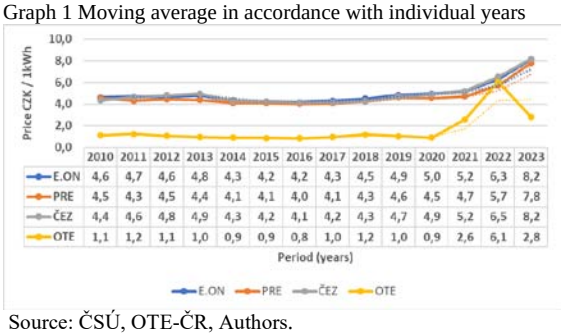
Source: ČSÚ, OTE-ČR, Authors.

When the values of minimal and maximal prices are analysed, there is a visible situation, when operators (sellers) have prices at the same level. When a purchase price (OTE) is compared, a percentage increase is visible. It is necessary to mention that all the fees related to distribution, EZO, seller's margin, etc., are included within the given increase.

Time series

It was found out within the analysis of available data by the method of moving average that the data of individual operators do not oscillate too much within the price range of individual years except for 2022, which was influenced by the conflict in the Ukraine in all respects.

Graph 1 Moving average in accordance with individual years



Source: ČSÚ, OTE-ČR, Authors.

Correlation analysis

Only the average prices of operators from 2010 and additional inflation values also from 2010 in accordance with individual years were used within correlation analysis.

Table 4 Pearson correlation coefficients.

E.ON	**PRE**	**ČEZ**	**OTE**
0.934608	0.915	0.94324	0.837711

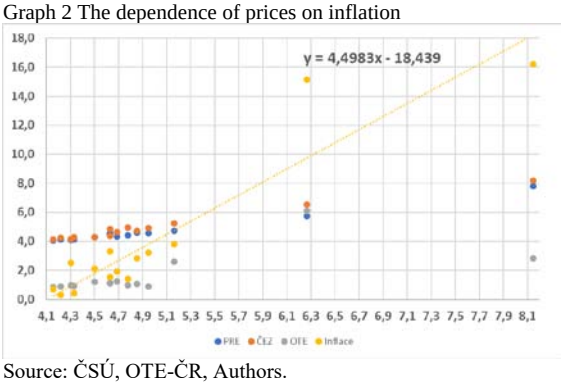
Source: ČSÚ, OTE-ČR, Authors.

The direct dependence of electrical energy prices on the size of inflation is visible from the obtained data. The data of all the operators are closer to the value of 1, which means in this

interpretation that that all values are in, so called, strong linear dependence against inflation.

Regression analysis

Graph 2 The dependence of prices on inflation



Source: ČSÚ, OTE-ČR, Authors.

It was found out within the results of regression analysis that inflation (violet points) bears influence on the prices of electrical energy. It confirms the determined hypothesis HO: Inflation bears influence on the prices of electrical energy in the Czech Republic in the monitored period.

5 Discussion

RQ1: What was the proportion of generated, exported and imported electrical energy within the Czech Republic in the past 10 years?

It is possible to observe several key trends in the production, consumption, export and import of electrical energy in the Czech Republic from 2010 to 2020 within the analysed data. Production vs consumption: There was a decreasing trend in the production of electrical energy in the Czech Republic, when it dropped from 83.7 TWh in 2010 to 70.6 TWh in 2020. On the contrary, there was a slight increase of energy consumption from 70.2 TWh in 2010 to 71.9 TWh in 2020. This trend indicates a growing dependency of the Czech Republic on the import of energy to satisfy its domestic demand. Production vs consumption ratio: The ratio of production to consumption gradually decreased from 1.19 in 2010 to 0.98:1 in 2020. This trend shows that the production and consumption of energy are increasingly becoming balanced in Czechia. In 2020 the consumption of energy in the Czech Republic was higher than its production for the first time in 10 years.

Export vs Import: The export from the Czech Republic dropped from 14.7 TWh in 2010 to 8.9 TWh in 2020, while the import gradually rose from 2.5 TWh in 2010 to 3.4 TWH in 2020. This trend shows that Czechia is increasingly becoming dependent on the import of energy to satisfy a growing domestic demand. Export vs import ratio: The ratio of export to import gradually decreased from 5.88 in 2010 to 2.62 in 2020. This trend shows that the difference between the export and the import of energy is increasingly diminishing in Czechia.

These trends indicate that Czech energy policy and strategy ought to take into consideration a growing dependency on the import of energy and seek ways how to increase a domestic production of energy to be able to satisfy a growing demand and simultaneously retain an energetic independence of the country.
RQ2: What was the development of the prices of electrical energy as a commodity in the past 10 years?

E.ON: The prices of electrical energy from E.ON oscillated between 4.2 and 4.8 CZK/kWh from 2010 to 2019. In 2020 there was a slight increase to 5.0 CZK/KWH and to 5.2 CZK/kWh in 2021. In 2022 there was a marked increase to 6.3 CZK/kWh and to 8.2 CZK/kWh in 2023.

PRE: The prices of PRE oscillated between 4.0 and 4.6 CZK/kWh from 2010 to 2019. In 2020 there was a slight decrease to 4.5 CZK/kWh and in 2021 there was an increase to 4.7 CZK/kWh. In 2022 there was a significant increase to 5.7 CZK/kWh and in 2023 there a rise to 7.8 CZK/kWh.

ČEZ: The prices of electrical energy from ČEZ oscillated between 4.1 and 4.9 CZK/kWh from 2010 to 2019. There was a slight increase to 4.9 CZK/kWh in 2020 and to 5.2 CZK/kWh in 2021. There was a significant increase to 6.5 CZK/kWh in 2022 and to 8.2 CZK/kWh in 2023.

Generally speaking, the prices of electrical energy in the Czech Republic increased in the course of the past 14 years, whereas the biggest rise was recorded in 2021 and in 2022.

RQ3: What was the proportion of using electrical energy in the Czech Republic in the past 10 years?

Renewable resources containing wind energy, solar energy, water and biomass displayed a marked oscillation in the course of years. They reached their peak amounting to 10.95% in 2014 followed by another peak amounting to 11.77% in 2015. However, it was followed by a decrease to the lowest value of 3.9% recorded in 2019. This trend may be influenced by various factors including the changes in the policy of renewable energy, technological innovations and economic conditions. Fossil resources, including lignite, coal, natural gas and oil used to be a dominant source of energy in the past. They reached their peak amounting to 59.53% in 2016, however, the proportion decreased to 52.50% in 2020. This decline may be the consequence of an effort to reduce greenhouse emissions and a transfer to cleaner sources of energy. Oil and oil products amounted to a small share in the sources of energy with a peak of 0.15% in 2019. Secondary resources and other resources also constituted a small proportion with a peak of 2.73% in 2017.

Nuclear resources, including the energy from nuclear power plants, showed a slight increase. Their peak was a 40.75% proportion in 2020, which is a significant rise comparing to 30.36% in 2016. This trend may be influenced by a growing recognition of nuclear energy as a low carbon source of energy.
The results manifest that the energy mix of the Czech Republic has changed in the course of time, whereas it seems to take a direction towards both a diversification of the sources of energy and an attempt to reduce the dependence on fossil fuels.

6 Conclusion

In the course of the past 10 years the development of electrical energy prices as a commodity has been quite dynamic in the Czech Republic. It was found out on the basis of an analysis of available data that the prices of electrical energy demonstrate certain volatility and are influenced by various factors.

The average electrical energy prices of individual operators (E.ON. PRE. ČEZ and OTE) have slightly changed in the course of years. Nevertheless, these differences were relatively small between 2010 to 2020. Average prices were around CZK 4-5/1kWh for households and CZK 0.9-1.2kWh for industrial consumers.

The electrical energy prices of individual operators increased in the course of monitored period, however, it differed in terms of extent in the case of individual operators. The most significant rise of prices was recorded in 2022 when there was a significant price rise of all operators as a consequence of geopolitical events in the Ukraine.

Correlation analysis showed a heavy positive dependence in terms of electrical energy and inflation. It indicates that inflation bears a significant influence on the prices of electrical energy in the Czech Republic. The high values of Pearson correlation coefficient existing in the case of all operators show a great dependency in terms of inflation and electricity prices.

With regard to these findings, it is important to take into consideration an inflation factor during planning and predicting the prices of electrical energy. Growing inflation may significantly influence the prices of electricity and it is important for energy policy and regulation to reflect such impacts.

RQ3: What was the proportion of using electrical energy in the Czech Republic in the past 10 years?

The analysis showed that the use of electrical energy in the Czech Republic slightly changed in the course of the past 10 years. Renewable sources of energy, such as solar and wind energy, gradually grew in significance, whereas their share oscillated between 10% and 15% of the total production of electrical energy.

Classical sources, such as coal fired and nuclear power plants, continued to dominate in the energy mix of the Czech Republic. Coal fired power plants provided the majority of electrical energy production, although, there has been a considerable pressure regarding the reduction of greenhouse gases in the past years.

Nuclear energy remained an important source of energy with a 30-35% share of total production. Although it is a low-carbon source of energy, there has been a continuous discussion about the future of nuclear energy and its possible substitution with renewable resources. Similarly, there has been a drop in the proportion of oil power plants, which have become less significant in the production of electricity.

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Primary Paper Section: A

Secondary Paper Section: AH