

DOI: <https://doi.org/10.34069/AI/2021.44.08.27>

How to Cite:

Loiko, V., Teremetskyi, V., Maliar, S., Rudenko, M., & Rudenko, V. (2021). Counteraction to offenses committed with the use of electronic payment systems: new challenges and problems. *Amazonia Investiga*, 10(44), 278-287. <https://doi.org/10.34069/AI/2021.44.08.27>

Critical infrastructure of the housing sector of the national economy: Economic and legal aspect

Критична інфраструктура житлового сектора національної економіки: економічно-правовий аспект

Received: July 19, 2021

Accepted: September 20, 2021

Written by:

Valeriia Loiko¹¹⁰<https://orcid.org/0000-0003-3248-1585>

Researcher ID: AAZ – 3619-2020

Vladyslav Teremetskyi¹¹¹<https://orcid.org/0000-0002-2667-5167>

Researcher ID: Y-1755-2018

Stanislav Maliar¹¹²<https://orcid.org/0000-0003-3136-853X>**Mykola Rudenko¹¹³**<https://orcid.org/0000-0002-9081-8716>**Valentyna Rudenko¹¹⁴**<https://orcid.org/0000-0001-9867-5951>

Abstract

The purpose of the study is to summarize the current state of the art in the economic and legal aspects of ensuring the functioning of critical infrastructure in the housing sector of the national economy and to substantiate proposals for its improvement. The study used general and special research methods: synergistic approach, trend statistical analysis method, economic-mathematical modelling using Statgraphics XV&I Centurion program, logical method and generalization method. The main results of the study include. It has been concluded that housing and public utilities infrastructure is the largest consumer of resources in the world economy, so its operation and development require further research. The authors have defined the tendencies for increasing the volumes of construction works on the territory of Ukraine for the period of 2016-2020 and slow rate for increasing the construction of housing stock. With the help of economic and mathematical modeling, the authors have obtained results of

Анотація

Метою дослідження є узагальнення сучасного стану щодо економіко-правових аспектів забезпечення функціонування критичної інфраструктури в житловому секторі національної економіки та обґрунтування пропозицій щодо його покращення. В процесі дослідження використовувалися загальні та спеціальні методи дослідження: синергетичний підхід, метод трендового статистичного аналізу, метод економіко-математичного моделювання із використанням програми Statgraphics XVIII Centurion, логічний метод та метод узагальнення. Основними результатами дослідження є наступні. Зроблено висновок, що житлово-комунальна інфраструктура є найбільшим споживачем ресурсів у світовій економіці, тому її функціонування та розвиток потребують подальших досліджень. Визначено тенденції зростання обсягів будівельних робіт на території України за період 2016-2020 рр. та повільний темп зростання будівництва житлового фонду. За допомогою економіко-

¹¹⁰ Doctor of Science of Economics, Professor, Professor of the Department of Finance and Economics of the Boris Grinchenko Kyiv University, Kyiv, Ukraine.

¹¹¹ Doctor of Law, Associate Professor, Western Ukrainian National University, Ternopil, Ukraine.

¹¹² Postgraduate student of the Department of Finance and Economics, Boris Grinchenko Kyiv University Kyiv, Ukraine.

¹¹³ Postgraduate student of the Department of Management, Chernihiv Polytechnic National University, Kyiv, Ukraine.

¹¹⁴ Postgraduate student of the Department of Finance and Economics, Boris Grinchenko Kyiv University Kyiv, Ukraine.

the forecast of the volume of commissioning of the total area of residential buildings in Ukraine. Based on the analysis of the dynamics of emergencies in residential buildings or constructions in Ukraine for the period of 2015-2020, the authors have made a conclusion on the need to implement measures on preventing emergencies. Critical infrastructure facilities within the residential sector of the national economy include both enterprises in the field of water supply, sewerage, production, transportation and marketing of heat and electricity, gas distribution and transportation and water heating and gas supply networks in residential buildings, as well as elevators and networks that provide communication.

Keywords: housing sector, critical infrastructure, human life and activities, needs, protection, security, legislation, monitoring.

Introduction

There is quite a relevant issue for the current economic situation in Ukraine – it is the issue what one should exactly refer to critical infrastructure: facilities, kinds of activities, certain territories, content of information messages or something else. Each country defines critical infrastructure facilities and the ways to protect them according to own legislation. The definition of the concept of “critical infrastructure” In Ukraine is only provided in the Law of Ukraine “On the Basic Principles of Cyber Security of Ukraine” (Law No 2163-VIII? 2021). The relevant legislation on critical infrastructure protection has not been adopted in Ukraine yet. When discussing the issues what exactly should be attributed to critical infrastructure and how to protect critical infrastructure, the scholars, politicians, military officers and journalists make many suggestions. In particular, foreign and Ukrainian speakers at the Lviv Security Forum made various propositions on what exactly should be attributed to the critical infrastructure (Grigorieva S. 2019). However, all speakers were inclined to believe that each state should independently identify critical infrastructure for its country and develop and approve legislation to protect it. Experts in Ukraine just begin to pay attention to the issues of economic and legal aspects of identifying, protecting and safe operation of critical

математичного моделювання отримано результати прогнозу обсягів введення в експлуатацію загальної площі житлових будинків в Україні. На основі проведеного аналізу динаміки виникнення надзвичайних ситуацій у будівлях або спорудах житлової призначеності території України за період 2015-2020 рр. зроблено висновок щодо необхідності запровадження заходів щодо попередження виникнення надзвичайних ситуацій. До об'єктів критичної інфраструктури у житловому секторі національної економіки віднесено як підприємства у сфері водопостачання, водовідведення, виробництва, транспортування та збуту теплової і електричної енергії, розподілу та транспортування газу так і мережі водо- тепло – та газопостачання у житлових будинках, а також ліфти та мережі, які забезпечують зв'язок.

Ключові слова: житловий сектор, критична інфраструктура, життєдіяльність людини, потреби, захист, безпека, законодавство, моніторинг.

infrastructure both in research and practice areas. Thus, it is advisable to continue research on this problematic issue.

Literature Review

A limited number of research papers is focused on the current economic and legal aspects of the critical infrastructure of the housing sector. It is a bright confirmation that the topic of critical infrastructure, in particular in the housing sector of Ukraine's economy, is new and relevant for conducting research.

Legal aspects of protecting critical infrastructure of the housing sector as a component of improving administrative and legal provision of relations in the field of housing and public utility services, are substantiated in the works of V. Teremetskyi (Teremetskyi, V.I., 2017a, 2020). The problems of restoring the housing rights of children, internally displaced persons and other categories of people have been considered in the work of Teremetskyi V. (Teremetskyi, V.I., 2017b). The article by V. Teremetskyi, O. Avramova, O. Svitlychnyy, V. Sloma, O. Bodnarchuk, A. Telestakova, V. Kokhan is focused on the issues of protecting housing rights as the basis for the formation of critical infrastructure's safe functioning in the housing

sector of Ukraine (V. Teremetskyi, O. Avramova, O. Svitlychnyy, V. Sloma, O. Bodnarchuk, A. Telestakova, V. Kokhan, 2021). Identification of critical infrastructure facilities in the housing sector of the national economy is related to the formation of requirements for housing in Ukraine, which have been studied within historical and legal aspect in the article prepared by Stefanchuk, A. Muzyka, M. Stefanchuk, O. Cherniak, N. Rudyi, I. Meshchan (M. Stefanchuk, A. Muzyka, M. Stefanchuk, O. Cherniak, N. Rudyi, I. Meshchan, 2021). The papers of such Ukrainian scholars as Biryukov, D.S., Kondratov, S.I. (Biryukov, D.S., Kondratov, S.I., 2012; Biryukov, D.S., 2015) and foreign scholars as Stergiopoulos, G., Kotzanikolaou, P., Theocharidou, M. and Gritzalis, D. (Stergiopoulos, G., Kotzanikolaou, P., Theocharidou, M. and Gritzalis, D., 2015) are focused on studying the essence of the concepts of “critical infrastructure” and “critical infrastructure facilities”. The legal and organizational aspects of ensuring the sustainability of critical infrastructure in Ukraine are under the focus of the analytical report of the authors Bobro D.G., Ivanyuta S.P., Kondratov S.I., Sukhodolya O.M. (Bobro D.G., Ivanyuta S.P., Kondratov S.I., Sukhodolya O.M.] / for the general. ed. O.M. Sukhodolya, 2015). Analysis of the level of provision by regulatory legal acts in the legislative base of Ukraine regarding the identification and protection of critical infrastructure has been carried out in the scientific work of Ukrainian scholars Loiko V., Khrapkina V., Maliar S., Rudenko M. (Loiko V., Khrapkina V., Maliar S., Rudenko M., 2020). Given the fact that scientific research, the results of which are already published in the scientific literature, were mostly about economic and legal aspects of critical infrastructure in general in the national economy of the country, then it is advisable to pay attention to a more narrow area of the research, namely the economic and legal aspects of the functioning of critical infrastructure in the housing sector of the national economy.

Methodology

Analysis of the problem of economic and legal provision for the functioning of the critical infrastructure of the housing sector of the national economy involves the use of several leading approaches. Synergetic is one of the approaches. It combines the results of the research in the economic and legal spheres to determine the priority while identifying critical infrastructure facilities of the housing sector of

the national economy. Economic and mathematical methods and forecasting methods have been also used in the research. To study the tendencies in dynamic processes, namely changes in the volume of construction and the volume of setting housing in operation, the method of trend statistical analysis has been used in Ukraine over the years. To establish the interdependence of changes in the volume of commissioned housing on the volume of construction, the Statgraphics XVIII Centurion Statistical Analysis Program was used. Forecasting of changes in the volume of commissioning of the total area of residential buildings has been carried out with the help of the same Program. The method of comprehensive statistical analysis has been used while analyzing the dynamics of emergencies in buildings or constructions of residential purpose in Ukraine. Methods of analysis and synthesis have been used while analyzing the essence of the norms of law related to critical infrastructure in Ukraine. The logical method and the method of generalization have been used in order to analyze the data, legislative acts of Ukraine and to form own conclusions.

Results and Discussion

The quick growth of the demand for housing is caused by the rapid pace of urbanization in all countries of the world and namely, in Ukraine. Accumulation of the volume of housing construction taking into account modern requirements for the comfort of living increases the provision of public utility services (electricity, heating, water supply and drainage, communications and Internet, garbage disposal), which increases the volume of resources used. According to the conducted research, most of the resources that enter the economy and, in particular, the housing and public utility services sector, are used by society during the year and are short-lived products. The volume of resources spent on utilities and can be attributed to non-durable products, is 52.6 billion tons annually (Haffmans et al, 2018). The materials used for building residential houses and their infrastructure are considered long-term stocks, the shelf life of which expires over decades. 48 billion tons annually are those resources that function in the economy in the form of buildings, infrastructure and capital equipment (Wiedenhof D., Fishman T., Lauk C., Haas W., Krausmann F., 2019; Bakker et al., 2014). Annually 38.8 billion tons of depleted resources are spent to meet the social needs of mankind to develop and maintain the proper state of housing and public utility infrastructure (Haffmans et al,

2018). Housing and public utility infrastructure is the largest consumer of resources in the world economy.

The analysis of the dynamics of the volume of construction work performed in Ukraine and the

volume of the total area of commissioned residential buildings for the period 2016 - 2020 (Table 1) allowed us to draw the following conclusions.

Table 1.

Dynamics of the volume of construction work performed and the volume of housing commissioned in Ukraine for the period 2016-2020

Indicator	2016	2017	2018	2019	2020	Deviation of 2020 data from 2016 data, %
Volumes of construction work performed, UAH million	73726,9	105682,8	141213,1	181697,9	202080,8	Growth of 2,74 times
Volumes of construction of residential buildings, UAH million	18012,8	23730,0	29344,8	32208,8	29083,6	Growth of 1,61 times
The share of construction of residential buildings in the total volume of construction works, %	20,26	22,45	20,78	17,72	14,39	- 5,87
Indices of construction products, in% to the previous year	128,18	143,34	133,62	128,67	105,6	- 22,58
The total area of residential buildings put into operation, thousand m ²	9367,0	10206,0	8689,36	11029,32	5749,92	- 38,62

Source: compiled by the authors according to the data (Statistical information. Official site of the State Statistics Service of Ukraine, 2021)

The volume of construction works in Ukraine for the period 2016-2020 within cost measurement increased by 2.74 times. Growth volumes of housing construction were much slower and increased by only by 1.61 times during the researched period. The share of residential buildings in the total volume of construction works during the researched period decreased by 5.87%. It should be noted that the share of construction of residential buildings within cost measurement in 2020 amounted to only 14.39% of the total volume of construction works in Ukraine, which is a low indicator. The growth rate of construction output slowed down by 22.58%. The total area of residential buildings put into operation decreased by 38.62% over the same period. The tendency observed in the Ukrainian economy over the past five years, namely, the decline in housing construction in Ukraine and the decline in the share of housing construction in the total volume of construction

works, may lead to social problems in the country.

Construction in general and the construction of residential buildings, in particular, as an economic activity, is a comprehensive complementary system with many internal relationships, so the study of this system and the establishment of mathematical dependences should be carried out by using special mathematical packages by multidimensional statistical analysis. The statistical analysis program Statgraphics XVIII Centurion was used to establish mathematical dependences and to build predictive models.

According to the conducted research, it was concluded that the volume of commissioning of the total area of residential buildings is not directly dependent on the growth rate of construction works (Table 2).

Table 2.

The results of the study of the total area of residential buildings, which were put into operation from the total area of construction works in Ukraine for the period 2000 - 2020.

Name of the dependence	Established dependence	Correlation coefficient	Confidence probability, %	Degree of influence of the argument on the change of the function, %
Dependence of the volume of commissioning of the total area of residential buildings from the volume of construction works	Commissioning of the total area = $1 / (0,0000782015 + 1,63035 / \text{volume of construction works})$	0,900153	95,0	96,89
Dependence of GDP volumes generated in the consumer sector of the economy from the household disposable income	GDP volume in the consumption = $\exp(4,15283 + 0,915146 * \ln(\text{household disposable income}))$	0,972515	95,0	94,57

The situation of declining housing construction volumes is explained by the presence of the “frozen” or not put into operation residential buildings for various reasons (Loiko, V.V., Maliar, S.A., Rudenko, M.V., 2020). One of the reasons for the decline in housing construction volumes is the decline in the purchasing power of the population and the slowdown in the rate of housing purchase. According to the established interdependence of GDP volumes generated in the consumer sector of the economy and the volumes of the household disposable income (Table 2), one can state that the decline in household income slows down the rate of purchase of all types of goods and housing, in particular. With the decline of the household disposable incomes, the population starts to buy only basic necessities, namely food, clothing, footwear, communications and emergency medical services (Loiko, D.M., Rudenko, V.S., 2020). In terms of limited financial resources in Ukrainian families the debt for public utility services increases, as evidenced by the statistical information of Ukraine. The growth of the household disposable income will contribute to the revival of the real estate market of the residential sector and will strengthen social

security as a factor of sustainable development of the country.

Using the Statgraphics XVIII Centurion statistical analysis program we have defined the best model for predicting possible further changes in the “commissioning volume of the total area of residential buildings”, which is described by the “exponential tendency” (2):

$$\exp(216734 + 0,00341451 t) \quad (2)$$

Graphical interpretation of this model demonstrates that the best forecast of future data for “commissioning of the total area of residential buildings” is given by the exponential regression curve, which corresponds to all previous statistics (Fig. 1). The result summarizes the statistical significance of the terms within the forecasting model. P values less than 0.05 are statistically significantly different from zero at the 95.0% confidence level. Thus, it can be stated that there will be the projected increase in the volume of commissioning of residential buildings, which should require an increase in resources.

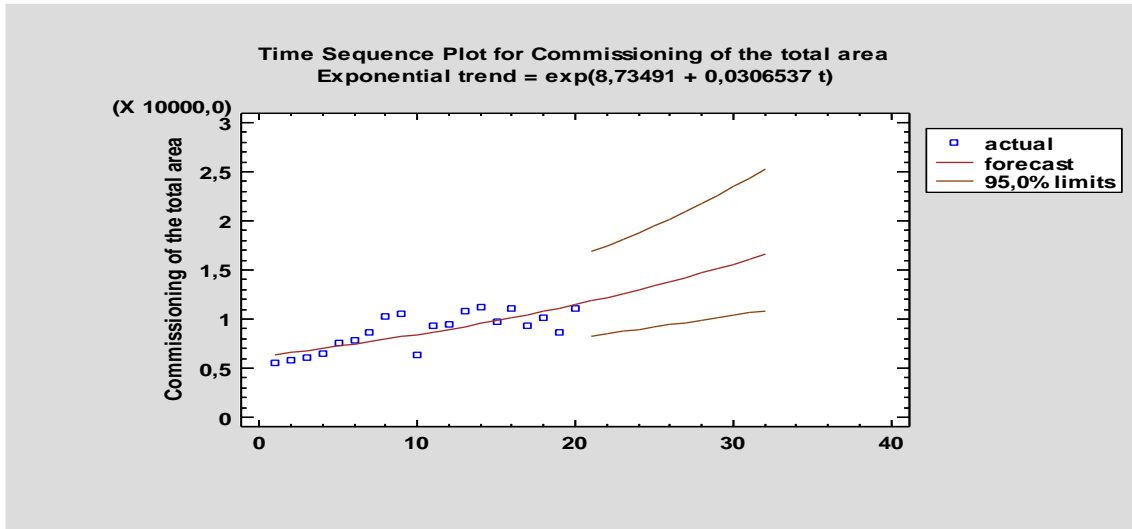


Fig. 1. Graphical interpretation of the forecast of commissioning volumes of the total area of residential buildings.

Source: original development.

The level of residential penetration per one Ukrainian resident was not changed during the period 2016-2002 and averaged 16 m² per man. The average level of providing square meters per one inhabitant of the country in residential buildings is much higher in European countries: one inhabitant of Lithuania has 30.9 m² of living space, in Finland – 36.2 m², in Germany – 39.4 m², in Denmark – 54.4 m², in Poland – 24.7 m².

The existing housing stock of Ukraine needs significant amounts of repair and reconstruction works. According to experts, the volume of residential buildings in need of major repairs is 72 million m². This significant amount of repair works requires a significant volume of resources. The constant lack of funds in the public utilities services of cities and villages of Ukraine leads to further destruction of the housing stock and bringing it to a state of impossibility of further operation. The category of dilapidated and emergency residential buildings in Ukraine includes 45,539 houses with a total area of 4,305,154 m², which is 0.30%, where 59,749 residents live permanently (Statistical information, 2021). It should be noted that

communications also need major repairs. The constant lack of funds and untimely repairs of communication networks of residential buildings leads to the loss of water, heat, destruction of buildings, unauthorized discharge of sewage and increased costs of residents to provide their own living conditions. According to the conducted research, the annual intake of clean drinking water over the past 20 years has increased on average 1.6 times in the world, from 2.5 to 3.9 thousand km³ per year (Food and Agriculture Organization of the United Nations, 2016). 11% of the total intake of clean drinking water goes for the needs of the housing and public utility sector, which is a significant amount in the global economy.

Lack of funds and late maintenance, as well as overhaul of housing and communications leads to emergencies and significant losses of financial resources. Analysis of the dynamics of emergencies in residential buildings or structures in Ukraine for the period 2015-2020 (Table 3) provided an opportunity to make the following conclusions.

Table 3.

Dynamics of emergencies in residential buildings or structures on the territory of Ukraine for the period 2015-2020

Name of the indicator	Years						Deviation 2020 data from 2015 data, %
	2015	2016	2017	2018	2019	2020	
The total number of emergencies of man-made nature	63	56	50	48	60	47	- 25,39
Including:	40	36	22	22	27	26	- 35,0
- due to fires, explosions - in residential buildings or constructions	30	29	14	17	13	13	- 56,67
- due to the sudden destruction of buildings and constructions	2	4	4	0	4	4	It is doubled
- due to accidents in power systems	1	1	2	1	3	0	- 100,0
- due to accidents in life support systems	5	4	7	5	10	4	- 20,0
- due to the presence of harmful or radioactive substances in the air above the maximum permissible concentration	1	0	1	2	3	0	- 100,0
People died as a result of emergencies of man- made nature	242	152	134	115	164	170	- 29,75
People injured as a result of emergencies of man-made nature	962	165	85	89	142	305	- 68,30
Financial damage, UAH million	532,72	265,31	896,8	496,97	1626,73	9916,68	Increased 18,62 times

Source: compiled by the authors according to the data (Official site of the State Service of Ukraine for Emergencies (2021a). Information and analytical report on the occurrence of emergencies in Ukraine during 2016; Official site of the State Service of Ukraine for Emergencies (2021b). Information and analytical report on the occurrence of emergencies in Ukraine during 2017; Official site of the State Service of Ukraine for Emergencies (2021c). Information and analytical report on the occurrence of emergencies in Ukraine during 2018; Official site of the State Service of Ukraine for Emergencies (2021d). Information and analytical report on the occurrence of emergencies in Ukraine during 2019; Official site of the State Service of Ukraine for Emergencies (2021e). Information and analytical report on the occurrence of emergencies in Ukraine during 2020).

The total number of man-made emergencies in Ukraine for the period of 2015-2020 has a positive tendency to decrease by 25.39%. Namely, the number of emergencies due to fires and explosions has decreased by 35.0% during the researched period. The number of emergencies in residential buildings or structures has decreased by 56.67%. The number of emergencies due to the sudden destruction of buildings has doubled and amounted to 4 cases in 2020; due to accidents in power systems has tripled in 2019 and amounted to 3 cases, and in 2020 – 0 cases; due to accidents in life support

systems has doubled and amounted to 10 cases in 2019 and 4 cases in 2020; due to the presence of harmful or radioactive substances in the air above the maximum allowable concentration has tripled and amounted to 3 cases in 2019 and 0 cases in 2020. The dynamics of the number of people, who died as a result of the emergency situation is positive, the number of such cases has decreased by 29.75%. The dynamics of the number of people affected by the emergency situation is also positive; the number of cases has decreased by 68.30%. The dynamics of the volume of financial damage caused to the economy of

Ukraine due to emergencies of man-made nature is negative; the volume of financial damage has increased by 18.62 times. A significant number of emergencies, which lead to both significant financial damage and the loss of health or ability to work of people after emergencies, require increased attention in regard to the use of preventive measures to prevent such situations. Persons affected by emergencies must apply to the authorities and local self-government agencies at their place of residence for a certificate confirming their status. Such a certificate gives them the right to compensation for damages. For example, if housing is destroyed as a result of an emergency, state authorities and local self-government agencies decide to solve housing problems at the expense of the reserve fund of the budget (they provide monetary compensation or buy other housing). Victims may be temporarily provided with accommodation, in particular, premises allocated to the interim housing or reserve fund. Unfortunately, there are very few such premises even in the city of Kyiv and they are usually in unsatisfactory sanitary conditions.

Local self-government agencies may also decide to provide other types of assistance (wounded, relatives of the dead, injured). In addition, there are social programs in the cities, when citizens who find themselves in difficult life circumstances can be provided with assistance.

However, this problem must be addressed comprehensively. The new Law of Ukraine “On Housing and Public Utility Services” provides responsibility insurance of the manager for damages caused to property by co-owners of houses due to improper performance of duties. The introduction of compulsory insurance by responsibility service providers will help to relieve the burden on the state and local budgets, at the expense of which compensation is paid, and will provide fast and full compensation for damages caused to victims.

There is no exhaustive list of facilities in Ukraine that need to be classified as critical infrastructure and there is virtually no legislation on their handling. At the same time, the Procedure for the formation of the list of information and telecommunication systems of critical infrastructure facilities of the state was approved on August 23, 2016 by the Resolution of the Cabinet of Ministers of Ukraine No. 563. It provides the definition to critical infrastructure as “a set of state infrastructure facilities that are most important for economy and industry, the functioning of society and security of the

population, the lay-up or destruction of which may affect national security and defense, the environment, may lead to significant financial losses and human toll” (Resolution of the Cabinet of Ministers of Ukraine № 563, 2016). Although the Decree has expired, the above definition of critical infrastructure is relevant.

Infrastructure is understood as “the set of fundamental facilities and systems that support the sustainable functionality of households and firms. Serving a country, city or other area, including the services and facilities necessary for its economy to function. The physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions” (Zavadsky, J.S., Osovskaya, T.V., Yushkevich, O.O., 2006).

According to the Law of Ukraine “On Basic Principles of Ensuring Cyber Security of Ukraine”, critical infrastructure facilities can include “enterprises, institutions and organizations regardless of the form of ownership that provide services in the spheres of life support, in particular in the spheres of centralized water supply, sewerage, electricity supply and gas, food production, agriculture, health care; are public utilities, emergency and rescue services, emergency services” (Law No 2163-VIII, 2021).

Threats to the critical infrastructure of the housing and public utilities sector of the national economy can be considered not only in terms of their origin, but also the elements of the critical infrastructure, to which these threats are directed to: physical elements, management systems, communication systems, personnel of critical infrastructure facilities.

Conclusion

It can be concluded that the critical infrastructure facilities in the housing and public utilities sector of the national economy include both enterprises in the field of water supply, sewerage, production, transportation and sale of heat and electricity, gas distribution and transportation and elevators in residential buildings and networks of water and heat and gas supply, as well as networks that provide communication.

The lack of special legislation, in particular criminal liability for failure of owners and managers of critical infrastructure to fulfill their obligations for its smooth operation and purposeful use, leads to threats to the population.

It is necessary to develop and adopt the Law of Ukraine “On Critical Infrastructure”, to amend the current Laws of Ukraine “On Privatization of State and Municipal Property”, “On the State Property Fund”, to amend antitrust legislation, the Criminal Code of Ukraine. The purpose of legislative amendments should be the provision of state control over critical infrastructure; the prevention of managers of critical infrastructure from abusing their capabilities to the detriment of people; the prevention of control of other countries over strategic facilities of Ukraine.

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