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Crisis management in the energy sector in conditions of increasing epidemiological risks

Abstract: The main objective of this paper is (i) to determinate the energy sector as an important part of the resource economy in conditions of increasing epidemiological risks, and (ii) to present the potential of crisis management instruments to influence and strengthen the energy sector in Ukraine.

This study uses expert assessments and monographic methods (for the assessment of crisis-management instruments) graphical methods Practical measures aimed at improving and reshaping the energy sector in Ukraine are defined by means of synthesis and economic analysis; statistical and interstate comparisons are used to analyze the Spanish experience of anti-crisis management measures in the post-COVID energy sector.

The study of the world electricity distribution issue shows its direct connection with the energy production source, including renewable energy use, which increased under the impact of COVID-19. The analysis of developed crisis-management systems provides the basis to propose measures to improve and reshape the energy sector in Ukraine. Thus, the results section represents findings to strengthen the energy sector, supporting crisis-management-system development in Ukraine.

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The study is a part of a research cycle on energy-sector development, its management and financing. The proposed measures to improve and reshape the energy sector in Ukraine can be applied to specific energy-sector projects, the optimization of investments in the energy sector, as well as being used for the modeling of complex crisis-management systems of various spheres of the economy.

KEYWORDS: energy resources, resource economics, epidemiological risks, crisis management

1. Introduction and review of literature

Nowadays, there are many challenges that present problems and risks for business and need additional requirements for the development of enterprises in order to maintain their position and increase competitiveness. In particular, in 2020, the coronavirus crisis created a background for one of the most significant global transformations in the global economy in the last century. For instance, the current structural crisis of 2020 is comparable to the Great Depression of 1929–1933 with regard to its impacts and consequences; in particular, major structural transformations took place in both periods.

Thereby, the problems of bankruptcy are among the most important factors influencing the development of mechanisms for the adaptation of economic entities to comprehensive social and economic change and transformation. To help enterprises to survive the above-mentioned crises, the implementation agreed measures to identify signs of bankruptcy in the early stages and boost business recovery needs to be carried out. Thus, the study and systematic improvement of crisis management strategies and tactics play an important role in addressing the above-mentioned issue.

In addition, special attention has to be paid to specific features of sectoral business development in order to provide the most effective recovery measures. Identifying and studying the needs of this business area and the economic conditions for the transformation of crisis-management measures is especially important for the effective functioning and development of the majority of enterprises.

Currently, energy-sector enterprises hold a special place in the system of crisis measures to overcome the effects of the pandemic and create conditions for sustainable socio-economic growth (NAN of Ukraine 2020). The energy sector is one of the strategically important areas for ensuring vital activity and improving the quality of most areas of society (Gernego and Liakhova 2021). In particular, the COVID-19 crisis caused a drop in demand for energy resources, which in turn led to structural transformations of the energy market, particularly in terms of the actualization of the alternative energy issue. In this context, the energy sector should be viewed as one of the most important for strengthening the competitiveness of the Ukrainian economy during the period of high epidemiological risks as well as in times of other types of crisis. In accordance with this, the development of an effective crisis-management

system is crucial to ensure the stability and competitiveness of the energy sector which in turn should reduce bankruptcy cases.

Several studies have documented the different approaches to the concept of “crisis management” within different sectors of the economy or particular business entities. In particular, evidence suggests that there is a link between the relational capital of the business entity and its susceptibility to crisis phenomena (Walecka 2021; Macerinskiene and Survilaite 2019). Some existing research recognizes the critical role played by crisis management within the different stages of company development, with consideration to a wide range of crisis-prevention methods and instruments (Meiste and Jakstiene 2015). Mocanu (2018) established that despite the practical implementation of crisis-management technologies, there is a lack of theoretical research in the area of crisis concept creation. Some well-known studies have examined the effectiveness of a wide range of instruments for the financial crisis-management system enterprises. In particular, the conceptual research on financial management and its role within financial strategy creation have been considered by Belén (2014). The specific approach on financial management and the principles of crisis instrument implementation has been investigated (Tennent 2018). Financial management has been analyzed from a contemporary perspective, concerning modern tendencies and issues that influence financial development and bankruptcy issues (Kothari 2017). A conceptual framework for enterprise resilience enhancement has been considered by Sanchis et al. (2020).

A number of cross-sectional studies suggest a connection between the success of the crisis-management strategy and business profitability (Cucchiella et al. 2015). However, despite the variety of approaches to justify measures in the crisis-management system, there is still a lack of research of crisis management in particular areas of the economy like the energy sector. In particular, there have so far been some attempts to define the energy sector problems and its profitability in the era of COVID-19 (Hosseini 2020; Ruggiero et al. 2021). Kuzmynchuk and Kutsenko (2021), among others, paid attention to the energy sector development as a part of sustainable environment, considering crisis-management conditions. Koval et al. (2019) considered the possibilities of energy-security straightening. Some studies propose managerial instruments to straighten the Ukrainian energy sector and increase its flexibility (Sabishchenko et al. 2020).

There is still uncertainty, however, in the issue of the potential of providing financial security, investment attractiveness and competitiveness of energy-sector enterprises (Masharsky et al. 2018).

To date, a search of literature has revealed some studies which consider crisis management as a system of measures at the enterprise that is already in crisis and has a significant threat of bankruptcy, including the research of Smereka (2016), Tereshchenko and Pavlovsky (2016). Other scientists, including Sytnyk (2016), Shtangred (2016) and Makhovka (2015), found that crisis management is a system aimed at ensuring a rapid response to cases that occur in the environment of the enterprise and the formation of measures to eliminate them mainly in the short term. The third approach, including the research of Kostyrko (2015), is used to assess crisis management as a precautionary measure and recognize it as a management system based on

strategic principles aimed at constantly anticipating internal and external threats to the effective functioning of the enterprise.

Thus, the studies mentioned above have shown that the existing crisis-management theory can now be divided into three concepts. According to the first concept, crisis management should take actions only in case of an actual crisis in the company and the detection of a bankruptcy threat. According to the second concept, crisis management is temporary, the purpose of which is to anticipate the risk of crisis and implement appropriate measures at any stage of the enterprise activity, mainly focused on short-term results in accordance with operational response objectives. The third crisis-management concept is based on continuity and strategic decision-making to ensure the effective operation of the enterprise as well as defining goals and objectives for operational crisis-management in the long run.

Up until now, the normative legal and scientific literature doesn't contain a single conceptual approach to the issue of crisis management in energy sector in the context of increasing epidemiological risks, including the COVID-19 pandemic. In order to identify the essence of the concept, we believe that it is necessary to distinguish several areas of research.

Thereby, the purpose of the article is substantiation of the specific features of crisis management in the energy sector, which is one of the key sectors within the resource economy in the face of increasing epidemiological risks, including the COVID-19 pandemic.

The object of the research is crisis-management measures in the post-COVID energy sector. The subject is the energy sector and potential for its development in conditions of increasing epidemiological risk.

This study has set out to describe crisis-management instruments and the potential for their implementation in the energy sector, based on scientific research both in the area of financial management and energy sector experts (assessments and monographic methods). The statistical data and documents form the basis for the analytical part of research. In particular, the methods for estimating structural dynamic shifts are used to analyze the electricity production structure in Ukraine. Statistical and interstate comparisons are used to analyze the Spanish experience of crisis-management measures in the post-COVID energy sector in the context of Spain's recovery and resilience plan for the period 2021–2026, implemented by the European Commission. Practical measures aimed at improving and reshaping the energy sector in Ukraine is defined by means of synthesis and economic analysis.

In the upcoming pages, the following aspects are covered:

- ◆ in the further section, attention is paid to crisis-management instruments and their use in the energy sector, representing the main theoretical assumptions of the current research;
- ◆ then, it aims to assess the current tendencies of the distribution of world electricity production and energy production in Ukraine;
- ◆ in light of the recovery and resilience facility over the period 2021–2026, the Spanish experience of crisis management is provided;
- ◆ possible ways to develop the crisis-management measures in the post-COVID energy sector in Ukraine are considered.

2. Results and discussion

2.1. Crisis-management instruments in the energy sector

It can be argued that crisis-management of an enterprise ensures its stable operation and aims to prevent or overcome the crisis, which manifests itself in insolvency, loss and bankruptcy of enterprises using operational and strategic management tools in the context of epidemiological risks.

Operational measures are aimed at maintaining the stability of the system and minimizing the negative consequences of activity in particular areas of the economy. Thus, in the energy sector, the tools of operational crisis management in the new market model should include a set of measures to regulate the market for the day ahead, the intraday market, the balancing market and the ancillary services market, tax benefits, preferential electricity connection, cash gap lending and the formation of a system of dynamic tariffs, including “green tariff”, which will ensure the sustainable operation of the integrated energy system and coordinated adjustment of the investment program of energy development as well as optimization of processes and cost reduction at energy facilities without reducing the reliability and quality of energy supply.

The main purpose of strategic measures aimed at preventing energy companies’ crises is to ensure the flexibility and adaptability of the system, to prevent situations of force majeure in the future. Strategic (preventive) measures include: the development of small generation, the development of distributed (territorial) generation systems, the use of advanced demand management mechanisms, the introduction of elements of “smart” or active-adaptive power grids (Smart Grid) and “smart” accounting systems (Smart Metering), the innovative development of energy engineering and electrical industry and a number of other measures aimed at increasing the sustainability of electricity and ensuring the country’s external energy security through import substitution. Relevant strategic tools in the energy sector include: energy demand management, development of distributed generation, cost management in the electricity sector and assets of energy companies (Fig. 1).

So far, there has been growing attention to the use of artificial intelligence in the energy sector, which opens up such prospects as increased safety in energy generation, increased energy efficiency and balanced energy-generation processes. The peculiarity of this instrument of Industry 4.0 is that it combines the processes of digitalization and intellectualization in the enterprise and forms a new part of the intellectual capital of the enterprise (Doroshuk 2021). In particular, in the context of modern crisis management in the energy sector, the smart-grid concept is relevant globally, which represents intelligent power systems as automated and self-regulated, based on advanced information technologies. In the global energy sector, there are different interpretations of the concept of the smart grid. In general, the “smart” network is an electrical network that, based on modern innovative technologies, effectively coordinates and manages the operation of all connected facilities from various systems of generation, transmission and

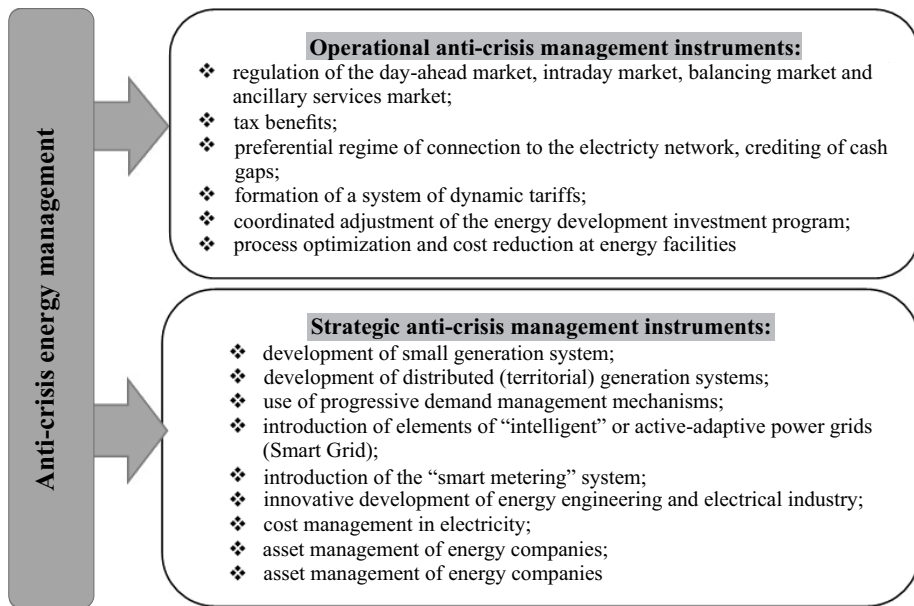


Fig. 1. Instruments of crisis management in the energy sector in view of epidemiological risks
Source: compared by authors

Rys. 1. Instrumenty zarządzania kryzysowego w energetyce wobec zagrożeń epidemiologicznych

distribution of electricity to its consumers to create a cost-effective and stable energy system with low losses and a high level of reliability and quality of energy supply. According to the European Technology Platform, the smart grid represents electrical networks that meet the requirements of energy efficiency and economical operation of the system through coordinated management through modern two-way communications between elements of power grids, power plants and electricity consumers (Werth et al. 2020; NEC 2018). Unfortunately, in the context of increasing epidemiological risks, strategic measures often take a back seat. However, they enable sustainable development and reduce the severity of future crises of the energy system.

2.2. The tendencies of the distribution of world electricity production

Despite the fact that energy industry is much less resilient to GDP in terms of GDP than, for example, the banking sector or manufacturing (the decline in world electricity consumption in 2020 was only about 3.5%), but it is developing in dialectical unity of current and long-term plans that are most often related to the implementation of investment programs, which in turn, directly affects the flow of energy capital. Relevant vulnerabilities and consequences for energy companies vary depending on the demand for electricity, the implementation of the course of

low-carbon development strategy and they also have various trends in different sectors of the economy and countries. Recently, the COVID-19 pandemic caused electricity consumption drop in industry, transport and commercial sectors (due to the closure of small and medium enterprises in real estate, services, the reduction of electric transport, the partial restriction of industry, etc.). At the same time, electricity consumption in households increased slightly and the daily load schedule changed.

In China, where the spread of coronavirus began, the overall decline in electricity consumption in January–February 2020 reached 7.8%, and the most notable were found in the fields of textile production (a decrease of 30%) and engineering (a decrease of 21%). The degree of reduction of electricity consumption depended on the rigidity and duration of quarantine. Thus, according to Wood Mackenzie, in the Chinese province of Hubei, this was the epicenter of the disease and underwent the most severe quarantine measures in January–February 2020, the peak load at the end of January decreased by 21% from the planned level (Huang et al 2020).

Similar trends were observed in Europe, namely up to a 30–40% drop in demand at the peak in Italy and Spain, after which demand gradually recovered. The maximum decline in electricity consumption in Europe was recorded in Italy, France and the United Kingdom, while in Scandinavian countries, where no strict quarantine was introduced, there was a slight increase in demand. At the same time, quarantine in Europe had a significant stimulating effect on the demand for thermal energy. According to Tado GmbH, household heat consumption in Germany in March 2020 increased by 9% compared to the previous year, in France by 13%, and in Italy and Spain by 41–42%. The survey was conducted on a sample of approximately 100,000 households in Europe. The main reason for this trend is the possibility of regulating heat supply. In the United States, according to the EIA, the coronavirus crisis led to a decline in overall electricity demand by 3% in 2020. The main decline was in the commercial sector (4.7%) and industry (4.2%), while in households, the electricity consumption fell by only 0.8% (BP Statistical Review of World Energy 2019; Chen et al. 2020).

In the previous decades, the structure of electricity production by energy sources changed globally and in 2019, it had the following structure: 63.94% for fossil energy sources, 10.14% for nuclear energy, and 36.06% for renewable energy sources (Fig. 2).

Gradually, starting in the mid-1980s, the third period of the global energy transition took place; this was the transition from oil to gas, which in 2019 in fossil energy amounted to 23.01% compared to oil 2.93% of total energy sources. In 2019, in order to increase energy efficiency, the fourth energy transition to the widespread use of renewable energy (and the displacement of fossil fuels) began, which under the influence of COVID-19, has had a tendency to accelerate. In particular, despite the crisis, the international community has intensified in the implementation of Green Deal initiatives. The development of a strategy aimed at developing renewable energy in the United States began in 2019. This strategy is based on the transition of the economy to an environmentally friendly and energy-efficient society by 2030 (Green New Deal 2020). In Europe, in early 2020, experts from the European Commission prepared and signed the European Green Deal. The European agreement is similar to the American one in terms of its targets. However, its implementation is planned for the period up

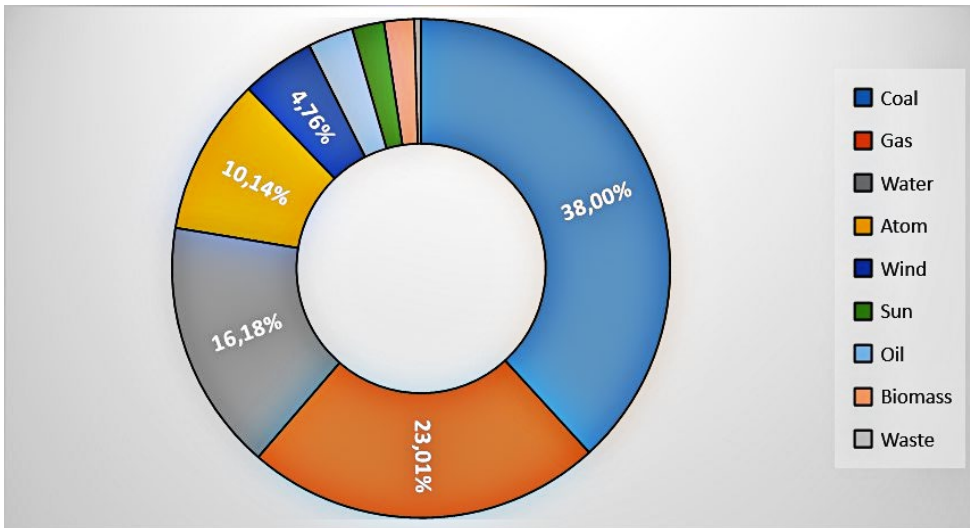


Fig. 2. Distribution of world electricity production depending on its sources as of 2019
Source: compared by authors on the basis of (BP Statistical Review of World Energy 2019)

Rys. 2. Światowa produkcja energii elektrycznej w podziale na źródła według stanu na 2019 r.

to 2050, which provides for more progressive actions (European Green Deal 2020; Gernego et al. 2021). It is worth noting that the energy conservation policy is one of the components of a green recovery strategy after a pandemic.

2.3. Energy production in Ukraine

In Ukraine, the structure of energy production remains quite “traditional”. The energy production system is represented by the following electricity producers: four nuclear power plants; fifteen thermal power plants, two of which are in the territory not controlled by Ukraine; forty-three CHPs, ten of which are located in the territory not controlled by Ukraine. The basis of Ukraine’s hydropower is a cascade of six large hydropower plants on the Dnipro River, as well as Tashlyk PSP on the Southern Bug River. There are eight HPPs and three PSPs in total. The largest Ukrainian wind farm is located in the Zaporizhian region.

During the first half of 2021, the volume of electricity production by the power plants of Ukraine amounted to 77,735.1 million kWh, which is 4,303.1 million kWh, or 5.9% more than during the first half of 2020. The main share in the total production for six months of 2021 is the production of NPPs – 54.0%, TPPs and CHPs – 29.6%, and the production of HPPs and PSPs – 8.0%. For six months of 2020, the share of production of NPPs, TPPs and CHPs and HPPs and PSPs was 53.6%, 32.9% and 4.9%, respectively. In 2020, about 52% of energy was produced

by NPP resources, TPPs and CHPs accounted for about 32.8%, the share of alternative energy is about 8%, HPPs and PSPs – 5.2%, other sources account for about 2% (State statistical service of Ukraine 2019).

The production of electricity is structured in comparative quantities as represented in Figure 3.

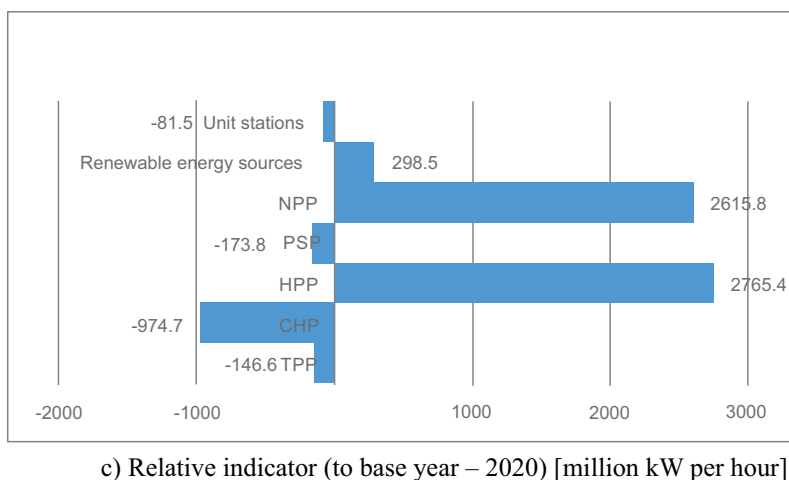
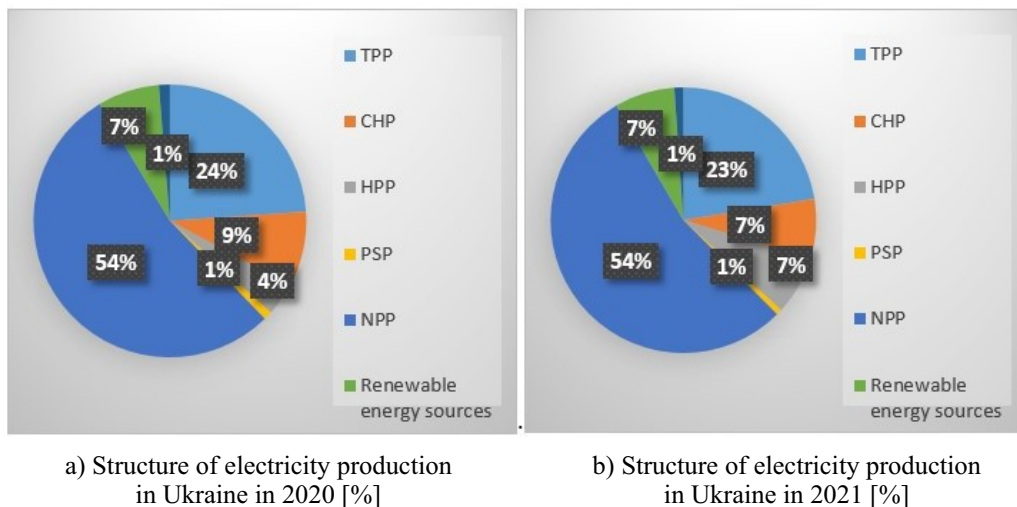


Fig. 3. Electricity production structure in Ukraine and its change during 2020–2021 (EnerghoVsesvit 2021)

Rys. 3. Struktura produkcji energii elektrycznej w Ukrainie i jej zmiana w latach 2020–2021

At the beginning of 2020, our country expressed its interest in joining the European Green Deal energy saving initiatives. In particular, in accordance with the Ukrainian energy strategy until 2030, the planned increase of alternative energy share is estimated at 20%. However, due to the corona crisis, those goals have not been reached the last year.

General problems caused by the coronavirus crisis in the global scale are listed in Figure 4.

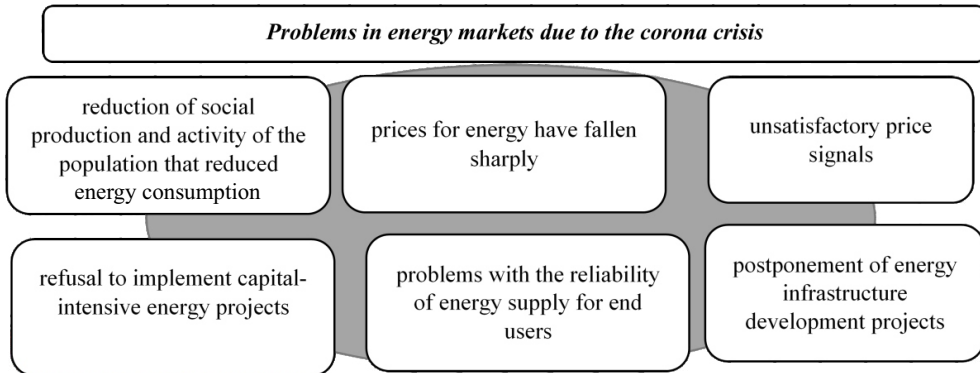


Fig. 4. Problems of the energy sector in times of epidemiological crises
(NAN of Ukraine 2020; Global Economic Prospects 2020)

Rys. 4. Problemy sektora energetycznego w czasie kryzysu epidemicznego

Experts note the dual nature of the COVID-19 impact on the energy sector of developed countries. Specifically, due to structural transformations, energy-saving technologies have been developed, digitalization trends have spread due to the introduction of remote operation in energy companies, slowing down day-to-day life has strengthened the position of the concepts of the circular economy and responsible consumption (Jiang et al. 2021; Yu-ChungTsao et al. 2021).

To address the above-mentioned issues, a number of crisis measures are planned on the global level to address structural transformations in the energy sector. In this context, measures to support energy-infrastructure-strengthening projects are also becoming especially relevant at the global level. A number of moratoriums on energy bills are envisaged within the framework of the system of crisis measures aimed at the well-being of end users of energy during the COVID-19 pandemic crises.

2.4. Crisis-management measures in the post-COVID energy sector

Although the impact of the pandemic on the energy sector is becoming increasingly significant, including declining demand and uneven recovery at the local level, the long-term pandemic effects on energy systems remain unknown. Therefore, during the global turmoil, the World Energy Council launched the World Energy Trilemma Index as an annual measure of national energy systems based on historical data to assess past energy performance. The national context is crucial for the process of countries developing their energy policies, dictated by local conditions and natural resources of these countries, geographical location and socio-economic systems. Those factors lead to the formation of different approaches to an energy system issue,

which means that there is no universal way to make a successful energy transition; instead, each country needs to determine its own energy policy, taking into account local factors and national priorities. This diversity means that direct comparisons of Trilemma ratings and scores are less informative, but can still help to establish a dialogue to help countries to exchange their experiences in the field of energy policy to determine the circumstances and reasons for which their energy policies are effective. The Energy Trilemma Index can help countries and stakeholders address energy sector issues and identify priorities in those energy policies that need to be addressed first and explore the most appropriate options.

To meet the above objectives, 127 countries took part in the Trilemma 2021 ranking. In the top ten countries included in the ranking, the OECD member states are still in the lead, with European countries showing particularly high results, which once again confirms the importance of pursuing an active energy policy in the long-term perspective. The top three ranked the same countries as in 2020: Sweden took first place, ahead of Switzerland, and Denmark remained in third place. The overall score of all three countries was eighty-three points and above. However, the monopoly of European OECD countries was broken by Canada, New Zealand and the USA (World Energy Council 2021).

At the level of national economies, it is important to pay systematic attention to the degree of “financial stability” of energy producers, namely the potential for the stabilization of economic entities, the presence or absence of guarantees to maintain solvency and creditworthiness, risk support, long-term plans, analysis of the effective use of financial resources and the possibility of obtaining support in a changing environment (Baranovsky 2018).

In response to the challenges of COVID-19 in Europe, a system of crisis-management tools has emerged, including: delays or reductions in tax and social contributions, financial guarantees for strategically important companies, subsidies and subventions, innovative lending schemes or negotiations with banking institutions in order to facilitate the receipt of new loans for strategically important sectors of the economy, the use of deferral mechanisms and soft loans, and the formation of a system of direct grants (NAN of Ukraine 2020). An important condition for the effectiveness of the implementation of the above-mentioned crisis management tools is their availability to representatives of strategically important sectors of the economy. Thus, their combination should serve as an important tool to support the European energy sector.

In particular, the European Commission supports energy-sector transformations within national recovery and resilience plans. In 2021, the European Commission has adopted a positive assessment of Spain’s recovery and resilience plan (European Commission 2021). Considering the direction of development in the energy sector, the Spanish experience of crisis management in the energy sector has proved to be successful, which deserves especial attention in view of further consequences of COVID-19 (Fig. 5).

Spain has developed the crisis-management system at the national level that responds to the challenges of the coronavirus crisis. The COVID-19 crisis led to the decrease of income of the majority of local energy consumers which in turn caused a reduction of energy consumption and its demand. Therefore, crisis management is aimed at regulating the prices of certain energy

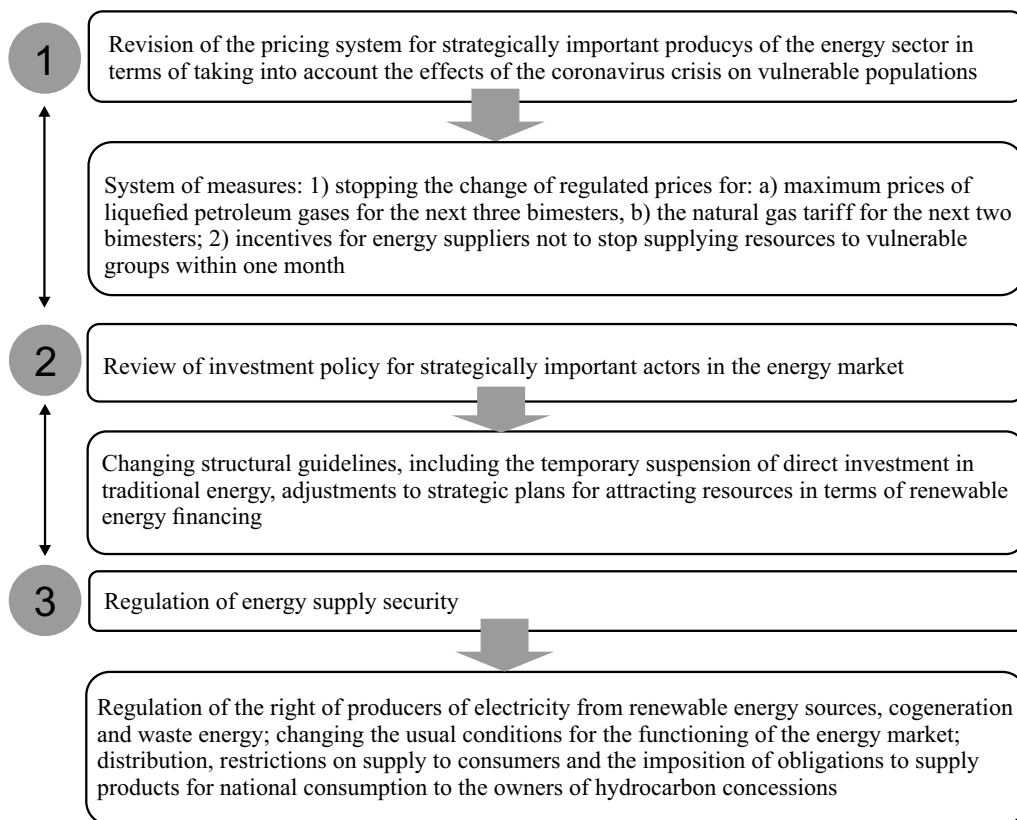


Fig. 5. Crisis-management measures in the post-COVID energy sector in Spain
(NAN of Ukraine 2020; ASHURST 2020)

Rys. 5. Środki zarządzania kryzysowego w sektorze energetycznym po COVID w Hiszpanii

resources, revising tariffs in order to stimulate access of vulnerable groups to energy supply. In turn, the spread of COVID-19 had a significant impact on changing the structure of investment. Therefore, in Spain, crisis regulation involves the use of a set of measures to stimulate change in the structure of investment in terms of reducing it for development purposes in relation to traditional energy sectors. Instead, investments in the development of alternative energy are further stimulated. In addition, during the coronavirus crisis, special delegated bodies form a number of guarantees regarding the security of the energy supply at the national level. Crisis management in the energy sector in Spain focuses on three key aspects: supporting progressive structural changes in the energy sector, security of the energy supply and maintaining the demand for energy products. The combination of crisis-management measures in these areas has slowed down the crisis impact on the energy sector and made it possible to continue the policy of implementing the priorities of the green course.

As Ukraine is only raising issues of the energy-efficient economy which have slowed down due to the COVID-19 crisis, a number of practical measures aimed at improving and reshaping the energy sector should be implemented at the national level (Fig. 6).

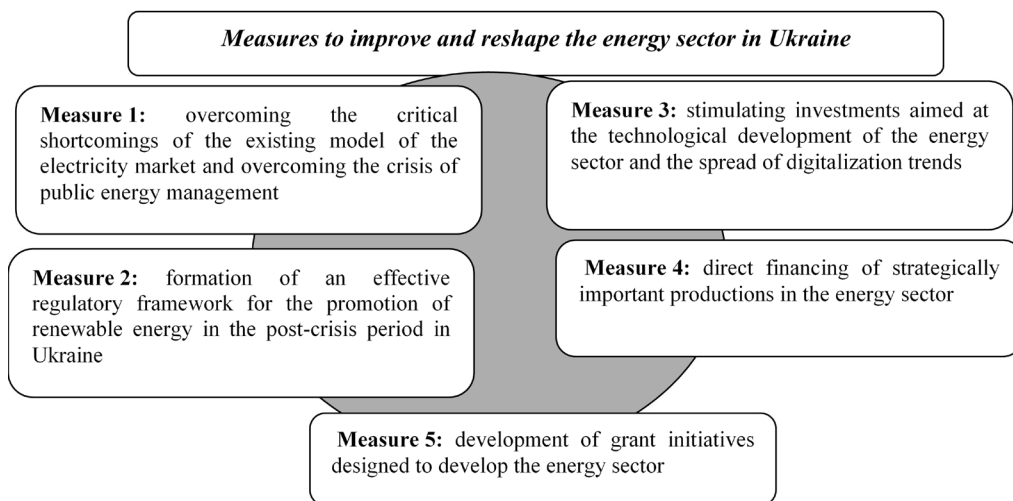


Fig. 6. Practical measures aimed at improving and reshaping the energy sector in Ukraine

*Source: considered by authors based on (Omelchenko 2022)

Rys. 6. Praktyczne działania mające na celu poprawę i przekształcenie sektora energetycznego w Ukrainie

The above-mentioned practical measures are implemented through a number of activities (Table 1).

TABLE 1. Activities to implement measures aimed at improving and reshaping the energy sector in Ukraine

TABELA 1. Działania na rzecz implementacji środków, które mają na celu poprawę i przekształcenie sektora energetycznego w Ukrainie

	Measures	Activities
1	2	3
1	Measure 1	to increase local natural gas production;
2		to take into account the recommendations of the Energy Community and stop the imposition of price caps (price caps), which can lead to artificial understatement of prices on Day-Ahead Energy Market, the level of which cannot be lower than the cost of all types of generation, and sometimes even lower than break-even points of the power system as a whole;
3		in order to balance the market situation, to regulate the mechanism of imposing special obligations for market participants, namely, not to impose subsidies on preferential tariffs for the population on state-owned SE “NNEGC “Energoatom” and PJSC Ukrenergo in the absence of state compensation;

1	2	3
4	Measure 1	to provide a basis for the correlation between the prices at Day-Ahead Energy Market in the United Energy System of Ukraine and related European markets. The wholesale electricity prices in Ukraine at Day-Ahead Energy Market were 2–3 times lower than in Europe. For instance, in May 2021, the price at Day-Ahead Energy Market in the United Energy System of Ukraine decreased to € 23 per MW, while in Poland, Hungary, Slovakia and Romania the price was € 70–72 per MW;
5		in order to increase the flexibility of the energy system, it is necessary to continue the support of integration of the energy system of Ukraine into the European energy system.
6	Measure 2	To create a legal framework for the introduction and operation of storage capacity;
7		to take into account incentives for the launch of storage capacity, as well as for the introduction of new high maneuverability;
8		to improve the legal field for investors, in order to better understand the economic system of Ukraine, and the economic model for banks.
9	Measure 3	Stimulating investment in the energy sector and the spread of digitalization as a third area of practice will allow for more widespread and reliable use of renewable energy, energy storage, dynamic pricing and consumer involvement in demand management, remote and smart energy management. Thereby, attention should be paid to blockchain projects in the field of renewable energy development and energy consumption accounting, which aims to reduce transaction costs, increase competitiveness and open access to small and medium-sized producers who can sell energy to other network members. There is no intermediary in this market, and consumers work through so-called smart contracts, through which they buy the required amount of energy directly from the manufacturer. Transparency helps increase trust between participants in the process and create a fair price for Ukrainian consumers.
10	Measure 4	Gradual reduction of subsidies to support the fossil fuel sector and traditional energy generation technologies;
11		introduction of separate funds and programs for the purpose of co-financing of municipal initiatives on energy transition, in particular within the framework of the Agreement of Mayors and transition of cities to 100% of renewable energy.
12	Measure 5	By grants use to reduce capital cost of investments in renewable energy projects. This will support projects involving innovative technologies at the implementation stage. Thus, projects will be supported mainly by voluntary payments from EU Member States, designed to fill «gaps» in the trajectory of the national renewable energy target.
13		To determine the amount of the grant according to the results of the tender procedure, which should select only the most competitive projects according to the price criterion. In addition, it is noted that all proposed projects must meet environmental criteria, and projects that are the most innovative (and do not necessarily pass the price filter), grant funding may be awarded according to individual criteria for a particular technology or project.

Source: considered by authors based on (Omelchenko 2022).

Thereby, the implementation of the domestic model of crisis management of the energy sector in times of difficult epidemiological situations considers global trends and should be correlated with the measures implemented by individual entities (Fig. 7).

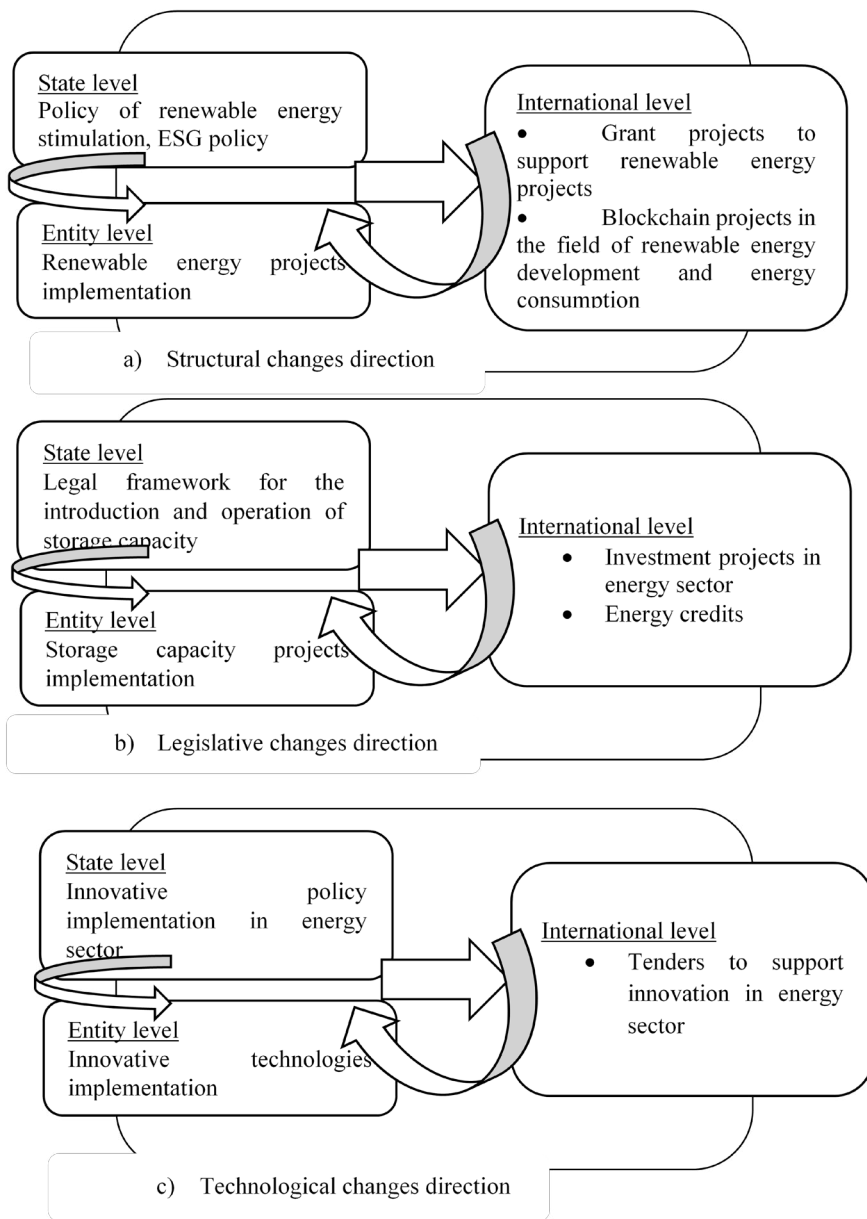


Fig. 7. Directions of Ukrainian energy-sector crisis management in times of difficult epidemiological situations
Source: considered by authors

Rys. 7. Kierunki zarządzania kryzysowego w ukraińskiej energetyce w czasie trudnej sytuacji epidemiologicznej

Conclusions

As a result of theoretical and applied researches of crisis management in the energy sector in the context of COVID-19 risks strengthening, it is possible to provide the following conclusions:

- ◆ Crisis management in the energy sector should ensure the stable operation of energy companies and be aimed at preventing or overcoming the crisis, which manifests itself in insolvency, loss and bankruptcy of the enterprises using specific tools of operational and strategic management in epidemiological risks.
- ◆ The crisis consequences for energy companies and their vulnerabilities differ depending on the demand for electricity, the implementation of the course of low-carbon development strategy and have different dynamics in variable sectors of the economy and in different countries.
- ◆ In order to increase energy efficiency in 2019, the implementation of the fourth energy transition to the widespread use of renewable energy (and the displacement of fossil fuels) has started, and this process has been accelerated by the COVID-19 crisis.
- ◆ The consequences of COVID-19 for the energy sector are twofold – the negative consequences for society are combined with a number of positive consequences. The negative consequences are based on changes in the structure of demand for energy products, income and price fluctuations in the relatively “traditional” parts of the energy sector; the positive effects of the crisis are related to the growing demand for energy-saving technologies and the intensification of energy production from alternative sources.
- ◆ The COVID-19 crisis created conditions for the transformation of the structure of demand for energy resources: along with the falling energy demand in the industrial sector, private energy consumption is growing and the declining demand for traditional energy sources is accompanied by the popularization of renewable energy.
- ◆ Measures to support energy infrastructure strengthening projects become especially relevant at the global level.
- ◆ Within the system of crisis measures aimed at the well-being of energy end users during the pandemic, a number of moratoriums on energy bills are envisaged.
- ◆ In Europe, the system of crisis management in the energy sector in a pandemic is to revise the pricing system for strategically important products of the energy sector, encourage investment in renewable energy, implement direct regulatory measures to ensure the security of energy supply in times of crisis, financial incentives for energy sector, in particular through soft loans and targeted grants.
- ◆ In Ukraine, in view of increased epidemiological crises, a number of practical measures aimed at improving and restructuring the energy sector should be implemented and crisis-management strategies should be revised in order to increase their effectiveness.

The application of the crisis solution system will ensure the adaptability and flexibility of the country’s energy system through the use of demand-management methods and the development of distributed generation. At the same time, conditions should be created to increase energy

efficiency. Coordinated and balanced decisions in the field of electricity asset management will make energy supply more reliable while reducing the costs of energy companies. This will create conditions for reducing tariffs. Cost-management solutions work in the same direction, but with more efficiency.

We believe that in view of increased epidemiological risks, it is extremely important to reconsider the existing strategic direction of crisis decisions. Reducing electricity consumption by industrial enterprises and limited financial resources against the background of government policies to reduce costs and curb tariffs create obstacles to the choice of alternatives. However, the same factors help to make flexible innovative decisions in the energy sector, which in turn could overcome many challenges in the face of uncertainty.

Thus, the key goal of implementing crisis-management measures in the energy sector at the global and national levels is to create conditions for the development of new opportunities and reduce the negative effects of the pandemic simultaneously.

References

- ASHURST 2020. Urgent measures in the energy sector in relation to the management and impact of COVID-19. ASHURST ENERGY SPAIN – COVID-19. [Online] <https://www.ashurst.com/en/news-and-insights/legal-updates/urgent-measures-in-the-energy-sector-in-relation-to-the-management-and-impact-of-covid-19/> [Accessed: 2022-02-05].
- BARANOVSKY, O.A. 2018. Theoretical aspects of assessing the financial stability of the enterprise. *Ekonomika i suspiljstvo* 15, pp. 206–212.
- BELÉN, V. 2014. *Finance and strategy*. Bingley, UK: Emerald, pp. 321–334.
- BP Statistical Review of World Energy 2019, 68th edition. [Online] <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf> [Accessed: 2022-02-05].
- BURYJ, S.A. 2006. Crisis management and management decisions – the problems of small businesses (*An-tykryzove upravlinnja ta upravlinsjki rishennja – problemy pidpryjemstv malogho biznesu*). Khmelnytsky: Triada-M. (in Ukrainian).
- CHEN et al. 2020 – CHEN, C.F., DE RUBENS, G.Z., XU, X. and LI, J. 2020. Coronavirus comes home? Energy use, home energy management, and the social-psychological factors of COVID-19. *Energy Res Social Sci*, 68, Article 101688, DOI: 10.1016/j.erss.2020.101688.
- CUCCHIELLA et al. 2015 – CUCCHIELLA, F., D’ADAMO, I. and GASTALDI, M. 2015. Financial analysis for investment and policy decisions in the renewable energy sector. *Clean Techn Environ Policy* 17, pp. 887–904, DOI: 10.1007/s10098-014-0839-z.
- DOROSHUK, H. 2021, Prospects and efficiency measurement of artificial intelligence in the management of enterprises in the energy sector in the era of Industry 4.0. *Polityka Energetyczna – Energy Policy Journal* 24(4), pp. 61–76, DOI: 10.33223/epj/144083.
- EnerghoVsesvit 2021. Electricity production in Ukraine for the first half of 2021 (*Vyrobnyctvo elektro-energhiji v Ukraini za I pivrichchja 2021 roku*), Kyiv. [Online] <https://vse.energy/news/pek-news/electro/1716-power-generation-202106> [Accessed: 2022-02-05].
- European Commission 2021. NextGenerationEU: European Commission endorses Spain’s €69.5 billion recovery and resilience plan. [Online] https://ec.europa.eu/commission/presscorner/detail/cs/ip_21_2987 [Accessed: 2022-05-01].

- European Green Deal 2020. [Online] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en [Accessed: 2022-02-05].
- GERNEGO, I.O. and LIAKHOVA, O.O. 2021, Financing the potential of alternative energy development in Ukraine. *Efektivna ekonomika* 3, DOI: 10.32702/2307-2105-2021.3.3.
- GERNEGO et al. 2021 – GERNEGO, I.U., PETRENKO, L., DYBA, M. and ONIKIENKO, S. 2021. Regional Environmental Systems as a Driver of Innovative Economy in Ukraine. *European Journal of Sustainable Development* 10(2), pp. 33–43, DOI: 10.14207/ejsd.2021.v10n2p33.
- Global Economic Prospects 2020. Pandemic, Recession: The Global Economy in Crisis. [Online] <https://www.worldbank.org/en/publication/global-economic-prospects> [Accessed: 2022-05-02].
- Green New Deal 2020. [Online] <https://www.congress.gov/116/bills/hres/109/BILLS116hres109ih.pdf> [Accessed: 2022-02-05].
- HOSSEINI, S.E. 2020. An outlook on the global development of renewable and sustainable energy at the time of Covid-19. *Energy Research & Social Science* 68, DOI: 10.1016/j.erss.2020.101633.
- HUANG et al. 2020 – HUANG, L., LIAO, Q., QIU, R., LIANG, Y. and LONG, Y. 2020. Prediction-based analysis on power consumption gap under long-term emergency: A case in China under COVID-19. *Applied Energy* 283, 14 p. DOI: 10.1016/j.apenergy.2020.116339.
- JIANG et al. 2021 – JIANG, P., VAN, Y.F. and KLEMEŠ, J.J. 2021. Impacts of COVID-19 on energy demand and consumption: Challenges, lessons and emerging opportunities. *Applied Energy* 285, DOI: 10.1016/j.apenergy.2021.116441.
- KHALATUR et al. 2020 – KHALATUR, S., KRIUCHKO, L. and SIRKO, A. 2020. World experience adaptation of anti-crisis management of enterprises in the conditions of national economy's transformation. *Baltic Journal of Economic Studies* 6(3), pp. 171–182, DOI: 10.30525/2256-0742/2020-6-3-171-182.
- KOSTYRKO, L.A. 2015. Formation of strategy of anti-crisis financial management of the enterprises in the conditions of uncertainty analytical maintenance of management. *Chasopys ekonomichnykh reform* 4, pp. 61–69.
- KOTHARI, R. 2017. *Financial management: a contemporary approach*. Los Angeles: SAGE, pp. 658–666.
- KOVAL et al. 2019 – KOVAL, V., SRIBNA, Y. and GASKA, K. 2019. Energy cooperation Ukraine-Poland to strengthen energy security. *E3S Web Conference*, 132, 01009, DOI: 10.1051/e3sconf/201913201009.
- KUZMYNCHUK et al. 2021 – KUZMYNCHUK, N., KUTSENKO, T., ZYMA, O., TEROVANESOVA, O. and BACHKIR, I. 2021. Paradigm towards ensuring of energy saving in the crisis management conditions in the aspect of sustainable environmental development. *E3S Web Conf.* 255, 01022, DOI: 10.1051/e3sconf/202125501022.
- MACERINSKIENE, I. and SURVILAITE, S. 2019. Company's intellectual capital impact on market value of Baltic countries listed enterprises. *Oeconomia Copernicana* 10(2), pp. 309–339, DOI: 10.24136/oc.2019.016.
- MAKHOVKA, V.M. 2015. Formation of anti-crisis management system of tourist enterprises (*Formuvannja systemy antykrizovogoho upravlinnja turystychnymy pidpryjemstvamy*). (PhD Thesis), Poltava.
- MASHARSKY et al. 2018 – MASHARSKY, A., AZARENKOVA, G., ORYEKHOVA, K. and YAVORSKY, S. 2018. Anti-crisis financial management on energy enterprises as a precondition of innovative conversion of the energy industry: case of Ukraine. *Marketing and Management of Innovations* 3, pp. 345–354, DOI: 10.21272/mmi.2018.3-31.
- MEISTE, R. and JAKSTIENE, S. 2015. Crisis Diagnosis in Anti-Crisis Management Process in a Company. *Oeconomia Copernicana* 6(4), pp. 49–58, DOI: 10.12775/OeC.2015.028.
- MOCANU, N. 2018. Implementation of Anti-Crisis Management Technologies. *International Journal of Innovation in the Digital Economy (IJIDE)*, IGI Global, 9(4), pp. 11–23, DOI: 10.4018/IJIDE.2018100102.
- NAN of Ukraine 2020. A comprehensive package of national anti-crisis measures to overcome the effects of the pandemic and create the conditions for sustainable socio-economic growth (*Naukovo-doslidnyj centr industrialnykh problem rozvytku NAN Ukrainy Kompleksnyj paket zahaljnoderzhavnykh*

- antykryzovykh zakhodiv podolannja naslidkiv pandemiji ta stvorennja peredumov do stalogho socialjno-ekonomichnogho zrostantnja*), Kharkiv (in Ukrainian).
- NEC 2018. Assessment of the state and implementation of concepts for the development of “intelligent” power grids in world practice (*Nacionaljna energhetychna kompanija Ukrenergho. Ocinka stanu ta realizaciji koncepcij rozvytku «intelektualjnykh» elektromerezh u svitovij praktyci*). [Online] <https://ua.energy/wp-content/uploads/2018/01/3.-Smart-Grid.pdf> [Accessed: 2021-12-10] (in Ukrainian).
- OMELCHENKO, V. 2022. Basic causes of the energy crisis in RAM 2021–2022 (*Bazovi prychny energhetychnoi kryzy v OZP 2021–2022 rr.*). [Online] <https://razumkov.org.ua/statti/bazovi-prychny-energhetychnoi-kryzy-v-ozp-2021-2022rr>. [Accessed: 2022-01-23] (in Ukrainian).
- RUGGIERO et al. 2021 – RUGGIERO, S., BUSCH, H., HANSEN, T. and ISAKOVIC, A. 2021. Context and agency in urban community energy initiatives: an analysis of six case studies from the Baltic Sea Region. *Energy Policy* 148, p. 111956, DOI: 10.1016/j.enpol.2020.111956.
- SABISHCHENKO et al. 2020 – SABISHCHENKO, O., REBILAS, R., SCZYGIOL, N. and URBAŃSKI, M. 2020. Ukraine Energy Sector Management Using Hybrid Renewable Energy Systems. *Energies* 13, 1776, DOI: 10.3390/en13071776.
- SANCHIS et al. 2020 – SANCHIS, R., CANETTA, L. and POLER, R. 2020. A conceptual reference framework for enterprise resilience enhancement. *Sustainability* 12(4), 1464, DOI: 10.3390/su12041464.
- SHTANGHRET, A.M. 2016. *Anti-crisis technologies in the management of economic security of the enterprise*. Lviv: Ukr. akad. Drukarstva, 249 p.
- SMEREKA, S.B. 2016. Features of anti-crisis management in housing and communal services (*Osoblyvosti antykryzovoho upravlinnja v zhytlovo-komunal'nomu hospodarstvi*). *Aktualni problemy ekonomiky* 1(91), pp. 92–97 (in Ukrainian).
- State statistical service of Ukraine 2019. Energy balance of Ukraine for 2019 (*Energhetychnyj balans Ukrainy za 2019 rik*). Derzhavna sluzhba statystyky Ukrainy, Kyiv: Informacijno-analitychne aghenstvo. [Online] <http://www.ukrstat.gov.ua/express/expr2020/11/148.doc> [Accessed: 2022-01-23] (in Ukrainian).
- SYTNYK, L.S. 2016. Anti-crisis marketing management. *Visnyk Khmelnytskoho natsionalnoho universytetu. Ekonomichni nauky*. 5(1), pp. 176–180.
- TENNENT, J. 2018. *Guide to financial management: understand and improve the bottom line*. Previous edition: New York: PublicAffairs. pp. 307–315.
- TERESHCHENKO, O.O. and PAVLOVSKY, S.V. 2016. Improving the financial mechanism of anti-crisis management of the enterprise. *Finansy Ukrainy* 6, pp. 108–123.
- WALECKA, A. 2021. The Role of Relational Capital in Anti-Crisis Measures Undertaken by Companies – Conclusions from a Case Study. *Sustainability* 13, 780, DOI: 10.3390/su13020780.
- WERTH et al. 2020 – WERTH, A., GRAVINO, P. and PREVEDELLO, G. 2020. Impact analysis of COVID-19 responses on energy grid dynamics in Europe. *Applied Energy* vol. 281, Article 116045.
- World Energy Council 2021. World Energy Trilemma Index 2021 Report. [Online] https://www.worldenergy.org/assets/downloads/WE_Trilemma_Index_2021_-_Executive_Summary.pdf?v=1634811254 [Accessed: 2022-01-23].
- YU-CHUNG TSAO et al. 2021 – YU-CHUNG TSAO, VO-VAN THANH, YI-YING CHANG and HSI-HSIEN WEI 2021. COVID-19: Government subsidy models for sustainable energy supply with disruption risks. *Renewable and Sustainable Energy Reviews* 150, Article 111425, DOI: 10.1016/j.rser.2021.111425.

Zarządzanie kryzysowe w energetyce w warunkach narastających zagrożeń epidemiologicznych

Streszczenie

Głównymi celami artykułu jest (i) określenie sektora energetycznego jako ważnej części gospodarki surowcowej w warunkach narastającego ryzyka epidemiologicznego oraz (ii) przedstawienie potencjału instrumentów zarządzania kryzysowego w zakresie oddziaływania i wzmocnienia sektora energetycznego w Ukrainie.

W opracowaniu wykorzystano oceny eksperckie i metody monograficzne (do oceny instrumentów zarządzania kryzysowego) metody graficzne. Praktyczne działania mające na celu poprawę i przekształcenie sektora energetycznego na Ukrainie określane są za pomocą syntezy i analizy ekonomicznej; porównania statystycznego i porównania z innymi krajami, gdzie wykorzystano analizy hiszpańskich doświadczeń w zakresie środków zarządzania kryzysowego w sektorze energetycznym po COVID.

Badanie problematyki dystrybucji energii elektrycznej na świecie pokazuje jej bezpośrednie powiązanie ze źródłami wytwarzania energii, w tym z wykorzystaniem energii odnawialnej, które nasiliło się pod wpływem COVID-19. Analiza wypracowanych systemów zarządzania kryzysowego daje podstawę do zaproponowania działań na rzecz poprawy i przekształcenia sektora energetycznego w Ukrainie. W związku z tym w części dotyczącej wyników przedstawiono wnioski mające na celu wzmocnienie sektora energetycznego w Ukrainie poprzez wsparcie rozwoju systemu zarządzaniem kryzysowym.

Studium jest częścią cyklu badawczego dotyczącego rozwoju sektora energetycznego, jego zarządzania i finansowania. Proponowane środki poprawy i przekształcenia sektora energetycznego w Ukrainie mogą być zastosowane do konkretnych projektów energetycznych, optymalizacji inwestycji w sektorze energetycznym, a także do modelowania złożonych systemów zarządzania kryzysowego w różnych sferach gospodarki.

SŁOWA KLUCZOWE: zasoby energetyczne, ekonomika zasobów, zagrożenia epidemiologiczne, zarządzanie kryzysowe