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PRICE TRENDS IN THE GLOBAL ELECTRICITY MARKET

The relevance of the research topic is determined by the need to adapt to rapid global changes in the electric power industry, which is associated with a change in the structure of the energy balance, the strengthening of geopolitical factors, the impact of climate change, economic globalization, new regulatory requirements, and the rapid development of energy storage technologies and smart networks. These changes lead, on the one hand, to challenges in ensuring energy security, and on the other hand, contribute to significant price volatility in the electricity market. As a result of the influence of

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ЦІНОВІ ТРЕНДИ СВІТОВОГО ЕЛЕКТРОЕНЕРГЕТИЧНОГО РИНКУ

Актуальність теми дослідження визначається необхідністю адаптації до швидких глобальних змін в електроенергетичній галузі, що пов'язано зі зміною структури енергетичного балансу, посиленням геополітичних факторів, впливом кліматичних змін, економічною глобалізацією, новими регуляторними вимогами та стрімким розвитком технологій зберігання енергії та інтелектуальних мереж. Ці зміни призводять, з одного боку, до викликів у забезпеченні енергетичної безпеки, а з іншого – сприяють значній волатильності цін на ринку електроенергетики. Внаслідок впливу глобальних цінових тенденцій і пріоритетів розвитку

global price trends and world energy development priorities on the domestic electricity sector, the study of these trends is of great importance for Ukraine. The aim of the research is to establish the price trends of the global electricity market with the determination of the key factors of price growth in the context of challenges for Ukraine regarding the stabilization of electricity prices. The research is based on the hypothesis that the factors that determine the trajectory of price changes on the international electricity market are also characteristic of the Ukrainian electricity market. The research was conducted using the methods of statistical analysis, synthesis, grouping, tabular and graphical display of results. A retrospective analysis of price dynamics on the global energy market was carried out, which showed a faster pace of price changes for energy products than for other products, with a faster increase in oil prices than for coal. The current trends in the development of changes in electricity prices were analyzed, the reasons for their rapid growth in 2021 were identified, and it was noted that in some countries, such as the USA and China, prices remained stable. Using the example of the EU countries, it has been analytically proven that electricity tariffs depend on the price structure. The factors that affect pricing in the field of electricity in the world are determined: energy prices, global crisis phenomena, the amount of available supply, weather conditions, supply chain problems, grid infrastructure and distribution, the structure of the electricity market, the share occupied by taxes and fees in electricity prices and the purchasing power of the population. The current state of the electricity market of Ukraine is analyzed, which is characterized by a price imbalance, especially in the retail sector, a settlement crisis between the main market participants, a lack of real competition, limited transparency of the market and opportunities for manipulation on it, and the imperfection of the legislative framework. These factors are exacerbated by external negative influences in the form of a full-scale Russian invasion due to the destruction of electric power infrastructure and loss of capacity.

Keywords: electricity, electricity price, global electricity market, energy security, electricity sector of Ukraine.

світової енергетики на вітчизняний електроенергетичний сектор дослідження цих трендів має важливе значення для України. Мета статті полягає у встановленні цінових тенденцій світового ринку електричної енергії з визначенням ключових чинників зростання цін у контексті викликів для України щодо стабілізації цін на електроенергію. В основу дослідження покладено гіпотезу про те, що чинники, які визначають траєкторію зміни цін на міжнародному ринку електроенергії, властиві також й для українського електроенергетичного ринку. Дослідження проведено з використанням методів статистичного аналізу, синтезу, групування, табличного та графічного відображення результатів. Здійснено ретроспективний аналіз цінової динаміки на світовому енергетичному ринку, який показав швидші темпи змін цін на енергетичні товари, ніж на іншу продукцію, при цьому швидше зростання цін на нафту, ніж на вугілля. Проаналізовано сучасні тренди розвитку зміни цін на електроенергію, ідентифіковано причини їх стрімкого зростання у 2021 р., до того ж зауважено, що в деяких країнах, як-от США та Китай, ціни залишалися стабільними. На прикладі країн ЄС аналітично доведено, що тарифи на електроенергію залежать від структури ціни. Визначено чинники, які впливають на ціноутворення у сфері електроенергетики у світі: ціни на енергоносії, світові кризові явища, обсяг доступної пропозиції, погодні умови, проблеми ланцюга поставок, грід-інфраструктура та розподіл, структура ринку електроенергії, частка, яку займають податки та збори в ціні на електроенергію та купівельна спроможність населення. Проаналізовано сучасний стан електроенергетичного ринку України, який характеризується ціновим дисбалансом, особливо у роздрібному секторі, кризою розрахунків між основними учасниками ринку, відсутністю реальної конкуренції, обмеженою прозорістю ринку й можливостями маніпулювання на ньому, недосконалістю законодавчої бази. Ці фактори посилюються зовнішніми негативними впливами у вигляді повномасштабного російського вторгнення через руйнування електроенергетичної інфраструктури та втрату потужностей.

Ключові слова: електроенергетика, ціна на електроенергію, світовий електроенергетичний ринок, енергетична безпека, електроенергетичний сектор України.

JEL Classification: H56, L94, Q41, Q43.

Introduction

A well-developed energy system is a key factor in social and economic development, which is achieved by ensuring everyone's access to affordable, reliable, sustainable and modern energy. Therefore, the creation of energy policy is one of the most important areas of activity of state authorities.

Between 2010 and 2020, the global level of access to electricity increased significantly from 83 to 91%. The number of people without access to the grid decreased from 1.2 billion in 2010 to 733 million in 2020. In 2020, 76% of the world's population without access to electricity lived in 20 countries, 15 of which were in southern Africa of the Sahara (IEA; IRENA, 2022).

The last 4 years were as a period of almost unprecedented upheavals in the European and global energy markets, a time of great international economic and political instability. First, the 2020 COVID-19 pandemic, which led to a sudden sharp drop in energy demand and energy prices, as lockdown restrictions around the world caused household consumption and industrial production to fall. The gradual opening of society in 2021 and the rapid recovery of demand have contributed to a rapid increase in energy prices – to higher price levels than ever before. The origins of the second of these shocks, the gas supply crisis, were laid back in the summer of 2021, when Russian state-owned Gazprom failed to replenish its gas storage facilities in Western Europe and refused to offer additional supplies of natural gas on European spot markets. The crisis was further aggravated by Russia's preparations for the invasion of Ukraine and its beginning in February 2022. Sanctions and counter-sanctions led to a sudden reduction in Russian gas supplies to the EU, which could not be compensated in time with an additional gas pipeline or LNG gas or other fuel.

The combination of these economic and geopolitical factors has caused gas and electricity prices in Europe to rise to peaks that no one could have previously predicted, with serious consequences for European households, industry, the economy in general and public finances. Together, they have focused an unprecedented level of attention on various aspects of energy policy, especially on security of supply, the competitiveness of European industry, the survival of small and medium-sized enterprises (SMEs) and energy affordability for European households.

The importance of the research topic is enhanced by the fact that in 2021 there was an increase in both energy consumption and prices, which significantly contributed to the growth of household expenses in this area. This can lead to an increase in the number of households at risk of energy poverty (Sharma et al., 2021). Recently, the problem has worsened due to the war in Ukraine. Energy poverty is a serious problem for the EU (European Commission, 2020) as it can lead to further inequities and inequalities, which can have a negative impact on health (Sovacool, 2017).

Electricity is an important determinant of social and economic development (Ouédraogo, 2010). In the long run, this has positive effects on

economic development as well as private and public sector development, including education and health (Zhang, 2019). These relationships are often multidimensional (Aklin et al., 2016) and multidirectional (Riva, 2018).

Close attention of foreign scientists is paid to the issue of price trends in the development of the electric power industry. In the work of Dragasevic et al. (2021) investigated the electricity market of Montenegro by applying a regression model, conducted a study of factors affecting the price of electricity, such as electricity production costs, transmission and distribution costs, as well as fees for market organization and electricity supply.

The effect of market deregulation (the purpose of which is to open the market to competitors (another electricity producer)) on reducing the price of electricity was studied by Andersson & Bergman (1995). The authors found that deregulation by default does not mean that individual producers will not affect the market price, which can make the fight against price uncertainty even more intense.

A study of electricity consumption and its impact on demand in various market forms is given in Ying et al. (2017).

Electricity is the second largest source of final energy consumption by households (Eurostat, 2020), which is mostly used for lighting and the operation of household appliances (Cabeza et al., 2014), and is also a source of heating and cooling (Krarti & Aldubyan, 2021).

The literature is described numerous examples of energy injustice and inequality that directly or indirectly affect households. The emergence of energy inequity can lead to uneven distribution of risks and benefits across multiple dimensions, including countries, social groups, and individuals. As stated in the work of Banerjee et al. (2017), energy injustice and inequality can be associated with all forms and stages of energy collection and transformation from collection to final use.

An example of energy injustice and imbalance is the energy burden that occurs when some households pay a disproportionately high percentage of their income to cover the cost of energy services. Bednar & Reames (2020) provide another example of energy poverty, where households cannot afford the energy needed to support daily life.

Recent studies have measured the impact of renewable sources on total energy consumption (Frodyma, 2017; Burgos-Payán et al., 2012; Ćosić et al., 2012; Brand & Zingerle, 2011), but there are relatively few studies that focus on the impact of renewable energy on the price of electricity (Perez & Garcia-Rendon, 2021; Azofra et al., 2015; Moreno et al., 2012) and, as a result, on changing the market structure.

The very price of energy carriers was the subject of many investigations. This is partly influenced by the wholesale market price as well as the distribution fee (Zhimin Wang et al., 2013). The wholesale market price is not fully passed on to the consumer due to various types of surcharges at the national level. For this reason, it is not a fully liberalized market. In the

work of Pepermans, you can find a description of the process of liberalization of the electricity market in the EU (2019). The EU's introduction of three directives in this area did not bring significant changes in this regard, for example, it did not reduce concentration or reduce energy prices. As noted by Lave et al., the situation may continue until a suitable competitive market is established (2004).

Therefore, a thorough analysis of foreign sources showed that, along with studies of individual price formation factors and their impact on household incomes, there are few studies devoted to current trends in electricity price dynamics in the context of the causes and consequences of such price shocks. This leads to the need for a scientific search for new ways and answers to the rapid increase in electricity prices in the direction of determining the causes and identifying the factors that lead to such an increase in order to predict and develop appropriate solutions to price shocks.

The energy sector of Ukraine is an important part of the global energy system, so it cannot remain aloof from the main directions of its development. Its priority should not be so much meeting current needs as preparing for the challenges that will determine the future, taking into account global energy trends.

The aim of the research is to establish the price trends of the world electricity market with the determination of the key factors of price growth in the context of challenges for Ukraine regarding the stabilization of electricity prices. The article puts forward a hypothesis regarding the significant impact of price trends on the world electricity market on the formation of electricity prices in Ukraine.

The main methods of research and implementation of the assigned tasks are methods of statistical analysis, synthesis, grouping, tabular and graphical display of results. Analytical and statistical data of Global Financial Data (GFD), European Commission (EC), International Energy Agency (IEA), Eurostat, Low Carbon Ukraine (LCU) project, GMK Center, National Commission for State Regulation in the spheres were used of Energy and Utilities (NCSR).

The structure of the research consists of four sections. The first one is devoted to retrospective studies of the formation of electricity prices in the world, the second section examines the current dynamics of prices on the global electricity market, the third section identifies the factors influencing pricing in the field of electricity, the fourth section defines the current trends of the electricity market of Ukraine.

1. Historical aspects of electricity price formation in the world

Looking back in history, from the 1200s to the 1800s, the main energy resource of the economy was firewood, while coal and lamp oil acted as secondary resources. Each in its own way provided different types of energy

for cooking, heating and electricity. Global Financial Data (GFD) data for firewood prices start from 1252, coal prices from 1447, and lamp oil prices from 1272. Although firewood was the main energy source from 1200-x to the 1800s, in the 1800s they were gradually replaced by electricity and gas. This is how energy was introduced directly into the house (Why are electricity prices rising again?, 2023).

In the 1860s, oil was discovered in Pennsylvania, which quickly replaced other sources of energy. At that time, the price of a barrel of oil was 20 dollars. US, but due to oversupply, the price quickly dropped to 10 cents by the end of 1861, making it extremely cheap.

Interestingly, by combining historical data for coal, coal gas, firewood, lamp oil, whale blubber, petroleum oil and natural gas, the GFD has created a commodity energy price index spanning the past 750 years.

Various studies have compared the behavior of energy prices with the prices of agricultural and industrial goods over the last century. Among the three, energy prices have increased the most, more than 500 times over the past 750 years, while manufactured goods have seen the least increase in price. A study of the dynamics shows that there were long periods of hundreds of years when the price of energy hardly changed, in particular between 1350 and 1550 and between 1700 and 1900. However, the 1900s and 2000s turned out to be a wild period, but in general growing changes in prices for energy carriers and other goods. It should be noted that industrial goods, in particular metals and non-food agricultural goods, have consistently increased in price less than other goods. In fact, the fall in the prices of manufactured goods in the 1930s returned the index to the level of the mid-16th century. Since then, prices for industrial goods have risen faster than for agricultural goods, but still not as fast as energy prices. Of the three main commodity indices that the GFD calculates for energy, agriculture and industry, the energy index has grown the most over the past 750 years. Between 1252 and 1970, energy prices increased 60 times.

Over the past 50 years, energy prices have rapidly outpaced agricultural commodity prices, particularly due to significant price increases in the 1970s and 2000s.Commodity prices have changed dramatically since 1970. From 1970 to 2016, the agricultural index increased almost fourfold, the industrial index increased tenfold, and the energy index increased thirtyfold! Thanks to comprehensive research, it is possible to understand the anomalous behavior of commodity prices, which has existed for the past 40 years and has broken the 700-year trend of relatively uniform growth in energy prices in the first place.

Interestingly, three global spikes occurred during wars: the 1810s during the Napoleonic Wars and the Wars of 1812, the 1860s during the American Civil War, and the 1910s during World War I. The first two spikes were followed by forty-year price falls as a return to the peacetime average. After the last two spikes in energy prices in the 1970s and 2000s, there has

yet to be a reversion to the mean. While supply-side factors, primarily shortages, caused energy prices to soar in the 1970s, strong demand from China and other countries led to higher prices in the 2000s. and industrial goods have similar prices, while the growth of prices for agricultural products was more stable.

Of course, the interplay between coal and oil prices with respect to the effect on the hindsight of energy prices is remarkable. Over the long term, the price of coal has risen steadily, following a 500-year trend that began in the 1500s. Even more surprising is the fact that the prices of oil and other energy resources showed no upward trend from the late 1500s to the 1930s During the 1900s, both oil and coal prices increased steadily, but over the past 100 years, oil prices have risen five times faster than coal prices due to the increased demand for oil relative to coal.

The dynamics of prices over the centuries demonstrate that the rise in electricity prices is characterized by the globality of the process and periodicity. This process is present in most countries of the world and occurs under the influence of global and country-specific factors. In the framework of tariff increases, states mostly provide assistance to consumers (especially households), which is taken into account in the budget of countries. But, despite this, citizens all over the world face rising energy prices and an increase in the cost of living.

In the world, it is political and economic factors that cause a global energy shortage, such as fluctuations in the prices of coal and oil. This leads to changes in the price of electricity for retailers, and therefore the price of electricity for customers.

2. Current electricity price trends

The reduction in economic activity in 2020 due to the quarantine measures related to COVID-19 led to historically low wholesale electricity prices in 2020: the EU day-ahead average price was €36/MWh.

The economic recovery following the easing of measures related to COVID-19, together with rising tensions with Russia, culminating in the Russian invasion of Ukraine, led to an increase in wholesale electricity prices, which reached an unprecedented level in the EU: average price a day ahead in the first half of 2022 (199 EUR/MWh) is four times higher than the average price in 2010-2020.

In the first half of 2021, the recovery of the global economy was the main driver of wholesale prices, together with increased spending on carbon emission allowances in response to the proposed plans to strengthen the EU energy system under the Commission's Fit for 55 proposal. The increase in gas prices, partly driven by the preparation Russia before the war, caused an increase in electricity prices from the 3rd quarter. 2021. Limited short-term options for replacing gas-based electricity generation with other fuels, as well

as shortages in hydropower (due to low water levels) and nuclear power (both due to unplanned repairs and scheduled shutdowns) also caused prices to remain high for a long period.

Around the world, other regions also saw an increase in electricity prices. Japan has experienced the same price increases as the EU due to its heavy reliance on LNG imports for power generation. Several other G20 countries (South Korea, Turkey, India, South Africa) also showed significant price growth in 2021 (and continued into 2022), but the rest of the G20 did not. For example, prices in the USA remain low and stable compared to the EU (*Figure 1*).

Prices in Japan increased significantly after the 2011 Fukushima accident and the subsequent closure of the nation's nuclear power plants, and remained significantly higher than in the EU until 2016. Between 2016 and 2020, prices were somewhat comparable, although prices remained higher in Japan, even through the peak of Japanese prices in December 2020 – January 2021 due to cold weather, LNG supply shortages and failures in the market mechanism (Koichiro, 2021). In both markets, electricity prices are driven by global LNG prices and followed similar growth trajectories through 2022.

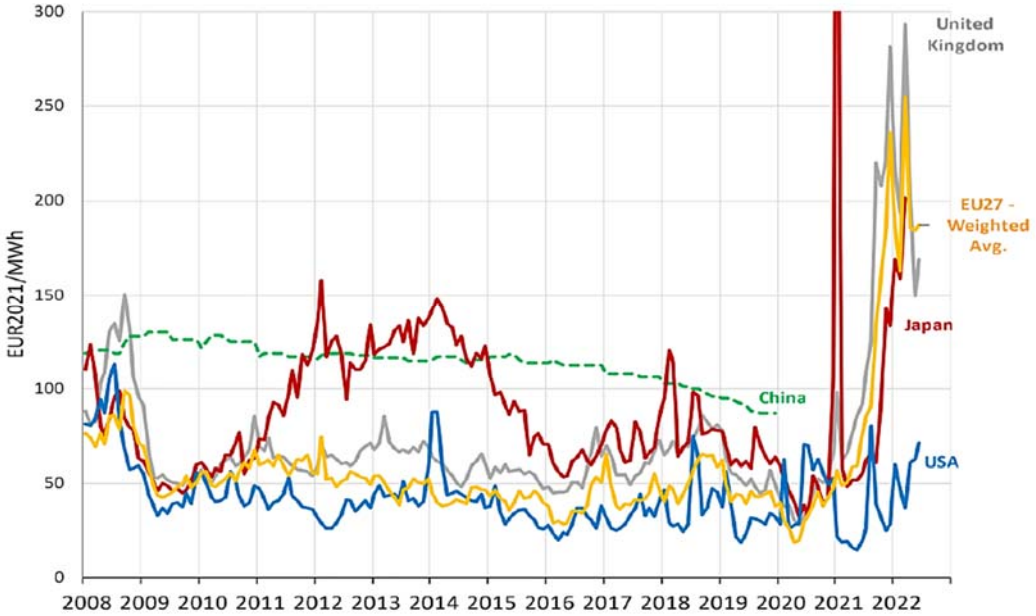

Figure 1. Dynamics of average monthly wholesale electricity prices per day in the EU, the US, the UK, Japan and China

Source: (Study on energy prices and costs, 2024).

China's wholesale electricity markets are still developing, but proxy prices (for large industrial consumers) have been relatively stable with a small continuous decline between 2017 and 2020. Data beyond 2020 are not available, but upward pressure on prices in 2021 and 2022 is considered strong due to rising coal prices (Integral, 2022).

Electricity prices in the United Kingdom have not been much different from the EU average over time, usually being slightly higher than the EU average. Their similarity stems from most of the same market factors, as well as the large capacity (both electricity and gas) between the EU and the UK.

Regarding trends in wholesale electricity prices in other G20 countries (Australia, Brazil, Canada, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa, and Turkey), it can be noted that consistently low electricity prices were observed in Canada and Russia between 2008 and 2022. The former are due to a large amount of hydropower and nuclear power generation (they together provide more than 80% of the electricity balance), and the latter are due to artificially low (subsidized) prices. Prices in Brazil and South Korea are highly volatile, reaching peaks between 2012 and 2015.

None of these countries experienced the same price spike as the EU-27 in 2021–2022. However, similar price spikes are evident in many (but not all) other G20 countries, notably India, South Africa, Turkey and South Korea. Prices in other countries did not rise as much, they are mainly correlated with countries that are mostly self-sufficient in fuel for electricity production.

Renewable energy continued to grow in the EU's electricity mix to 36% in 2021, particularly thanks to increased wind and solar generation. Fossil fuel demand for power generation has been slowly declining, but current high gas prices have led to increased use of coal and lignite for power generation and increased LNG imports to offset reduced pipeline gas supplies from Russia.

Also, 2021–2022 a reduction in nuclear power production was noticed, due to plant decommissioning and unplanned maintenance outages (mainly in France), which further contributed to the tension in the supply of electricity in the EU.

Although there are some differences in prices between European regions, prices in all regions showed the same trend of very high prices. The northern region was the only region where prices were significantly lower, but still high, a result of hydropower being often a marginal technology due to advantages, while in most other regions expensive fossil fuel plants are the marginal unit. From 2021 onwards, regions with a high dependence on fossil fuels and limited connectivity, such as Italy and the UK, will consistently have slightly higher prices.

The increase in retail electricity prices for household consumers between 2019 and 2021 is due mainly to the increase in wholesale prices, as already indicated. In the case of households, the average retail price in the EU-27 increased by 8% (+16 EUR/MWh) to 231 EUR/MWh in 2021.

Data for the first half of 2022 showed that retail prices are lagging behind wholesale price trends, with average household prices rising to €311/MWh (+32%). A significant tax cut (by 43%) has helped moderate this increase, with average taxes around €20/MWh lower by mid-2022 than in 2021.

The rapid development of the wholesale electricity market resulted in electricity prices for households being lower than the wholesale price in most EU markets. This shortage is an important factor in the financial difficulties and bankruptcy of some electricity suppliers.

Compared to the international level, retail prices for households in the EU remain higher than in almost all G20 countries. Only prices in Australia, Great Britain and Japan are at a similar level. Industrial prices also rose, except in China and the US. This indicates a deterioration in the global industrial competitiveness of the EU, as prices in the EU were among the highest before the energy crisis.

Electricity prices vary widely around the world, and sometimes even within a country, depending on factors such as infrastructure, geographic location, and politically determined taxes and fees.

Regarding the component prices for households, for example in 2021, the share of energy supply, network costs and taxes in the total price is very different between EU member states. In *Figure 2* shows that while energy and supply costs tend to account for the largest share of the total price, the shares of the various components vary widely. For example, in Germany and Denmark, the costs of energy and supplies are much lower than the costs of taxes and other charges. In countries such as Malta and Greece, the cost of electricity and supply is over 60% of the total. Network costs are the lowest in Bulgaria, Denmark, Portugal and Italy. The highest network costs are recorded in Belgium (€105/MWh), Ireland (€94/MWh) and Sweden (€80/MWh). The lowest component of taxes and fees is in Malta. In the EU-27, the share of taxes and charges in the total price of electricity for households decreased by 4%, while network costs increased by 6% and energy and supply increased by 23% between 2019 and 2021.

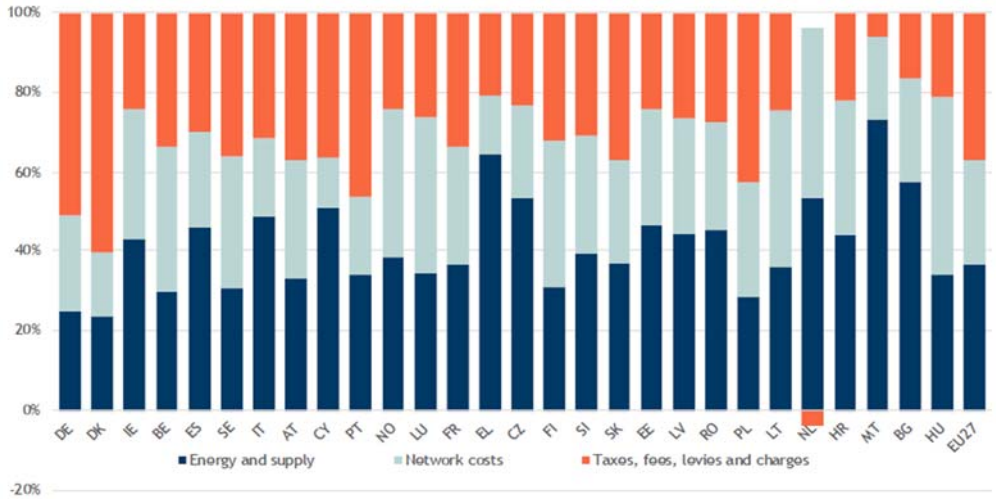

Figure 2. Composition of electricity prices for EU households in 2021, % of total price

Source: (Study on energy prices and costs, 2024)

Thanks to the large production of crude oil and natural gas, countries such as Iran, Qatar and Russia have some of the lowest electricity prices in the world – in these countries, the average family pays less than 0.1 USD. US per kWh. In contrast, countries that depend on imported fossil fuels for electricity production are more vulnerable to fluctuations in market prices. The largest importers of natural gas in Europe in 2022 were Italy and Germany, where this source of energy makes up a significant share in the structure of the energy balance. The countries have some of the highest electricity prices in the world, having been hit by the energy crisis of 2022. Overall, Western Europe is the most expensive region to purchase electricity for households, while many major energy producing countries, such as Russia and Saudi Arabia, offer their residents the cheapest average rates.

The factors that influenced the formation of the electricity price are: the global energy crisis, high inflation and interest rates, the energy transition to net zero and decarbonization, digitalization and decentralization. Along with this, many other common factors underlie these factors, such as weather conditions and market forces, which are mentioned a lot and amplify or offset their effects. These drivers and trends are expected to continue to influence to varying degrees in 2024 and require shaping responses from governments, regulators, utilities and customers. In general, according to the analysis of recent years, a decrease in the demand for electricity in developed economies was predicted due to the permanent consequences of the global energy crisis and the slowdown in economic growth. In 2024, when expectations about the economic outlook show improvement, global electricity demand growth is expected to recover to 3.3% (Raza, 2023, December 31).

Since the beginning of 2024, electricity prices in Europe have been declining significantly. Thus, in February, average monthly wholesale electricity prices per day in major European markets fell, with most of them reaching their lowest level since the first half of 2021:

Sweden – 44.4 EUR/MWh (-45%);
Spain – 39.9 EUR/MWh (-35%);
France – 58.4 EUR/MWh (-23.8%);
Germany – 61.36 EUR/MWh (-19.9%);
Italy – 87.6 EUR/MWh (-11.6% m/m) (Yermolenko, 2024).

In Ukraine, the weighted average price of electricity on the day-ahead market (DAM) in February 2024 decreased by 15.3% compared to the previous month to UAH 3268.6/MWh (EUR 78.6 at the exchange rate of UAH 41.59/EUR). Total demand for the period decreased by 13.16% mom.

According to the data of The European Energy Exchange (EEX), the Central European exchange of electricity and related products, the base settlement price of electricity futures on the German market in March 2024 was 61.27 EUR/MWh, on the French market – 58.81 EUR/MWh h., Spain – 19.83 EUR/MWh, Italy – 84.73 EUR/MWh (Yermolenko, 2024).

From the point of view of maintaining current trends in the future, two logical conclusions can be drawn. First, the prices of energy products are rising faster than the prices of other products. Second, oil prices are increasing faster than coal prices. The reality of supply and demand in the market further reinforces these trends. In developed countries, energy consumption per unit of production is decreasing, and this is to some extent offsetting the increase in energy demand in emerging markets. Countries such as China, which are heavily dependent on oil imports, are reducing their energy dependence through the development of solar energy and improved energy storage. Services play an increasing role in both developed and emerging markets, and as the share of services in GDP increases, the economy's relative dependence on oil and coal will decrease. The overall potential trend of energy supply and demand depends on technology and how quickly solar and innovative technologies can improve, as well as how much fracking and related technologies can increase the amount of oil that can be extracted from the ground. Due to the global warming effect of carbon energy, the world is trying to reduce its dependence on coal and oil, and of course this has an effect on the cost of electricity.

That seems unlikely now, the researchers say, but the system model has shown no signs of change over the past 100 years. Currently, the safest thing is to increase the prices of raw materials, especially energy (Taylor, 2017). As a result of the generalization of the trends of changes in world electricity prices, it is possible to single out the key factors that significantly affect the price change.

3. Factors affecting the price in the electricity sector

The price of fuel is one of the main factors affecting energy pricing and electricity tariffs for the population. The price of oil, natural gas and coal fluctuates depending on global factors such as production volumes, refinery output, tariffs and transportation costs.

Natural gas is one of the most used types of fuel in power plants. The laws of supply and demand, along with regional factors, affect the price of natural gas and other fuels. When natural gas prices rise, electricity prices are likely to rise. As the demand for a commodity like natural gas increases, so does the price. Likewise, when demand decreases, prices can fall.

This is because, thanks to the current market clearing mechanism, electricity prices are determined by the auction clearing price determined by the marginal technology. Previously, this technology was coal, and after several periods of higher demand – gas. The increase in the cost of carbon emissions in recent years has led to higher coal prices and market prices, while lower gas prices have caused lower market prices for gas stations. Consequently, marginal technologies in many markets have slowly transitioned to gas production. This is especially relevant for times of market

shortage, when gas installations have become a common high-cost "balancing" unit.

This dependence between electricity prices and gas prices has strengthened in recent years. Compared to previous years, 80% of gas plants in the EU purchase gas under futures contracts. Consequently, gas futures prices, such as those at the Dutch TTF hub, influence prices in electricity markets over many time frames, and often average prices. The Russian invasion of Ukraine demonstrated that there is a close relationship between electricity prices and gas futures prices. You can clearly see this relationship in *Figure 3*, which shows an increase in gas prices, followed by a significant increase in prices in the European electricity market. Economic recovery following the COVID-19 pandemic has also boosted demand for gas and electricity, putting additional demand-side pressure on market prices.

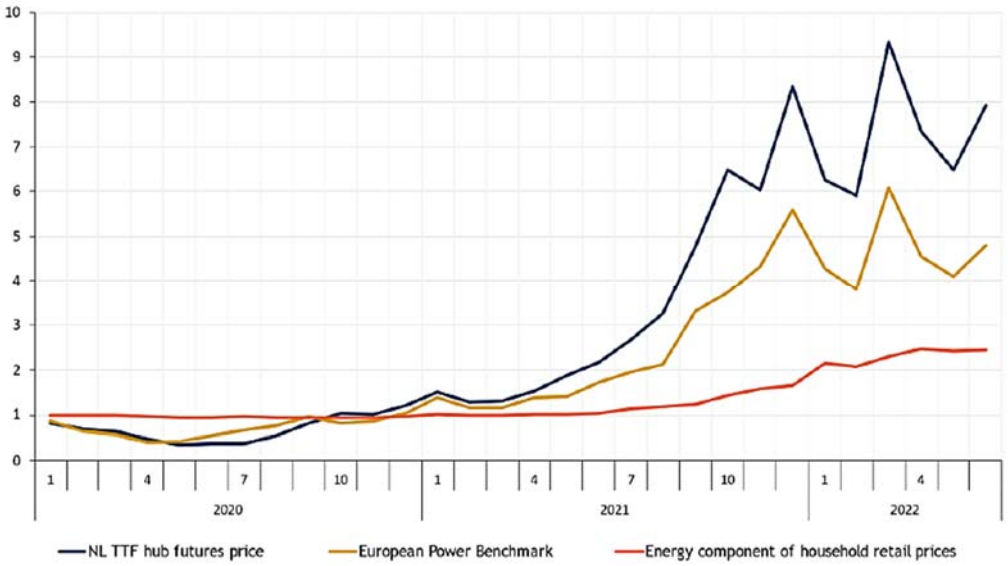

Figure 3. Day-ahead gas prices (NL TTF hub futures), day-ahead electricity prices (European Electricity Benchmark) and the average energy component of retail price development for households since 2020 (index 1 = average price in 2019)

Source: (Study on energy prices and costs, 2024).

The relationship between the price of gas and the price of electricity varies across Europe. By 2020, most gas (96%) in Europe was already purchased using futures contracts, so electricity prices were highly dependent on gas price fluctuations. However, in the Mediterranean (53%), Scandinavia and the Baltics (66%) and South-Eastern Europe (84%) a larger share is traded through indices linked to oil prices (which rose less than oil futures gas). Therefore, the vulnerability of electricity prices in these regions to fluctuations in gas prices was lower.

Another important factor is world events, such as wars or health crises, which can also affect energy prices. If conflict causes large-scale changes in energy demand, it could affect the availability of commodities like natural

gas and oil or slow down global supply chains. So average consumers may notice a change in their bill growth.

For example, Russia's invasion of Ukraine led to a significant increase in electricity prices due to concerns about natural gas supplies. During 2022, wholesale energy prices in Europe increased by 237% (Gazzani & Ferriani, 2022). Such price increases are a typical result of global disruptions, but some events can lead to lower demand. For example, during the quarantine due to COVID-19, the demand for electricity fell (COVID-19 impact on electricity, 2021) as a number of businesses closed down, which reduced electricity prices for a while.

Geopolitical conflicts can have a long-term impact on the cost of electricity. In times of uncertainty, investors are less likely to provide capital for grid improvements or renewable energy projects. This hesitancy could delay progress that could make electricity more reliable and cheaper in the future.

The amount of available supply can also affect electricity tariffs. If there is a surplus, prices may fall; and when supplies are scarce, energy prices often rise.

In addition to supply and demand, other factors influence energy pricing. Among other factors that can cause energy prices to rise, the following can be distinguished:

Weather conditions, including extreme temperatures and other changes in weather conditions, are a common cause of power outages and increased energy demand. According to Climate Central, 83% of power outages were weather-related (Surging Weather-related Power Outages, 2022) between 2000 and 2021. This percentage increased significantly in the following decade, with a further increase in weather-related outages from 2011 to 2021 by 78%. Such disruptions could cause an increase in wholesale electricity prices (Wholesale U.S. electricity prices, 2023), which utility companies usually pass on to consumers in the form of higher tariffs.

Extreme temperatures can also cause utility bills to spike. Demand for electricity increases as people turn on energy-intensive appliances, such as furnaces or air conditioners, so prices rise. A vivid example of this was observed in Texas (USA) in the summer of 2023, when prices from the annual average of $101. US per MWh rose to $5,000. USA per MWh.

While consumers can expect some seasonal fluctuations in prices as a matter of course, unpredictable extreme weather events tend to have a much greater impact on electricity costs.

Supply chain problems, which can be expressed by disruptions in the supply of spare parts for turbines and other equipment from the manufacturer to the power plant (Thomson et al., 2022). For example, delivery delays can affect repairs, maintenance, and system improvements because needed parts or equipment could not arrive in time due to a transportation delay.

In addition, limited access to raw materials can stop renewable energy projects. In addition to logistical bottlenecks or high shipping costs, energy

companies may have to source materials for solar panels or battery systems from risky countries where transportation is a problem or supply is unstable.

Failure to upgrade or repair systems can delay cost savings and lead to failures or inefficiencies, ultimately driving up energy prices.

Grid infrastructure and distribution. It takes time to add high-voltage power lines and switches to the grid, so supply may not grow as fast as demand. Damage to the network infrastructure, in turn, can limit the amount of electricity available to consumers.

Structure of the electricity market. The rules governing electricity markets vary greatly by location, but there are two main types of market structures in the United States: regulated and deregulated markets (Understanding Electricity Market Frameworks & Policies, 2024). A regulated market is one in which one public utility company controls most of the electricity generation and infrastructure. A deregulated market allows electricity to be bought and sold between different electricity suppliers, with a public entity responsible for only certain aspects of the transmission infrastructure.

Examining the presence of the largest electric power companies by market capitalization from a list of 240 units in the world, it can be considered that the US electric power market is the most deregulated (*Table 1*).

Table 1

Number of the largest electricity companies in the world
as of May 01, 2024

Largest electricity companies by country (240 companies)									
Quantity, pcs.	The USA	Great Britain	Germany	France	Spain	Italy	Poland	Turkey	***Uraine***
	80	5	13	3	9	7	3	2	***0***

Source: compiled by the authors according to (Largest electricity companies by market cap, n. d.).

But the impact of this factor cannot be considered unambiguous, as deregulation aims to encourage competition and ultimately lower prices for consumers, but the results in practice vary. A deregulated market tends to have an uneven distribution of electricity and more volatile price swings, and according to a New York Times report, customers in deregulated markets pay an average of $40 more per month than customers in regulated electricity markets (Penn, 2023, January 4).

For the final consumer, an influential factor on the final tariff is the share of taxes and fees in the price of electricity.

In addition, another factor is the purchasing power of the population. Looking at the general trends of global purchasing power, an increasing trend is recorded across countries. A significant drop in opportunities to purchase electricity can be observed on the domestic market. This trend is caused by the increase in electricity tariffs for household consumers from 01.06.2024 by Resolution of the CMU No. 632 dated 31.05.2024, regarding the establishment of a single fixed price for electricity for all residents of Ukraine – 4/32 hryvnias/kWh. regardless of the volume of consumption, and accordingly, a slight increase in the minimum income of citizens. In addition, the incomparable increase in the minimum wage and the fall in the national currency additionally do not provide an opportunity for a progressive increase in purchasing power.

4. Electricity market of Ukraine

Two and a half years of war became a difficult test for energy companies and enterprises that produce, sell, distribute and supply electricity. The main reasons for this were the decrease in consumption by commercial consumers, massive shelling by the Russian occupiers of the energy infrastructure in 2022-2023, and huge debts created as a result of an unbalanced model of assigning special responsibilities to state-owned companies. Analysts of the energy sector emphasize that the existing mechanism for providing the population with electricity (PSO) ensures a low price for electricity for the population at the expense of potentially profitable state-owned companies: mainly "Energoatom", which is the operator of nuclear power plants and "Ukrhydroenergo" which is the operator of hydroelectric plants. Despite the instability of the surrounding conditions, several market participants were able to earn significant profits in 2023.

Electricity prices in Ukraine have gradually increased over the past 10 years: from UAH 0.35 to UAH 1.51 in 2023, and then rapidly to UAH 4.32 per kWh in 2024, i.e. by 186%. Such an increase in the cost of electricity hit Ukrainians hard during the war years: from UAH 1.51 in 2023 to UAH 2.64 at the beginning of 2024, and to UAH 4.32 per kWh from June 2024. Experts state that the sharp increase in electricity bills is caused by several factors, but most of it can be attributed to the huge investment in the country’s crumbling energy infrastructure. At the same time, utility providers are working to upgrade and increase generation capacity to keep up with higher demand, which will be driven in part by artificial intelligence.

Until 2019, an inefficient monopolized model of relations in the field of electricity sales operated in Ukraine, where pricing was under the control of centralized management, which negatively affected all market participants. Since July 1, 2019, a new electricity market model based on the rules and standards of the European Union has been implemented in Ukraine. This allowed Ukraine to improve the system of buying and selling electricity,

and now the updated market is constantly undergoing qualitative changes (Metelenko et al., 2023).

According to this model of the electricity market in Ukraine, companies that are engaged in: generation (producers); transportation of electricity; direct supply of electricity to the consumer (*Figure 4*).

The electric power system of Ukraine includes the following producers: 4 nuclear power plants; 15 thermal power plants (of which 2 are in uncontrolled territory); 43 thermal power plants (of which 10 are in uncontrolled territory). Hydropower consists of 8 hydroelectric power stations and 3 hydroelectric power stations, the largest of which are 6 large hydroelectric power stations on the Dnipro River and the Tashlytsky hydroelectric power station on the South Bug River. The largest solar power plant in

Ukraine is located in the Dnipropetrovsk region; it has the second largest capacity in Europe. Zaporizhzhia region has the largest wind power plant.

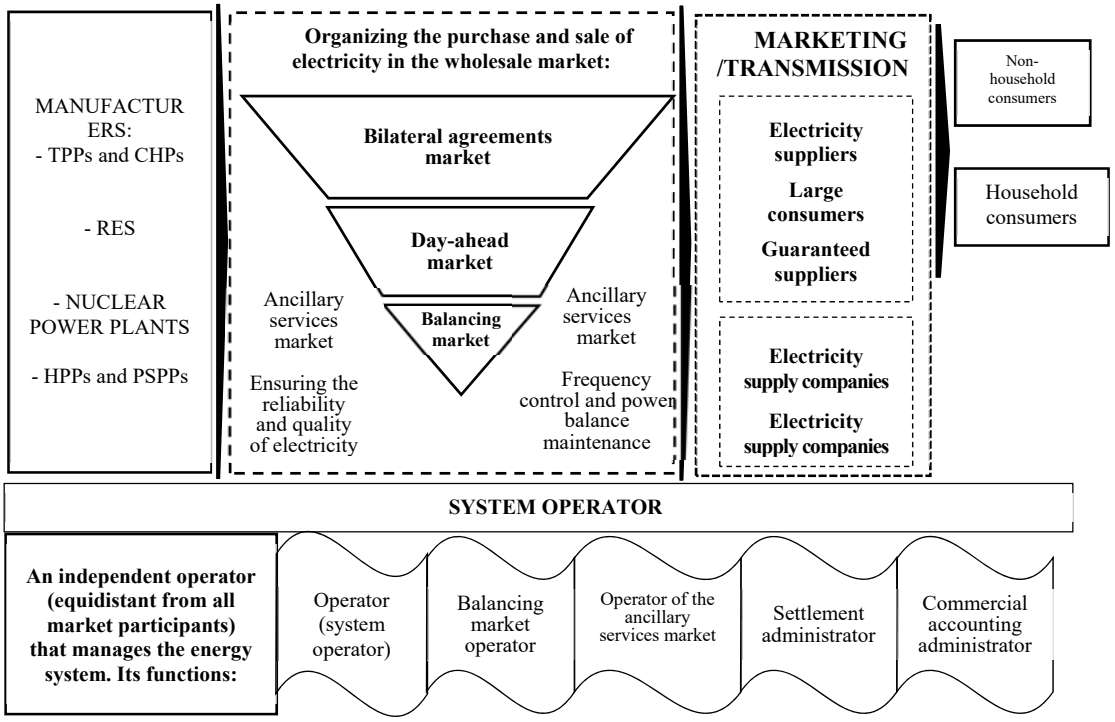

Figure 4. Model of the electricity market in Ukraine

Source: compiled by the authors according to (National Commission for State Regulation of Energy and Utilities, 2018).

A sharp decrease in electricity production in 2022 is caused by a full-scale Russian invasion, temporary occupation of certain territories, and missile strikes. As a result, Ukraine lost about 10 GW of various generation capacities, of which 6 GW is accounted for by Zaporizhzhya NPP. In addition, about 1/4 of the installed capacity of renewable energy sources is currently located in the occupied territories, including 75% of wind farms

and up to 15% of solar energy facilities. The demand for energy products has decreased significantly due to the mass evacuation of the population and the suspension of business activities. Previously, the main consumer of electricity was industry, which used 42% of total electricity consumption in the pre-war year. In 2022, this indicator decreased to 33%, and overall industrial consumption decreased by 45%.

In 2022, the share of electricity consumed by the population reached a record 38% of the total volume (in 2021 – 31%). This happened against the background of a significant economic downturn, a significant decrease in production volumes, and other factors. Currently, the population is the largest consumer of electricity in Ukraine.

Demand and supply in the power system must always be balanced to avoid interruptions in the supply of electricity. This creates a need for markets where transmission system operators (TSOs) can purchase the energy needed to balance the grid close to the time of physical delivery – in balancing markets. "Imbalance" trading takes place in this segment. Electricity prices in the balancing market are usually higher than in the day-ahead market, and this market is often characterized by sharp price fluctuations.

Proponents of liberal policies are unanimously in favor of the abolition of price restrictions in all segments of the electricity market, warning that further maintenance of these restrictions may lead to a reduction in foreign investment, a decrease in the necessary reserves and a decrease in the level of energy security. This, in turn, may complicate Ukraine's compliance with the requirements of EU legislation and harm the process of full integration with the EU electricity market. Currently, the situation is such that, on the one hand, energy companies support the idea of completely abolishing price restrictions in order to be able to sell electricity at higher prices. On the other hand, Ukrainian consumer enterprises oppose the increase in electricity prices, as it will increase the cost of their products and reduce competitiveness. For the public, an increase in wholesale electricity prices means an increase in the cost of goods and services.

The market price mostly for consumers and suppliers at free prices (cost of electricity) is formed on the basis of electricity purchase prices and tariffs in four market segments: on the market of bilateral contracts (BCC), where contract prices apply; on the day-ahead market (DAN); on the intraday market (IDR) and the balancing market (BR), which are organized segments with hourly prices (Metelenko et al., 2023). The most transparent segment of the energy market, which best reflects the real ratio of supply and demand, is RDN.

Studies show that the main factors affecting the level of electricity prices for consumers at free prices in the conditions of market pricing are the following: price dynamics in various wholesale market segments; formation of tariffs for services of operators of distribution systems (OSR) and transmission systems (OSP); cost of electricity supplier services; a system of commercial electricity accounting for legal entities, which is based on market

principles. The price depends on several factors, such as consumption volumes, payment schedule, payment discipline and consumption schedule during the day.

According to the results of the Report of the Low Carbon Ukraine (LCU) project, which is part of the International Climate Initiative (ICI) and financed by the German government (Low Carbon Ukraine, 2020, September, 4), it is stated that among the main problems of the electricity market of Ukraine is the lack of real competition. High market concentration allows all market participants to adapt. The authors note that in 2020, the final tariff in Europe for the population was much higher than in Ukraine, for small commercial consumers – the same or slightly higher, and for large consumers – sometimes electricity is cheaper in Europe. The reason for this is the market power of individual players, in particular R. Akhmetov's DTEK. This company, which has a share of 75.1%, definitely demonstrates dominance and dominance in terms of proposals among the studied companies. The closest competitor, Ukrhydroenergo, has a market share of only 16.5% (*Table 2*).

Table 2

The most profitable companies of the national electricity market in 2023

Position	Company	Owner	Revenue in 2023, UAH billion	Share, %
1	Ukrhydroenergo	State	48.6	16,5
2	D.Trading	DTEK. Rinat Akhmetov	165.7	56,1
3	DTEK Kyiv power grids		5.7	1,9
4	DTEK Kyiv regional power grids		7.6	2,6
5	DTEK Pokrovska SES		1.7	0,6
6	DTEK Odesa Power Grids		6.9	2,3
7	Kyiv energy services		34.2	11,6
8	Electricity trading group	Tolk. Yuriy Boyko	7.6	2,5
9	ERU Trading	THE E.R.U. Yaroslav Mudryi	13.6	4,6
10	Poltavaoblenergo	Privat. Ihor Kolomoisky	3.9	1,3
In total			295.4	100.0

Source: compiled from (YouControl, n. d.).

Previously, on the Ukrainian electricity market, only one company had the signs of a monopoly – "Energoatom", whose share of production in the total amount of electricity exceeded 50%. But the so-called "state monopoly" in world practice does not abuse its monopoly position and in fact protects the rights to available resources of consumers under the control of the state. From the point of view of the situation that has developed in the electricity market of Ukraine, it is difficult to think about competitive pricing conditions for electricity in the domestic market and protection from the private monopolist.

A possible promising option for reducing the price of electricity in Ukraine may be a nationwide transition to renewable energy sources as an alternative form of energy supply, but this is associated with significant initial costs. Solar and wind farms are still more expensive to build than natural gas generators, although construction costs for all three have fallen in recent years. The expansion of wind and solar power will also require new transmission infrastructure.

In addition, it is hardly possible to build large solar power plants in the urban centers of the country. They must be built in rural areas that require an additional power grid. Utility customers are currently bearing the brunt of these investments, but in the long term, these sources offer financial benefits, namely that they can produce cheaper electricity with less price volatility, which can benefit end users. However, higher future demand presents an increasing challenge. The global acceleration is due to the growth of artificial intelligence. According to The Wall Street Journal, AI demand for electricity in the U.S. could be five to six times the total amount needed to charge American electric vehicles. Analysts say artificial intelligence data processing, not electric cars, is now the "biggest challenge" for grid planners. So, to improve reliability and avoid permanent outages, the North American Electric Reliability Corporation (NERC) recommended expanding the transmission network, adding new power sources and making existing resources more reliable. This will take time and money, which means higher energy bills for consumers in a global environment (Penn, 2023, January 4).

It is noted that in most countries of the world, electricity is supplied through utility companies, which have been granted a monopoly. Economists generally discourage monopolies, but electricity has traditionally been considered a special case. The bottom line is that it is analytically cheaper for one firm to operate several large plants than for many companies to operate smaller plants, and in general the nature of electricity markets favors centralization and large companies. But on the other hand, in today’s world, the improvement of technology has led to the fact that monopolies on electric services have become obsolete. The emergence of smaller, competitive power plants and the reduction of transaction costs between consumers and suppliers make systems of retail choice possible.

In general, the available scientific research unequivocally refutes the idea that a monopoly is the most efficient market structure for the retail sale of electricity. World practices show that electricity prices, for example in the USA, which allow a wide retail choice, are generally lower than they would be under monopolies. Under competitive conditions, prices more accurately reflect marginal costs. In addition, in the States with the most developed retail markets, there is evidence of product differentiation, which can create additional value for consumers. Contrary to natural monopoly theory, no studies have found that retail competition per se has caused price increases, although several studies have found that imperfections in the market structure led to price increases.

Studies of duopolistic competition between utilities that engage in both retail and distribution produce results qualitatively similar to those of states that have introduced retail competition. Econometric studies show that under conditions of duopoly, electricity companies have lower costs and charge lower prices than under conditions of monopoly (Ellig, 2021, September 13).

Therefore, regardless of the form of retail competition, there is no economic justification for the monopolization of retail electricity trade.

Due to today's global challenges in Ukraine, the issue of providing the country's population with high-quality, affordable electrical energy becomes especially urgent. This year, Ukraine is extremely experiencing a significant shortage of electricity, which leads to emergency power outages in the country. If previously power outages affected only industrial or critical infrastructure facilities, now household consumers are affected as well. The problem is that the total capacity of the power plants is not enough to cover the consumption, and the imports are not enough to cover the deficit (due to cold in winter or due to heat in summer).

Due to Russian shelling, Ukraine lost 8 GW of capacity (Visit Ukraine, 2024)[1], which further complicates the situation regarding the provision of electricity to the population. On the one hand, this demonstrates the need to adapt to modern circumstances, speed up restorations, and accumulate actions in the researched direction. On the other hand, a global understanding and reorientation to international practices of regulation of the country's electric energy supply system is necessary in order to be ready for the critical challenges of today and current transformations.

It is advisable for state regulators to ensure that the monopoly on electricity services is limited only where it is economically necessary. The emergence of other competitive market participants and the reduction of transaction costs between consumers and suppliers make retail choice systems possible. The state should encourage consumer choice by reforming traditional monopolies to offer more options through retail choice. Offering more choice will allow consumers to find products that better suit their needs.

Conclusions

Historical global energy commodity price dynamics show periodicity and show that energy commodity prices are increasing faster than other commodity prices, while oil prices are increasing faster than coal prices. It has been established that price growth occurs under the influence of global and country-specific factors. Global energy shortages, caused by a number of political and economic factors, are driving up electricity prices for retailers. Despite the fact that most countries provide budgetary assistance to households in the face of rising tariffs, end consumers around the world face rising energy prices and rising costs of living.

[1] *It was a matter of time: why are the power cuts in Ukraine happening again and are there any schedules*? https://visitukraine.today/blog/3946/it-was-a-matter-of-time-why-are-the-power-cuts-in-ukraine-happening-again-and-are-there-any-schedules

The economic recovery after COVID-19, along with rising tensions with Russia, culminating in the Russian invasion of Ukraine, has led to an unprecedented spike in wholesale electricity prices, especially in the EU. The main reasons for this were the increase in gas prices and the impossibility of replacing it in the short term with other types of fuel, as well as the shortage of hydro and nuclear energy. In addition to the EU, price increases occurred in many countries – Japan, South Korea, Turkey, India, Brazil, South Africa, but in the USA and China and some other countries, which are mostly self-sufficient in fuel for electricity production, prices remained relatively stable.

Electricity prices vary widely around the world, and sometimes even within a country, depending on factors such as infrastructure, geographic location, and politically determined taxes and fees. Among EU member states, the components of the total price vary greatly: the highest component of taxes and fees is in Denmark, Germany and Portugal; Malta and Greece have the highest level of electricity and supply costs, the highest network costs were recorded in Belgium, Ireland and Sweden.

Factors affecting pricing in the field of electricity in the world have been identified. These include: energy prices, global crisis phenomena, the amount of available supply, weather conditions, supply chain problems, grid infrastructure and distribution, electricity market structure, the share of taxes and fees in the price of electricity, and the purchasing power of the population. The close correlation between gas futures prices and electricity prices is substantiated, especially during the Russian invasion of Ukraine. The ambiguity of the factor of deregulation in the electricity market is proven, since the deregulated market is prone to uneven distribution of electricity and sharper price fluctuations.

Ukraine's electricity market, like other sectors of the economy, is currently in a crisis situation. Due to the war, the energy infrastructure was destroyed, causing a shortage of electricity and rising prices. Along with this, the market is characterized by a price imbalance, especially in the retail sector, a crisis of settlements between the main market participants, a lack of real competition, limited transparency of the market and possibilities of manipulation on it, imperfection of the legislative framework, etc. This requires a global approach to understanding problems and a reorientation to international practices of regulating the country's electric energy supply system in order to be ready for today's critical challenges and ongoing transformations.

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